2008 Status of the Nation's Highways, Bridges, and Transit:

Conditions & Performance

REPORT TO CONGRESS

U.S. Department of Transportation
Federal Highway Administration
Federal Transit Administration

Table of Contents

List of Exhibits

Executive Summary

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Main Report

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act of 1990
ADT	average daily traffic
ATPPL	Alternative Transportation in Parks and Public Lands
ATS	alternative transportation system
BAC	blood alcohol concentration
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
BOO	Build-Own-Operate
BOR	Bureau of Reclamation
BOT	Build-Operate-Transfer
BPI	Bid Price Index
BPR	U.S. Bureau of Public Roads
BRT	bus rapid transit
CAFE	Corporate Average Fuel Economy
CEV	capacity-equivalent vehicle
CFR	Code of Federal Regulations
CFS	Commodity Flow Survey
CMAQ	Congestion Mitigation and Air Quality Improvement Program
Combo	combination truck
CPI	Consumer Price Index
CREATE	Chicago Region Environmental and Transportation Efficiency Program
CTAA	Community Transportation Association of America
DAR	Defense Access Road Program
DBFO	Design-Build-Finance-Operate
DBOM	Design-Build-Operate-Maintain
DFW	Dallas/Fort Worth
DHS	U.S. Department of Homeland Security
DMS	dynamic message signs
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DVMT	daily vehicle miles traveled
EFM	Electronic Freight Manifest
EIA	Energy Information Administration
ERFO	Emergency Relief for Federally Owned Roads
FAF	Freight Analysis Framework
FARS	Fatality Analysis Reporting System
FEMA	Federal Emergency Management Agency
FH	Forest Highways Program
FHWA	U.S. Federal Highway Administration

FLH	Federal Lands Highway
FLHP	Federal Lands Highway Program
FLMA	Federal Lands Management Agency
FLREA	Federal Lands Recreation Enhancement Act
FMCSA	Federal Motor Carrier Safety Administration
FPM	freight performance manifest
FTA	U.S. Federal Transit Administration
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GAN	Grant Anticipation Note
GARVEE	Grant Anticipation Revenue Vehicle
GDP	gross domestic product
HERS	Highway Economic Requirements System
HFCS	Highway Functional Classification System
HI	health index
HMCRP	Hazardous Materials Cooperative Research Program
HOT	high-occupancy toll
HOV	high-occupancy vehicle
HPMS	Highway Performance Monitoring System
HPMS-AP	HPMS Analytical Process
HSAS	Homeland Security Advisory System
HTF	Highway Trust Fund
ICM	integrated corridor management
IFTWG	Intermodal Freight Technology Working Group
IRI	International Roughness Index
IRR	Indian Reservation Roads
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation Systems
LMHS	Land Management Highway System
LNG	liquefied natural gas
LPG	liquefied petroleum gas
M&O	management and operations
MCS	maintain current spending
MEI	maximum economic investment
MinBCR	minimum benefit-cost ratio
MIR	Military Installation Roads
MPO	metropolitan planning organization
MTA	Mass Transit Account
NAFTA	North American Free Trade Agreement
NBI	National Bridge Inventory
NBIAS	National Bridge Investment Analysis System
NBIS	National Bridge Inspection Standards
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NFSR	National Forest System Roads
NHS	National Highway System
NHTS	National Household Travel Survey

NHTSA	National Highway Traffic Safety Administration
NOx	nitrogen oxide
NPS	National Park Service
NPTS	Nationwide Personal Transportation Survey
NTD	National Transit Database
PCR	Pavement Condition Rating
PL	Public Law
PLH	Public Lands Highways
PLDR	Public Lands Development Roads
PMT	passenger miles traveled
POV	privately owned vehicle
PPP	public-private partnership
PRP	Park Roads and Parkways
PSR	Present Serviceability Rating
PV	passenger vehicle
RFP	Request for Proposals
RFQ	Request for Quotation
RRP	Refuge Roads Program
RTD	Regional Transportation District
RVD	recreation visitor day
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SDDC	Surface Deployment and Distribution Command
SDDCTEA	Surface Deployment and Distribution Command Transportation Engineering Agency
SEP-15	Special Experimental Project No. 15
SIB	State Infrastructure Bank
SQC	Synthesis Quantity, and Condition
SR	sufficiency rating
SSI	Sensitive Security Information
STP	Surface Transportation Program
STRAHNET	Strategic Highway Network
STSIP	Surface Transportation Security Inspection Program
SU	single-unit truck
SUV	sports utility vehicle
TDM	traffic demand management
TEA-21	Transportation Equity Act for the 21st Century
TERM	Transit Economic Requirements Model
TEU	twenty-foot equivalent unit
TIFIA	Transportation Infrastructure Finance and Innovation Act
TMC	traffic management center
TOT	truck-only toll
TSA	Transportation Security Administration
TTC	Trans-Texas Corridor
TTI	Texas Transportation Institute
TVT	Traffic Volume Trends
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture

USFS	U.S. Forest Service
UZA	urbanized area
VII	vehicle infrastructure integration
VMS	variable message sign
VMT	vehicle miles traveled
VRM	vehicle revenue mile
V/SF	volume to service flow
VSL	variable speed limit

Introduction

This is the eighth in a series of combined documents prepared by the U.S. Department of Transportation (DOT) to satisfy requirements for reports to Congress on the condition, performance, and future capital investment needs of the Nation's highway and transit systems. This report incorporates highway, bridge, and transit information required by Section 502(h) of Title 23, United States Code (U.S.C.), as well as transit system information required by Section 308(e) of Title 49, U.S.C. Beginning in 1993, the Department combined two separate existing report series that covered highways and transit to form this report series; prior to this, 11 reports had been issued on the condition and performance of the Nation's highway systems, starting in 1968. Five separate reports on the Nation's transit systems' performance and conditions were issued beginning in 1984.

This *2008 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* report to Congress (C&P report) draws primarily on 2006 data. The 2006 C&P report, transmitted on February 12, 2007, was based primarily on 2004 data.

Report Purpose

This document is intended to provide decision makers with an objective appraisal of the physical conditions, operational performances, and financing mechanisms of highways, bridges, and transit systems based both on the current state of these systems and on the projected future state of these systems under a set of alternative future investment scenarios. This report offers a comprehensive, data-driven background to support the development and evaluation of legislative, program, and budget options at all levels of government. It also serves as a primary source of information for national and international news media, transportation associations, and industry.

This C&P report consolidates conditions, performance, and financial data provided by States, local governments, and mass transit operators to provide a national-level summary. Some of the underlying data are available through the DOT's regular statistical publications. The future investment scenario analyses are developed specifically for this report and provide national-level projections only.

Report Organization

This report begins with a "Highlights" section that lists key findings. These findings focus on changes in various indicators since 1997, the last year prior to the enactment of the Transportation Equity Act for the 21st Century (TEA-21), which authorized Federal highway and transit funding for 1998 through 2003. TEA-21 was followed by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which authorized funding from 2005 to 2009. The indicators, therefore, reflect the state of highway and transit conditions and performance during the TEA-21 and early SAFETEA-LU periods.

The "Highlights" section is followed by an Executive Summary that highlights the key findings in each individual chapter. These two sections will also be published as a separate stand-alone summary document.

The main body of the report is organized into four major sections. The six chapters in Part I, "Description of Current System," contain the core retrospective analyses of the report. Chapters 2 through 6 each start with separate highway and transit sections discussing each mode in depth, followed by a combined section comparing key highway and transit statistics with those presented in the 2006 edition. This structure is intended to accommodate report users who may primarily be interested in only one of the two modes, as well as those who want a quick multimodal perspective on recent trends.

- **Chapter 1** provides a broad overview of the functions served by the Nation's highways and transit systems.
- **Chapter 2** describes recent trends in highway, bridge, and transit system characteristics.
- **Chapter 3** depicts the current physical conditions of highways, bridges, and transit systems.
- **Chapter 4** describes the current operational performance of highways and transit systems.
- **Chapter 5** discusses issues relating to the safety of highways and transit.
- **Chapter 6** discusses outlines highway and transit revenue sources and expenditure patterns for all levels of government, as well as recent innovations in highway finance.

The four chapters in Part II, "Investment/Performance Analysis," contain the core prospective analyses of the report. The Introduction to Part II provides critical background information and caveats that should be considered while interpreting the findings presented in Chapters 7 through 10. Within Part II, the structure of the chapters has been modified; therefore some of the material presented in a particular chapter in the 2006 edition may be found in a different chapter in this report.

- **Chapter 7** projects the potential impacts of different levels of future highway, bridge, and transit capital investment on the future performance of various components of the system.
- **Chapter 8** describes selected capital investment scenarios in more detail and relates these scenarios to the current levels of capital investment for highways, bridges, and transit.
- **Chapter 9** relates the future investment scenario findings to observations regarding the impacts that past highway, bridge, and transit investment has had on the conditions and operational performance of the system, and discusses future implications of the scenarios.
- **Chapter 10** discusses how some future highway and transit investment scenarios would be affected by changing the assumptions about travel growth and other key variables.

Part III, "Special Topics," explores further some topics related to the primary analyses in the earlier sections of the report. Some of these chapters reflect recurring themes that have been discussed in previous editions of the C&P report, while others address new topics of particular interest that will be included in this edition only.

- **Chapter 11** examines the serviceability of bridges on the National Highway System (NHS) and projects the future state of these bridges over a 50-year period under alternative future management strategies.
- **Chapter 12** includes an analysis of condition and performance of transportation serving Federal and Indian lands.
- **Chapter 13** discusses the role of freight transportation and identifies investment and performance issues specific to the freight area.

- **Chapter 14** identifies congestion reduction strategies to address the highway operational performance problems identified in Chapter 4.
- **Chapter 15** discusses selected findings from the 2001 National Household Travel Survey (NHTS).

Part IV, "Afterword: A View to the Future," describes ongoing research activities and identifies potential areas for improvement in the data and analytical tools used to produce the analyses contained in this report.

The report also contains three technical appendices that describe the investment/performance methodologies used in the report for highways, bridges, and transit.

In assessing recent trends, different parts of this report focus on different time intervals; for example, the "Highlights" section generally compares 2006 statistics with those for 1997. The "Comparison" sections at the end of Chapters 2 through 6 compare 2006 statistics with those for 2004 presented in the last edition of the C&P report. Within the main body of the chapters, many exhibits present statistics for the primary data years reflected in the last five C&P reports (1997, 2000, 2002, 2004, and 2006). Other exhibits cover a longer period of time, depending on data availability and years of significance for particular data series.

This report also discusses security issues that affect the Nation's highway and transit infrastructure. Although not the primary focus of the report, security remains of paramount importance to policymakers and the general public. Information on these issues is included in Q&A boxes in Chapters 1 and 2.

Highway Data Sources

Highway conditions and performance data are derived from the Highway Performance Monitoring System (HPMS), a cooperative data/analytical effort dating from the late-1970s that involves the Federal Highway Administration (FHWA) and State and local governments. The HPMS includes a statistically drawn sample of more than 100,000 highway sections containing data on current physical and operating characteristics, as well as projections of future travel growth on a section-by-section basis. All HPMS data are provided to FHWA through State departments of transportation from existing State or local government databases or transportation plans and programs, including those of metropolitan planning organizations.

The HPMS data are collected in accordance with the *Highway Performance Monitoring System Field Manual for the Continuing Analytical and Statistical Database.* This document is designed to create a uniform and consistent database by providing standardized collection, coding, and reporting instructions for the various data items. The FHWA reviews the State-reported HPMS data for completeness, consistency, and adherence to reporting guidelines. Where necessary, and with close State cooperation, data may be adjusted to improve uniformity. The HPMS data also serve as a critical input to other studies that are cited in various parts of this report, such as the Texas Transportation Institute's *2007 Urban Mobility Report* and a 2005 report commissioned by the FHWA, *An Initial Assessment of Freight Bottlenecks on Highways.*

State and local finance data are derived from the financial reports provided by the States to FHWA in accordance with *A Guide to Reporting Highway Statistics.* These are the same data used in compiling the annual *Highway Statistics* report. The FHWA adjusts these data to improve completeness, consistency, and uniformity. Highway safety performance data are drawn from the Fatality Analysis Reporting System (FARS).

Bridge Data Sources

The FHWA collects bridge inventory and inspection data from the National Bridge Inventory (NBI) annually. The NBI contains information from all bridges covered by the National Bridge Inspection Standards (Title 23, Code of Federal Regulations, Part 650) located on public roads throughout the United States and Puerto Rico. Inventory information for each bridge includes descriptive identification data, functional characteristics, structural design types and materials, location, age and service, geometric characteristics, navigation data, and functional classifications; conditions information includes inspectors' evaluations of the primary components of a bridge, such as the deck, superstructure, and substructure. According to the National Bridge Inspection Standards, bridges are inspected once every 24 months with the flexibility to decrease the frequency based on owner-established criteria or increase the frequency based on justification and FHWA approval. The archival NBI data sets represent the most comprehensive uniform source of information available on the conditions and performance of bridges located on public roads throughout the United States.

Transit Data Sources

Transit data are derived from the National Transit Database (NTD). (This information was formerly known as Section 15 data.) The NTD includes detailed summaries of financial and operating information provided to the Federal Transit Administration (FTA) by the Nation's transit agencies. The NTD provides information needed for planning public transportation services and investment strategies. The information from the NTD on transit fleets and facilities is supplemented with information collected directly from transit operators in order to provide a more complete picture of the Nation's total transit infrastructure.

Other Data Sources

Other data sources are also used in the special topics and supplemental analyses sections of the report. For example, the NHTS provides information on the characteristics, volume, and proportion of passenger travel across all modes of transportation; transit user characteristics and system benefits are based on customer survey statistics collected by the Transit Performance Monitoring System; and information on freight activity is collected by the Census Bureau through the Commodity Flow Survey and the Vehicle Inventory and Use Survey, and then merged with other data in FHWA's Freight Analysis Framework.

Investment/Performance Analytical Procedures

The earliest versions of the reports in this combined series relied exclusively on engineering-based estimates for future investment/performance analysis, which considered only the costs of transportation agencies. This philosophy failed to adequately consider another critical dimension of transportation programs, such as the impacts of transportation investments on the costs incurred by the users of the transportation system. Executive Order 12893, *Principles for Federal Infrastructure Investments,* dated January 1994, directs each executive department and agency with infrastructure responsibilities to base investments on " . . . systematic analysis of expected benefits and costs, including both quantitative and qualitative measures . . . ." New approaches have been developed to address the deficiencies in earlier versions of this report and to meet the challenge of this executive order. The analytical tools now used in this report have added an economic overlay to the development of future investment scenarios. These newer tools use benefit-cost analysis to minimize the combination of capital investment and user costs to achieve different levels of highway performance.

The highway investment scenarios presented in this report are developed in part from the Highway Economic Requirements System (HERS), which uses marginal benefit-cost analysis to optimize highway investment. The HERS model quantifies user, agency, and societal costs for various types and combinations of improvements, including travel time and vehicle operating, safety, capital, maintenance, and emissions costs.

Bridge investment scenario estimates were developed from the National Bridge Investment Analysis System (NBIAS) model, which was used for the first time in the 2002 edition of the C&P report. Unlike earlier bridge models (and similar to HERS), NBIAS incorporates benefit-cost analysis into the bridge investment/performance evaluation.

The transit investment analysis is based on the Transit Economic Requirements Model (TERM). The TERM consolidates older engineering-based evaluation tools and introduces a benefit-cost analysis to ensure that investment benefits exceed investment costs. TERM identifies the investments needed to replace and rehabilitate existing assets, improve operating performance, and expand transit systems to address the growth in travel demand.

While HERS, NBIAS, and TERM all utilize benefit-cost analysis, their methods for implementing this analysis are very different. The highway, transit, and bridge models are all based on separate databases that are very different from one another. Each model makes use of the specific data available for its part of the transportation system and addresses issues unique to each mode. These three models have not yet evolved to the point where direct multimodal analysis is possible. For example, HERS assumes that when lanes are added to a highway, this causes highway user costs to fall, resulting in additional highway travel. Under this assumption, some of this would be newly generated travel and some would be the result of travel shifting from transit to highways. However, HERS does not distinguish between different sources of additional highway travel. At present, there is no truly accurate method for predicting the impact that a given level of highway investment would have on the future performance of transit systems. Likewise, TERM's benefit-cost analysis assumes that some travel shifts from automobile to transit as a result of transit investments, but cannot project these investments' impact on highways.

In interpreting the findings of this report, it is important to recognize the limitations of these analytical tools and the potential impacts of different assumptions that have been made as part of the analysis. Part IV and the Introduction to Part II both contain information critical to contextualizing the future investment scenarios, and these issues are also discussed in Q&A boxes located in Chapters 7 through 10. Immediately following this Introduction is the "Highlights" section, which summarizes a few of the most critical caveats associated with this analysis.

Highlights

In order to correctly interpret the analyses presented in this report, it is important to understand the framework in which they were developed and to recognize their limitations. As stated in the "Introduction," this document is intended to provide Congress with an objective appraisal of the physical conditions, operational performance, and financing mechanisms of highways, bridges, and transit systems based both on the current state of these systems and on the projected future state of these systems under a set of alternative future investment scenarios. The trends identified in this report reflect more recent data than the last edition, as well as enhancements to the analyses based on ongoing work by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). These enhancements improve the estimation of the conditions and performance of highways, bridges, and transit and better forecast the impact that future investment may be expected to have on maintaining and improving this transportation infrastructure.

Since this edition of the C&P report is based primarily on data through the year 2006, it does not yet fully reflect the effects of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which authorized Federal highway and transit funding for Federal fiscal years 2005 through 2009. This "Highlights" section generally compares 2006 statistics with those for 1997, the last year preceding the enactment of the Transportation Equity Act for the 21st Century (TEA-21). As discussed in the "Introduction," other sections within this report assess recent trends over different time periods.

Cautionary Note on Using This Report

It is important to note that this document is not a statement of Administration policy and that the future investment scenarios presented in this report are intended to be illustrative only. **The report does not endorse any particular level of future highway, bridge, or transit investment**; it does not address questions as to what future Federal surface transportation programs should look like, or what level of future surface transportation funding can or should be provided by the Federal government, State governments, local governments, the private sector, or system users. Making recommendations on policy issues such as these would go beyond the legislative mandate for the report and would violate its objectivity. Outside analysts can and do make use of the statistics presented in the C&P report to draw their own conclusions, but any analysis attempting to use the information presented in this report to determine a target Federal program size would require a whole series of additional policy and technical assumptions that go well beyond what is reflected in the report itself.

What is a "Need"?

The current legislative requirement for an "Infrastructure Investment Needs Report" in 23 USC 502(h), and the comparable legislative requirements for this type of report in the past (dating back to 1968 on the highway side and 1984 on the transit side), do not define exactly what a "need" is; economists largely reject a concept of a "need" that is divorced from demand and price considerations. The report series began as a combined "wish list" of State highway needs. Over time, national engineering standards were defined and utilized to develop a set of "needs" on a uniform national basis. As the report series evolved further, economic considerations were brought into the analysis, looking at the impact of system conditions and performance on highway and transit users as well as on highway agencies and transit operators. The current generation of analytical tools attempt to combine engineering and economic procedures, determining deficiencies based on engineering standards while applying benefit-cost analysis procedures to identify potential capital improvements to address those deficiencies that may have positive net benefits.

The investment scenario estimates presented in this report represent an estimate of what level of performance **could** be achieved with a given level of funding, not what **would** be achieved with it. While the models assume that projects are prioritized based on their benefit-cost ratios, that assumption is not consistent with actual patterns of project selection and funding distribution that occur in the real world. Consequently, the level of investment identified as the amount required to maintain a certain performance level should be viewed as the minimum amount that would be required if all other modeling assumptions prove to be accurate.

It is important to note that the benefit-cost analysis procedures currently employed are not equally robust among all of the different types of infrastructure investments covered in this report. Further, this approach does not subject potential capital improvements to the type of rate of return analysis that would typically be employed in the private sector. The United States Department of Transportation (DOT) continues to look for ways to address the limitations of the existing analytical procedures.

Uncertainty in Transportation Investment/Performance Modeling

As in any modeling process, simplifying assumptions have been made to make analysis practical and to meet the limitations of available data. Since the ultimate decisions concerning highways, bridges, and transit systems are primarily made by their owners at the State and local level, they have a much stronger business case for collecting and retaining detailed data on individual system components. The Federal government collects selected data from States and transit operators to support this report, as well as a number of other Federal activities, but these data are not sufficiently robust to make definitive recommendations concerning specific transportation investments in specific locations. While potential improvements are evaluated based on benefit-cost analysis, not all external costs (such as noise pollution) or external benefits (such as the impact of transportation investments on productivity) are fully considered. Across a broad program of investment projects, such external effects may cancel each other; but, to the extent that they do not, the true "needs" may be either higher or lower than would be predicted by the models. This topic is discussed in the Introduction to Part II.

A State or local government performing an investment analysis for a real-world project would presumably have better information concerning the capital costs associated with the project, as well as localized information that would influence the evaluation of the project's potential benefits and external societal costs. To the extent that State and local governments include other factors beyond economic considerations in their investment decision-making process, benefit-cost ratios will not be maximized. In fact, there is mounting evidence that the benefit-cost ratios of highway and public transportation investments have declined significantly in recent years. Moreover, current processes and approaches do little to ensure that investment resources are appropriately targeted.

Impact of Financing Structures on Transportation Investment/ Performance Analysis

This report has traditionally identified the amount of additional spending above current levels that would be required to achieve certain performance benchmarks, without incorporating the impact of the types of revenues that would support this additional spending. This approach was in keeping with the general philosophy referenced earlier that the assignment of responsibility for the costs associated with a given scenario to any particular level of government or funding source falls beyond the legislative mandate for this report. However, the implicit assumption built into this approach has been that the financing mechanisms would not have any impact on investment scenarios themselves. In reality, however, increasing funding from general revenue sources (such as property taxes, sales taxes, income taxes, etc.) would have different implications than increased funding from user charges (such as fuel taxes, tolls, and fares).

For this report, a series of parallel highway investment/performance analyses have been developed to compare the implications of funding potential increases in capital spending through non-user based financing mechanisms, fixed rate user financing mechanisms, or variable rate user financing mechanisms. The analyses assuming fixed rate or variable rate user financing presume that any funding to support increases in highway and bridge investment above 2006 levels would be financed by highway users on a per-VMT basis. A feedback loop has been added to the modeling process to account for the impact that this change in the "price" of travel experienced by individual system users would have on projected future travel volumes and overall system performance. The methodology used for these analyses is presented in greater detail in Appendix A.

When highway users make decisions about whether, when, and where to travel, they consider both implicit costs (such as travel time and safety risk) and explicit, out-of-pocket costs (such as fuel costs and tolls). Under uncongested conditions, their use of the road will not have an appreciable effect on the costs faced by other users. As traffic volumes begin to approach the carrying capacity of the road, however, traffic congestion and delays begin to set in and travel times for all users begin to rise, with each additional vehicle making the situation progressively worse. However, individual travelers do not take into account the delays and additional costs that their use of the facility imposes on other travelers, focusing instead only on the costs that they bear themselves. To maximize net social benefits, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby more efficiently spreading traffic volumes and allowing the diverse preferences of users to be expressed. In the absence of efficient pricing, options for reducing congestion externalities and increasing societal benefits are limited. In addition, the efficient level of investment in highway capacity is larger under the current system of highway user charges (primarily fuel and other indirect taxes) than would be the case with full-cost pricing of highway use.

The variable rate user financing analyses presented in this report assume the immediate widespread adoption of congestion pricing on all Federal-aid Highways, with peak period charges set independently for individual congested highway sections based on the estimated cost of the negative impact that each driver has on all other users of that section. The projected revenue that would be generated from such congestion charges was then applied to cover the difference between the investment level being studied and the current 2006 level of combined public and private highway capital investment. If the revenue from these variable rate charges would not be sufficient for this purpose, the analyses assumed the imposition of an additional fixed rate charge. In cases where projected congestion pricing revenue exceeded the level needed to support the level of investment being studied, a negative fixed rate charge was applied, simulating the effects of lowering existing fuel taxes, fixed rate tolls, or other fees imposed on highway users.

While the above discussion focuses on highway pricing, the same considerations may apply to transit investments. Anecdotal evidence suggests that transit routes in major metropolitan areas are approaching their passenger-carrying capacities during peak travel hours, with a commensurate deterioration in the quality of service. Some of this crowding could be reduced by increasing fares during peak hours. Certain considerations, however, may limit the ability of transportation authorities to price transit services more efficiently, such as the ability of the fare system to handle peak pricing, and the desire to provide transit as a low-cost service to transit-dependent riders. Additionally, the fact that overcrowded transit lines are often in corridors with heavily congested highways makes a joint solution to the pricing problems on both highways and transit more complicated to analyze, devise, and implement. Measuring the actual crowding on transit systems during peak periods, and the development of a more sophisticated crowding metric than the one currently used by FTA, are areas for further research.

Impact of New Technologies

The highway investment analysis procedures used to develop the investment scenarios for this report have been modified to reflect the impact that certain types of operational strategies and intelligent transportation systems (ITS) deployments may have on system performance in the future, based on current deployment trends. However, any more aggressive and effective deployment of ITS and other technologies beyond that modeled in this analysis is expected to further reduce the level of future capacity investment required to achieve any specific level of performance. The sensitivity analysis in Chapter 10 explores the potential impacts of more rapid deployment of existing technologies.

New technology holds promise in other areas as well. Improved pavement and bridge technologies have the potential to reduce future system rehabilitation costs, while improved highway and transit vehicle technologies could interact with ITS deployments to enhance operating efficiency. The baseline analyses presented in this report do not attempt to assume the future impacts of these types of technological improvements, but it is important to recognize their potential when considering the findings of this report. The sensitivity analysis in Chapter 10 explores the potential impacts of a significant extension of pavement life. Further discussion of new technologies is included in Part IV.

What Does it Mean to "Maintain?"

There are many different ways to measure well how various components of the transportation system are operating; no single performance metric captures all aspects of system conditions and performance. The "Maintain" scenarios presented in this report each point to a level of capital investment that could keep the conditions and performance of the overall system 20 years from now in roughly the same shape that it is in today. The "Maintain" scenarios are defined differently in this report for different system components. This is because of the different characteristics of the highway, bridge, and transit systems; the capability of the different analytical tools to analyze highway, bridge, and transit investment for this report; and the limitations of the underlying data.

The highway investment/performance analyses presented in this report identify the potential impacts of a range of alternative investment levels on varying indicators of system conditions and performance. The primary "Maintain" scenarios for highways focus on maintaining adjusted highway user costs, reflecting the impact that the physical conditions and operational performance of the highway system has on highway users. An alternative "Maintain" scenario for highways identifies levels of investment in pavement improvements that could be adequate to sustain average pavement conditions for various subsets of the highway system at base year levels, and the level of system expansion investment that could be adequate to keep average traveler delay from rising. The "Maintain" scenarios for bridges reflect estimated levels of investment that could be sufficient to keep the backlog of economically justifiable bridge improvements in 20 years at the same size as it is today. The "Maintain" scenarios for transit reflect the estimated level of investment that would be sufficient to accelerate the rehabilitation and replacement of transit assets to achieve the following objectives: (1) to keep the average transit asset condition in 20 years equal to the average transit asset condition in the base year, and (2) to have the average occupancy rate for each mode, as measured by passenger miles per peak vehicle, remain the same in 20 years as in the base year.

In each case, the investment scenarios outlined in this report represent an estimate of what level of performance **could** be achieved with a given level of funding, not what **would** be achieved with it. While the models assume that projects are prioritized based on their benefit-cost ratios, that assumption is not consistent with actual patterns of project selection and funding distribution that occur in the real world. Consequently, the level of investment identified as the amount sufficient to maintain a certain performance level should be viewed as the minimum amount that would be sufficient if all other modeling assumptions prove to be accurate.

While the investment scenarios presented in this report focus on sustaining conditions at base-year levels, the base year is different for each edition of the report; i.e., the prevailing conditions and performance in the 2006 base year analyzed in this report differ from those for the 2004 base year presented in the 2006 edition of the report. Hence, as the level of current system conditions and performance varies over time, the investment scenarios that are based on maintaining the status quo are effectively targeting something different each time. It is important to recognize this when comparing the results of different reports in the series.

It should be noted that some of the investment scenarios in this report have been renamed using the term "sustain" rather than "maintain." This change was made to reduce confusion as all of the scenarios pertain to capital improvements only, and none includes the costs associated with routine maintenance.

What Does it Mean to "Improve?"

In theory, if the estimated investment level associated with a "Maintain" scenario is accurate, and the "correct" projects are chosen, then spending $1 more than that level would result in an improved system. In practice, the "Improve" scenarios in this report have been more aggressive, picking some higher target level of future conditions and performance. Three alternative "Improve" scenarios for highways are presented, which focus on identifying levels of investment at which all potential projects with benefit-cost ratios of 1.5, 1.2, and 1.0, respectively, could be implemented. The scenarios reflecting a minimum benefit-cost ratio of 1.0 can be viewed as an "investment ceiling" above which it would not be cost beneficial to invest, even if unlimited funding were available. The scenarios reflecting higher minimum benefit-cost ratios are included in recognition that available funding is not unlimited, and many decisions on highway funding levels must be weighed against potential cost beneficial investments in other government programs and across various industries within the private sector that would produce more benefits to society.

Due to limitations in data availability and current analytical modeling capabilities, the "Improve" scenarios for bridges and transit are defined differently from those for highways. The "Improve" scenarios for bridges reflect the estimated level of investment that would be sufficient to eliminate the backlog of economically justifiable bridge improvements by the end of 20 years. The "Improve" scenarios for transit reflect the estimated level of investment that would be sufficient to accelerate the rehabilitation and replacement of transit assets to achieve the following objectives: (1) to reach an average condition of "good" for transit assets at the end of the 20-year period, (2) to reduce vehicle occupancy levels in agency-modes with occupancy levels one deviation above the national average to that level, and (3) to increase speeds in urbanized areas with average speeds one deviation below the national average to that level by investing in new rail or bus rapid transit service. Two sets of "Improve" transit scenarios are presented which reflect costs associated with those agency-modes passing an initial benefit-cost ratio screen of 1.0 or 1.2, respectively. [Note the term agency-mode refers to each mode (e.g. passenger rail, motor bus, etc.) within each transit agency.]

It is important to recognize several key limitations of the "Improve" scenarios presented in this report. First, while the models assume that projects are prioritized based on their benefit-cost ratios, that assumption is not consistent with actual patterns of project selection and funding distribution that occur in actual practice. Consequently, if investment rose to the levels identified in the "Improve" scenarios, there are few mechanisms to ensure that these funds would be invested in projects that would be cost beneficial. As a result, the impacts on actual conditions and performance may be far less significant than what is projected for these scenarios. Second, simple benefit-cost analysis is not a commonly utilized capital investment model in the private sector. Instead, firms utilize a rate of return approach focusing on cash revenues and costs and compare various investment options and their corresponding risk. In other words, a project that is barely cost beneficial would almost certainly not be undertaken when compared to an array of investment options that potentially produce higher returns at equivalent or lower risk. Third, these scenarios do not address practical considerations concerning whether the highway and transit construction industries would be capable of absorbing such a large increase in funding within the 20-year analysis period. Such an expansion of infrastructure investment could significantly increase the rate of inflation within these industry sectors, a factor that is not considered in the constant dollar investment analyses presented in this report. Fourth, the legal and political complexities frequently associated with major highway capacity projects might preclude certain improvements from being made, even if they could be justified on benefit-cost criteria. In particular, the time required to move an urban capacity expansion project from "first thought" to actual completion may well exceed the 20-year analysis period.

Highlights: Highways and Bridges

In nominal dollar terms, combined investment by all levels of government in highway and bridge infrastructure has increased sharply since TEA-21 was enacted. Total highway expenditures by Federal, State, and local governments increased by 58.0 percent between 1997 and 2006, to $161.1 billion. Highway capital spending alone rose from $48.4 billion in 1997 to $78.7 billion in 2006, a 62.7 percent increase. However, recent sharp increases in highway construction costs have eroded the purchasing power of this investment; in constant dollar terms, capital spending fell by 4.4 percent over this period. The FHWA Composite Bid Price Index increased by 43.3 percent between 2004 and 2006 due to sharp increases in the prices of materials such as steel, asphalt, and cement.

Because the Federal-aid Highway program is a multiple-year reimbursable program, the impact of increases in obligation levels phases in gradually over a number of years. The portion of total highway capital spending funded by the Federal government rose from 41.6 percent to 44.0 percent between 1997 and 2006. This share dipped below 40 percent in 1998 for the first time since 1959; TEA-21's passage relatively late in fiscal year 1998 reduced its impact on cash expenditures during that initial year, but subsequently this share rebounded up to 46 percent in 2002 before tailing back off more recently to the 44 percent to 45 percent range.

The TEA-21 era and the early portion of the SAFETEA-LU era have also coincided with a shift in the types of capital improvements being made by State and local governments. The portion of capital investment going for "system rehabilitation" (the resurfacing, rehabilitation, or reconstruction of existing highway lanes and bridges) increased from 47.6 percent in 1997 to 51.3 percent in 2006. The percentage of capital spending directed towards "system expansion" (the construction of new highways and bridges and lane additions to existing highways) decreased from 44.4 percent to 38.2 percent over this period, while the portion used for "system enhancement" (including safety enhancements, traffic control facilities, and environmental enhancements) increased from 8.0 percent to 10.5 percent.

Investment in system rehabilitation rose by 0.4 percent in constant dollar terms between 1997 and 2006, despite the overall decline of 4.4 percent for all capital spending over this period noted above. Funding for system enhancement rose by 22.7 percent in constant dollar terms over this period, while investment in system expansion decreased by 14.2 percent in constant dollar terms.

Physical Conditions Have Improved in Some Areas

The increase in system rehabilitation investment since 1997 has had a positive effect on the physical condition of key subsets of the Nation's highway and bridge infrastructure. The National Highway System (NHS) includes those roads that are most important to interstate travel, economic expansion, and national defense. While the NHS makes up only 4.0 percent of total mileage, it carries 44.6 percent of total travel in the United States. The percentage of NHS VMT on pavements with "good" ride quality rose from 39 percent in 1997 to 57 percent in 2006. The share of NHS VMT on roads with "acceptable" ride quality (a lower standard that includes roads classified as "good") has also increased over this period, from 89 percent to 93 percent. The percentage of deck area on NHS bridges classified as deficient declined from 33.0 percent in 1997 to 29.2 percent in 2006. About three-quarters of deficiencies on NHS bridges relate to functional obsolescence rather than to structural issues; some NHS bridges are narrower than current design standards would call for given the traffic volumes they currently carry.

Looking beyond the NHS to all arterials and collectors for which pavement condition data are collected reveals less favorable trends. While the percentage of all VMT on pavements with "good" ride quality rose from 39.4 percent in 1997 to 47.0 percent in 2006, the share of VMT on roads with "acceptable" ride quality fell from 86.4 percent to 86.0 percent. While the percentage of pavements with acceptable ride quality has been growing in rural and small urban areas, urbanized areas have experienced declines.

The raw share (not weighted by deck area) of all bridges classified as deficient dropped from 32.7 percent in 1997 to 27.6 percent in 2006. Most of this decline was the due to reductions in the percent of structurally deficient bridges. Bridge conditions tend to vary by functional system; for example, the percentage of Interstate bridges classified as structurally deficient or functionally obsolete is lower than the comparable percentages for bridges on collectors or local roads.

Operational Performance Has Declined, But Shows Signs of Stabilizing

Despite improving conditions on many roads and bridges, operational performance—the quality of use of that infrastructure—has deteriorated since 1997. This is reflected in measures of congestion in all urbanized areas developed for FHWA by the Texas Transportation Institute (TTI). From 1997 to 2005, the estimated percentage of travel occurring under congested conditions rose from 24.9 percent to 28.7 percent; however, this statistic increased by only 0.1 percentage point between 2004 and 2005. The average length of congested conditions increased from 5.9 hours per day in 1997 to 6.4 hours per day, but has remained constant at that level since 2002. TTI estimates that drivers experienced over 4.2 billion hours of delay and wasted approximately 2.9 billion gallons of fuel in 2005.

Highway Safety Has Improved

Considerable progress has been made in reducing fatality rates and injury rates over time, including the period from 1997 through 2006. The fatality rate per 100 million VMT has declined from 1.64 to 1.41 over that period. The actual number of highway fatalities has remained relatively constant over this period, remaining in a range from 41,500 to 43,500 per year. The injury rate per 100 million VMT declined from 131 in 1997 to 85 in 2006. Preliminary data for 2007 show a decline in both fatalities and injuries.

Highway safety remains a top priority within the DOT, and the improvement of the Nation's roadway infrastructure is an important component of the effort to reduce highway fatalities and injuries.

Future Capital Investment Scenarios

This report includes a series of highway and bridge investment/performance analyses examining 24 alternative levels of future combined public and private capital spending for the period from 2007 through 2026, each of which assumes a uniform annual rate of increase or decrease relative to the $78.7 billion of combined highway capital spending in 2006. These alternatives covered a wide range of possible future spending, extending from a level consistent with a decrease in capital spending in constant dollar terms of 7.64 percent per year (equating to an average annual investment level of $37.9 billion over 20 years) up to a level consistent with an annual constant dollar increase in capital spending of 7.76 percent per year (equating to an average annual investment level of $188.9 billion for the period from 2007 through 2026).

Drawing upon these investment/performance analyses, a series of illustrative scenarios were selected for further exploration and presentation in more detail. For each type of scenario, two versions were developed assuming any increases in investment would be supported by either a fixed rate user financing mechanism (such as tolls, VMT charges, or fuel taxes) or a variable rate user financing mechanism (such as congestion pricing). The scenario criteria were applied separately to the Interstate System, the NHS, and the highway system overall.

The **Sustain Current Spending scenarios** assume that capital spending is maintained in constant dollar terms at base year 2006 levels between 2007 and 2026. The **Sustain Conditions and Performance scenarios** assume that capital investment gradually changes in constant dollar terms over 20 years to the point at which future conditions and performance would be maintained at a level sufficient to keep adjusted average user costs and the economic backlog of potential bridge investments from rising above their 2006 levels, based on projections of future highway use.

Three scenarios are presented that would each improve overall system conditions and performance. The **MinBCR=1.5 scenario** assumes that investment gradually increases in constant dollar terms over 20 years up to the point at which all potential capital improvements with a benefit-cost ratio of 1.5 or higher are funded by 2026, and the economic backlog of potential bridges investment is reduced to zero. The **MinBCR=1.2 scenario** makes the same assumptions, but at a benefit-cost ratio of 1.2 or higher. The **MinBCR=1.0 scenario**, meanwhile, assumes that investment gradually increases over 20 years up to the point at which all potentially cost beneficial investments are funded by 2026; the version of this scenario assuming variable rate user financing (i.e., congestion pricing) is also described as the **Maximum Economic Investment scenario**.

Interstate System Scenarios

All levels of government spent a combined $16.5 billion in 2006 on capital improvements to the Interstate Highway System. Assuming fixed rate user financing, system conditions and performance are projected to decline below base-year levels at this level of investment. Achieving the **Sustain Conditions and Performance scenario** objectives would require an annual spending increase of 3.71 percent in constant dollar terms, translating into an average annual investment level of $25.8 billion over the period from 2007 through 2026, stated in constant 2006 dollars. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $39.0 billion, $43.5 billion, and $47.0 billion, respectively, translating into annual constant dollar spending growth rates

Derivation of the Highway Capital Investment Scenarios

The highway capital investment scenarios presented in this report are derived from separate analyses developed using the Highway Economic Requirements System (HERS), the National Bridge Investment Analysis System (NBIAS), combined with estimates for types of highway capital investments that are not presently modeled. Separate versions of each scenario are presented based on alternative assumptions about future financing mechanisms (as the manner in which future investment is financed would have an impact on future VMT), and the scenario criteria are applied separately to the Interstate Highway System, the National Highway System, and all roads combined.

1) The first step in developing the highway capital investment scenarios is determining the portion of current highway capital spending that is equivalent to the investment types that are modeled in HERS, modeled in NBIAS, or not currently modeled. [*See Exhibit 7-1.*]
2) The second step is to specify a series of alternative spending levels for HERS or NBIAS to analyze.
    a) Each alternative is determined by applying a uniform annual rate of growth (or decline) in constant dollar terms relative to actual expenditures in 2006 for the system component being analyzed. [*See Exhibit 7-2.*]
    b) For example, highway capital spending totaled approximately $78.7 billion in 2006. If spending were to grow by 1 percent per year in constant dollar terms, this would translate into annual levels (all stated in constant 2006 dollars) of $79.5 billion in 2007, $80.3 billion in 2008, $81.1billion in 2009, etc., reaching $96.0 billion in 2026, producing a 20-year total of $1.75 trillion, which would translate into an average annual investment level of $87.5 billion in constant 2006 dollars.
    c) Each individual HERS model run tied to a specified alternative spending level produces a series of outputs, including projections of future measures of system conditions and performance such as average pavement condition, average delay, adjusted average user costs, and the economic backlog of bridge investments; HERS also identifies the benefit-cost ratio of the last project implemented (as the model assumes available funding will be directed to projects with the highest values first). NBIAS produces output on the economic bridge investment backlog, representing bridge investments that would be cost-beneficial.
3) The third step is to identify the individual HERS and NBIAS runs that would meet the criteria defined for a specific scenario. This step must be repeated for each financing mechanism (fixed rate user financing or variable rate user financing) and system subset (Interstate, NHS, or all roads) being analyzed.
    a) By definition, the **Sustain Current Spending scenario** assumes no growth in constant dollar spending (i.e., that spending will keep pace with future inflation), and that future investments in the types of improvements modeled in HERS and NBIAS would remain unchanged for the system subset being analyzed.
    b) The HERS component of the **Sustain Conditions and Performance scenario** is defined as the level of investment that results in adjusted average user costs in 2026 matching those in 2006. [*See Exhibits 7-5, 7-15, and 7-18 for information on all roads, the NHS, and the Interstate System, respectively.*] The NBIAS component is defined as the level of investment at which the economic bridge investment backlog in 2026 would match that in 2006. [*See Exhibits 7-21, 7-12, and 7-23.*]
    c) The HERS component of the **MinBCR=1.5 scenario** is defined as the level of investment for which the lowest benefit-cost ratio for any project implemented would be exactly 1.5. The HERS component of the **MinBCR=1.2** and **MinBCR=1.0 scenarios** are defined in the same manner, except that their benefit-cost ratio cutoffs are 1.2 and 1.0, respectively. [*See Exhibit 7-14.*] The NBIAS component of all three of these scenarios is defined as the level of investment that would eliminate the economic bridge investment backlog by 2026. [*See Exhibits 7-21, 7-12, and 7-23.*]
4) The final step is to combine the investment levels identified for the separate HERS and NBIAS analyses meeting the criteria for the scenario; the combined results are then adjusted upwards to account for types of capital investments that are not captured in either model. [*See Exhibits 8-1, 8-6, and 8-11.*]

of 7.61 percent, 8.52 percent, and 9.15 percent. Each of these higher investment levels would achieve progressively larger improvements to Interstate System conditions and performance, but would be subject to diminishing returns, because each would incorporate a progressively larger share of projects with relatively smaller net benefits.

Assuming variable rate user financing, with congestion charges imposed immediately on a widespread basis and with rates set at a level consistent with the cost each driver imposes on other drivers on a congested facility, system conditions and performance would be projected to improve if spending were sustained at $16.5 billion per year in constant dollar terms. The objectives of the **Sustain Conditions and Performance scenario** could be achieved even if annual spending were to decrease by 3.49 percent in constant dollar terms, translating into an average annual investment level of $11.6 billion over the period from 2007 through 2026. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $24.0 billion, 27.5 billion, and $30.4 billion, respectively, translating into annual constant dollar spending growth rates of 3.43 percent, 4.64 percent, and 5.49 percent. Each of these investment levels is stated in constant 2006 dollars.

The estimated annual revenue that would be generated by the congestion charges on the Interstate System range from $20.1 billion for the **MinBCR=1.0 scenario** up to $29.9 billion for the **Sustain Conditions and Performance scenario**, stated in constant 2006 dollars. The scenarios with higher overall spending levels would generate less revenue, because the additional capacity expansion investments included in these scenarios would cause the overall level of congestion to be lower, so that drivers have smaller negative impact on each other. For all of these scenarios, the amount of congestion pricing revenue generated would be more than sufficient to cover the additional spending associated with that scenario. While these analyses assumed that such surplus revenues would be rebated to highway users in the form of reductions to existing fixed rate user charges (such as fixed rate tolls or fuel taxes), they could also be used to support increased investment in transit, or for other purposes.

NHS Scenarios

All levels of government spent a combined $37.1 billion in 2006 on capital improvements to the NHS. Assuming fixed rate user financing, system conditions and performance are projected to decline below base-year levels at this level of investment for the period through 2026. Achieving the **Sustain Conditions and Performance scenario** objectives would require an annual spending increase of 0.41 percent in constant dollar terms, translating into an average annual investment level of $38.7 billion over the period from 2007 through 2026, stated in constant 2006 dollars. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $60.7 billion, $69.2 billion, and $76.1 billion, respectively, translating into annual constant dollar spending growth rates of 4.49 percent, 5.62 percent, and 6.43 percent. As these growth rates are smaller than those identified for the comparable Interstate scenarios above, this suggests that current spending on the non-Interstate portions of the NHS is addressing a greater share of capital investment needs than is current spending on the Interstate System.

Assuming variable rate user financing (i.e., widespread congestion pricing), system conditions and performance would be projected to improve if spending were sustained at $37.1 billion per year in constant dollar terms. The objectives of the **Sustain Conditions and Performance scenario** could be achieved even if annual spending were to decrease by 6.54 percent in constant dollar terms, translating into an average annual investment level of $19.6 billion over the period from 2007 through 2026. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $38.9 billion, $44.9 billion, and $50.1 billion, respectively, translating into annual constant dollar spending growth rates of 0.46 percent, 1.80 percent, and 2.79 percent. Each of these investment levels is stated in constant 2006 dollars.

The estimated annual revenue that would be generated by the congestion tolls on the NHS system range from $30.0 billion for the **MinBCR=1.0 scenario** up to $42.9 billion for the **Sustain Conditions and Performance scenario**, stated in constant 2006 dollars. For all of these scenarios, the amount of congestion pricing revenue generated would be more than sufficient to cover the additional spending associated with that scenario.

Systemwide Scenarios

All levels of government spent a combined $78.7 billion in 2006 on capital improvements to roads and bridges. Assuming fixed rate user financing, system conditions and performance are projected to decline below base year levels at this level of investment for the period through 2026. Achieving the **Sustain Conditions and Performance scenario** objectives would require an annual spending increase of 2.72 percent in constant dollar terms, translating into an average annual investment level of $105.6 billion over the period from 2007 through 2026, stated in constant 2006 dollars. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $137.4 billion, $157.1 billion, and $174.6 billion, respectively, translating into annual constant dollar spending growth rates of 5.05 percent, 6.21 percent, and 7.10 percent. As these growth rates are higher than those identified for the comparable NHS scenarios above, this suggests that current spending on the NHS is addressing a greater share of capital investment needs than is current spending off of the NHS.

Assuming variable rate user financing, system conditions and performance would be projected to improve if spending were sustained at $78.7 billion per year in constant dollar terms. The objectives of the **Sustain Conditions and Performance scenario** could be achieved even if spending were to decrease by 0.94 percent per year in constant dollar terms, translating into an average annual investment level of $71.3 billion over the period from 2007 through 2026. The average annual investment levels for this period associated with the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** are $101.8 billion, $117.2 billion, and $131.3 billion, respectively, translating into annual constant dollar spending growth rates of 2.40 percent, 3.65 percent, and 4.66 percent. Each of these investment levels is stated in constant 2006 dollars.

The estimated annual revenue that would be generated by the congestion tolls on the system as a whole range from $38.1 billion for the **MinBCR=1.0 scenario** up to $47.0 billion for the **Sustain Conditions and Performance scenario**, stated in constant 2006 dollars. In this case, the level of revenue generated under the **MinBCR=1.0 scenario** was insufficient to cover the full cost of the scenario, so the analysis assumed an additional fixed rate user charge would be applied to cover the difference.

While the **Sustain Current Spending scenario** and the **Sustain Conditions and Performance scenario** are not defined in terms of specific minimum benefit-cost ratio thresholds, the underlying analyses used to develop these scenarios do indicate the benefit-cost ratio of the last project selected. The fixed rate user financing and variable rate user financing versions of the **Sustain Current Spending scenario** for all roads are associated with benefit-cost ratio cutoffs of 2.89 and 1.90, respectively. The comparable values for the fixed rate user financing and variable rate user financing versions of the **Sustain Conditions and Performance scenario** for all roads are 1.98 and 2.25, respectively.

Supplemental Systemwide Scenarios

Two supplemental scenarios were developed at the systemwide level only. The **Sustain Conditions and Performance of System Components scenario** represents a more aggressive "Maintain" scenario than the **Sustain Conditions and Performance scenario** discussed above. Rather than targeting average conditions and performance on a systemwide basis, the **Sustain Conditions and Performance of System Components scenario** would sustain average pavement condition and traveler delay on each individual highway functional system at 2006 levels where it is cost beneficial to do so.

The **Sustain Conditions and Improve Performance scenario** represents a hybrid between a "Maintain" and an "Improve" scenario, combining system rehabilitation investments from the **Sustain Conditions and Performance of System Components scenario** with system expansion investments from the **MinBCR=1.0 scenario**.

Assuming fixed rate user financing, achieving the goals of the **Sustain Conditions and Performance of System Components scenario** would require an annual spending increase of 3.83 percent in constant dollar terms, translating into an average annual investment level of $119.5 billion over the period from 2007 through 2026. The average annual investment level for this period associated with the **Sustain Conditions and Improve Performance scenario** is $145.3 billion stated in constant 2006 dollars, translating into an annual constant dollar spending growth rate of 5.54 percent.

Assuming variable rate user financing, the objectives of the **Sustain Conditions and Performance of System Components scenario** could be achieved if spending were to increase by 0.55 percent per year in constant dollar terms, translating into an average annual investment level of $83.4 billion over the period from 2007 through 2026. The average annual investment level for this period associated with the **Sustain Conditions and Improve Performance scenario** is $104.9 billion stated in constant 2006 dollars, translating into an annual constant dollar spending growth rate of 2.67 percent.

Highlights: Transit

Record levels of Federal investment in transit under TEA-21 were not only matched, but exceeded by the combined investments of State and local governments from 1997 through 2006. Total funding by Federal, State, and local governments reached its highest level of $30.9 billion in 2006, a 76.9 percent increase in current dollars from $17.5 billion in 1997, equal to a 40.9 percent increase in constant dollar terms (the gross domestic product deflator was used to develop constant dollar estimates). Federal funding in current dollars increased by 70.3 percent, from $4.7 billion in 1997 to $8.1 billion in 2006, equal to a 35.6 percent increase in constant dollar terms. State and local funding in current dollars increased by 79.4 percent, from $12.7 billion in 1997 to $22.8 billion in 2006, equal to a 42.8 percent increase in constant dollar terms Total funding for transit, including system-generated revenues, increased by 66.8 percent, from $26.0 billion in 1997 to $43.4 billion in 2006, an increase of 32.8 percent in constant dollars.

In 2006, total transit agency expenditures for capital investment were $12.8 billion in current dollars, accounting for 29.3 percent of total transit spending. Federal funds provided $5.6 billion of total transit agency capital investments, State funds provided $1.7 billion, and local funds provided $5.5 billion. Capital investment funding for transit from the Federal government increased by 34.2 percent from 1997 to 2006, and capital investment funding for transit from State and local sources increased by 105.7 percent from 1997 to 2006. Between 2004 and 2006, State and local funding for transit capital expenditures declined by 6.5 percent. Federal funding for transit capital investment was $4.1 billion in 1997 and $5.6 billion in 2006.

Transit Infrastructure Has Expanded

The significant growth in total capital investment under TEA-21 is reflected in an expansion of the Nation's transit infrastructure. Between 1997 and 2006, the number of active urban transit vehicles as reported to the National Transit Database increased by 25.3 percent, from 102,258 to 128,132. Track mileage grew by 18.9 percent, from 9,922 miles in 1997 to 11,796 miles in 2006. The number of stations increased by 13.9 percent, from 2,681 in 1997 to 3,053 in 2006; and the number of urban maintenance facilities increased by 11.5 percent, from 729 in 1997 to 813 in 2006.

Transit Use Has Increased

With new and modernized transit vehicles and facilities, passenger use has also increased, particularly transit rail use. Passenger miles traveled (PMT) on transit increased by 23.1 percent, from 40.2 billion in 1997 to 49.5 billion in 2006. PMT on nonrail transit (primarily buses) increased by 18.4 percent, from 19.0 billion in 1997 to 22.5 billion in 2006. PMT on rail increased by 28.0 percent, from 21.1 billion in 1997 to 27.0 billion in 2006. The distance traveled by all transit vehicles in revenue service, adjusted for differences in carrying capacities, increased by 31.8 percent, from 3.5 billion full-capacity bus miles in 1997 to 4.6 billion equivalent miles in 2006.

Physical Conditions for Most Assets Have Improved

The FTA uses a numerical scale ranging from 1 to 5 to describe the condition of transit assets. A rating of 5, or "excellent," indicates that the asset is in nearly new condition or lacks visible defects. At the other end of the scale, a rating of 1 indicates that the asset needs immediate repair and may have one or more seriously damaged components. In between, 2 indicates "poor," a condition rating of 3 indicates "adequate" condition, and a condition rating of 4 indicates the asset is in "good" condition. It is important to note that the numerical scale used by FTA is continuous, meaning that condition ratings may take on any value within the 1 to 5 interval. For the purposes of this report, state of good repair was defined using TERM's numerically based system for evaluating transit asset conditions. Specifically, this report considers an asset to be in a state of good repair when the physical condition of that asset is at or above a specific condition rating value of 2.5 (the mid-point between adequate and marginal). Similarly, an entire transit system would be in a state of good repair if all of its assets have an estimated condition value of 2.5 or higher. The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value.

Bus and rail vehicle conditions have improved since 1997. Bus vehicle condition ratings increased from 2.94 in 1997 to 3.01 in 2006. However, it should be noted that average bus vehicle conditions have declined since 2004, with an average estimated condition of 3.08. Rail vehicle condition ratings increased from 3.42 in 1997 to 3.51 in 2006, representing the highest condition rating over that time period.

Urban bus maintenance facility condition ratings improved slightly from 3.23 in 2000 to 3.26 in 2006. Average condition is not available for 1997. Sixty-four percent of all urban bus maintenance facilities were in adequate (3) or better condition in 2006, compared with 67 percent in 2000 and 77 percent in 1997. Rail facility condition ratings improved from 3.18 in 2000 to 3.68 in 2006. As with buses, average condition is not available for 1997. Approximately 74 percent of rail facilities were estimated to be in adequate or better condition in 2006, compared with 80 percent in 2002 and 77 percent in 1997. (Note that the deterioration schedules used to estimate 1997 facility conditions were revised and that 1997 conditions are not directly comparable to those for 2002 and 2004.)

Between 2004 and 2006, the conditions of track and structures declined, with vehicle storage yards improving slightly. The average condition rating estimates for systems, including traction power, communications, and revenue collection, declined from 2004 to 2006. However, one component of systems, train control, improved slightly during this time period from 3.39 to 3.50. The condition ratings of rail stations increased from 3.37 in 2004 to 3.53 in 2006. The changes in the conditions of nonvehicle assets reflect both actual changes and changes based on new information. The nonvehicle transit asset data used by FTA to estimate conditions are updated for selected operators with each report cycle. Most of this information is not reported to the NTD and must be collected directly from transit agencies.

Comparison: Rail Modernization and the Conditions and Performance Report

In February of 2009, FTA released a Report to Congress on Rail Modernization. The objective of that study was to assess what steps would be needed to overcome capital investment backlogs at the nation's seven largest transit rail operators. Data from those operators that were used for that study are consistent with data used for this report. However, the C&P report also includes data representing the rest of the Nation's transit systems. The two reports vary in terms of scope, scenarios, key assumptions, and types of analyses.

The key distinguishing factor between the reports is the selection of scenarios. For the Rail Modernization analysis, the focus centered upon determining the level of investment required to bring all assets to a **State of Good Repair,** which for the purposes of the report was defined as:

- **State of Good Repair:** A state of good repair was defined using TERM's numerically based condition rating scale of 1 to 5 (poor to excellent) for evaluating transit asset conditions. An asset or a transit system is considered be in a state of good repair if the asset or system has an estimated condition value of 2.5 or higher (the mid-point between adequate (3) and marginal (2)). The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value. The backlog to achieve a state of good repair includes the cost of postponed rehabilitations.

The C&P report traditionally focuses upon four primary investment scenarios, including:

- **Maintain Conditions:** Transit assets are replaced and rehabilitated over the 20-year period such that the average condition of the assets existing at the beginning of the period remains the same at the end of the period.
- **Maintain Performance**: New transit vehicles and infrastructure investments are undertaken to accommodate increases in transit ridership so that the vehicle utilization rate existing at the beginning of the period remains the same at the end of the period.
- **Improve Conditions:** Transit asset rehabilitation and replacement is accelerated to improve the average condition of all transit assets to a "good" level (4) at the end of the 20-year period (2026). However, if an average condition of good can be reached only by replacing assets that are still in operationally acceptable condition, then the "Improve Conditions" scenario instead targets a slightly lower condition level.
- **Improve Performance:** The performance of the Nation's transit system is improved as additional investments in bus rapid transit, light rail, or heavy rail are undertaken in urbanized areas with the most crowded vehicles and the systems with the slowest speeds to reduce vehicle utilization rates (and crowding) and increase average transit operating speeds.

Further, the C&P report scenarios have differing maintain and improve condition rating standards by asset category (guideway, facilities, systems, stations, and vehicles). One limitation of these scenarios is that the concept of backlog is not well defined, and the estimates do not include postponed rehabs.

In addition to the differences in the scenarios, the two studies vary in the base year dollars employed (2008 vs. 2006) and the application of benefit-cost tests. TERM's benefit-cost test was not used for the Rail Modernization study; thus, the cost effectiveness of the investments required to attain a state of good repair was not considered. The Rail Modernization study can be described as an "engineering approach" while the C&P report takes more of an "economic approach." They are equally valid, within the limits of their assumptions. Future C&P reports will include a version of the **State of Good Repair** scenario.

Operational Performance

FTA analyzes speed and vehicle utilization on the basis of the direction of their change only, as the optimal levels are unknown. While transit speed and utilization are frequently inversely related, this relationship may not always hold; it appears to hold most consistently for major rail modes. Vehicle speed on nonrail modes may be affected by road congestion, and capacity utilization may be affected by changes in agency-reported vehicle passenger-carrying capacities.

Vehicle speed is calculated by dividing vehicle revenue miles by vehicle revenue hours and, therefore, takes into account the effects of the number of stops, vehicle dwell times, road congestion, and operational deficiencies on average vehicle speed. In 2006, average vehicle speed was 20.0 miles per hour compared with 20.1 in 2004 and 19.6 miles per hour in 2002. Average nonrail vehicle speed was 14.4 miles per hour in 2006 compared with 14.0 miles per hour in 2004. Average rail vehicle speed in 2006 was 24.8 miles per hour, which was lower than the 25.0 miles per hour observed in 2004.

Vehicle utilization is measured by the ratio of passenger miles traveled to vehicles operated in maximum service, adjusted to take into account differences in vehicle capacity. The utilization of heavy rail, commuter rail, and light rail overall increased from 1997 to 2000 and declined from 2001 to 2003, moving inversely with rail speeds. For 2006, utilization for heavy rail and commuter rail declined while utilization for light rail increased in comparison to 2004 levels.

Vehicle utilization of motor bus was higher in 2006 than in 1997. For all other nonrail modes, including demand response, ferryboat, trolleybus, and vanpool, vehicle utilization has declined since that time.

Potential Transit Capital Investment Impacts

Select Capital Investment Scenarios

The average annual **Maintain Conditions and Performance scenario** for transit asset conditions and operating performance is estimated to be $15.1 billion, compared with the $12.8 billion in actual 2006 capital spending. Asset expansion accounts for 28 percent of these projected funding requirements.

This estimated $15.1 billion investment to maintain transit conditions and performance is based on maintaining transit asset conditions and on expanding service to meet an increase in ridership consistent with metropolitan planning organization (MPO) estimates of 1.5 percent per year.

Urban areas with populations of more than 1 million make up 88.6 percent of transit investment estimates, reflecting the fact that, in 2006, 92 percent of the Nation's passenger miles were in those areas. Under the **Maintain Conditions and Performance scenario**, 68.2 percent of total transit investment in large urban areas, or $8.8 billion annually, is for rail infrastructure.

Fifty-nine percent of the total amount estimated by the **Maintain Conditions and Performance scenario** ($8.9 billion dollars annually) and 60.2 percent of the total amount estimated by the **Improve Conditions and Performance scenario** ($12.7 billion annually) are for rail infrastructure. Under the **Maintain Conditions and Performance scenario,** vehicles account for the highest proportion, approximately 36.3 percent, of projected capital outlays for both rail and nonrail modes. Guideways account for 19.0 percent of rail and nonrail investments. Changes in investment needs by asset type have not changed materially from those reported in the 2006 C&P Report.

The average annual cost to **Improve Conditions and Performance** for both the physical condition of transit assets and transit operational performance to targeted levels by 2026 is estimated to be $21.1 billion in constant 2006 dollars, 64.8 percent higher than transit capital spending of $12.8 billion in 2006. The **Improve Conditions and Performance scenario** is an upper limit of the economically justifiable level of transit investments. The **Improve Conditions and Performance scenario** assumes that all assets are close to good condition (4) by the end of the investment period. Of this $21.1 billion total, $5.9 billion is estimated as a measure to increase passenger speeds and reduce crowding in systems not operating at a condition of good performance threshold levels. Similarly to the **Maintain Conditions and Performance scenario,** vehicles make up the highest proportion of investments, at 35.5 percent across rail and nonrail asset types.

The variable rate user financing scenarios examined in the highway analysis assume a reduction in peak period VMT, a portion of which could be diverted to transit. Continuing with the pricing scenarios presented in the highway sections of this report, as VMT are diverted from highways to transit, expansion investment is required to support the increase in transit ridership while maintaining current performance at today's levels. The analysis assumes that between 25 percent and 50 percent of diverted auto users shift to transit as their preferred modal choice, based on the projected VMT for the highway **Sustain Current Spending** and **Maximum Economic Investment scenarios.** In summary, at a benefit-ratio of greater than or equal to 1.0 in the **Improve Conditions and Performance scenario**, this range increases to $24.6 billion to $28.8 billion per year. In addition to impacting the investment requirements for transit expansion needs, the diversion of highway VMT to transit would reduce the resultant emissions from automobiles for the diverted travelers by nearly 50 percent across all scenarios evaluated.

The projected investment scenarios are sensitive to forecasts of PMT. The investment scenario estimates presented in this report are based on an average annual increase in ridership of 1.5 percent, an average of transit travel forecasts from 92 MPOs. At this level, the annual cost to **Maintain Conditions and Performance** is projected at $15.1 billion, with the projected annual cost to **Improve Conditions and Performance** is $21.1 billion. As the PMT growth rate increases by 50 percent to 2.25 percent, an additional 11.0 percent is required in the **Maintain Conditions and Performance scenario,** with an additional 10.2 percent required for improvement. Similarly, if the PMT growth rate is reduced by 50 percent (to 0.75 percent), the impact is a reduction of 14.6 percent to **Maintain** and 8.0 percent to **Improve Conditions and Performance.**

Chapter 1

An Introduction to Highways and Transit

Highways and public transit in the U.S. form the foundation for one of the most extensive and complicated transportation networks in the world.

The Essential Functions of Highway and Transit Infrastructure

There are several ways that highways and transit interact to provide service for the American people.

First, highways and transit provide the American people with a high degree of personal mobility. Many of the Nation's social, governmental, and legal principles were built around the concept of freedom of movement.

Second, the Nation's surface transportation system plays an essential role in moving freight. Most goods are moved by truck over the Nation's highways. By reducing traffic volume, transit can reduce congestion and free up highway capacity for freight movement.

Third, transportation plays an essential role in the economic viability of communities. Highway and transit corridors support commerce and employment and allow cities to target investment in areas that best promote livable and sustainable urban development. Property values are higher in areas with the best access to transportation.

Fourth, highways and transit systems play an important role in protecting the American public. The Nation's highway system is essential for much of the Nation's military mobilization. Highways must also be able to quickly accommodate police, fire, and rescue vehicles. Both highways and transit can help evacuate cities when there are emergencies.

The Complementary Role of Highways and Transit

Highways and transit are complementary, serving distinct but overlapping markets in the Nation's transportation system. An efficient transit system gives people living in dense, urban environments increased mobility. An effective highway system does the same for people in suburban or rural areas.

Highway investments can benefit those transit modes that share roadways with private automobiles, such as buses, vanpools, and demand response vehicles. Having good highway access to transit stations in outlying areas, meanwhile, increases accessibility to transit.

Transit improvements can enhance the operational performance of highways by attracting private vehicle drivers off the road during peak periods of congestion.

Public and private assets also complement one another. Although the Nation's highways are typically publicly owned, many people use the system through privately owned automobiles. Transit is generally provided by public agencies, either directly or through private contractors.

Chapter 2

System Characteristics: Highways and Bridges

In 2006, a network of 4.03 million miles of public roads provided mobility for the American people. (The terms "roads" and "highways" are used interchangeably in this report). Rural areas accounted for 74.2 percent of this mileage. While urban mileage constitutes only 25.8 percent of total mileage, these roads carried 66.3 percent of the 3.0 trillion vehicle miles traveled (VMT) in the United States in 2006. In 2006, there were 597,562 bridges throughout the Nation; 75.5 percent of these were in rural areas.

Rural local roads made up 50.8 percent of total mileage, but carried only 4.3 percent of total VMT. In contrast, urban Interstate highways made up only 0.4 percent of total mileage but carried 16.3 percent of total VMT.

Percentage of Highway Miles, Bridges, and Vehicle Miles Traveled by Functional System, 2006

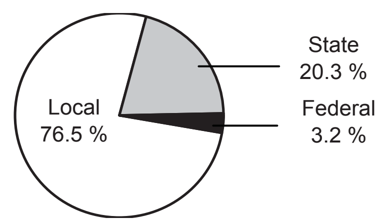
Functional System	Miles	Bridges	VMT
Rural Areas			
Interstate	0.8%	4.5%	8.4%
Other Principal Arterial	2.4%	6.0%	7.5%
Minor Arterial	3.4%	6.6%	5.3%
Major Collector	10.4%	15.7%	6.3%
Minor Collector	6.5%	8.1%	1.9%
Local	50.8%	34.7%	4.3%
Subtotal Rural	**74.2%**	**75.5%**	**33.7%**
Urban Areas			
Interstate	0.4%	4.8%	16.3%
Other Freeway and Expressway	0.3%	3.0%	7.5%
Other Principal Arterial	1.6%	4.4%	15.4%
Minor Arterial	2.6%	4.4%	12.6%
Collector	2.7%	2.9%	5.8%
Local	18.3%	4.9%	8.8%
Subtotal Urban	**25.8%**	**24.4%**	**66.3%**
Total	**100.0%**	**100.0%**	**100.0%**

Total highway mileage increased at an average annual rate of 0.2 percent between 1997 and 2006, while total VMT grew at an average annual rate of 1.9 percent. Rural road mileage has declined since 1997, due in part to the reclassification of some Federal roads as nonpublic and the expansion of urban area boundaries as a result of the decennial Census. Urban areas are defined to include all places with a population of 5,000 or greater; all other locations are classified as rural.

Rural VMT grew at an average annual rate of 0.4 percent from 1997 to 2006, compared with an average annual increase of 1.7 percent in small urban areas (population 5,000 to 50,000) and 2.9 percent in urbanized areas.

In 2006, 76.5 percent of highway miles were locally owned, 20.3 percent were owned by States, and 3.2 percent were owned by the Federal government. The share of locally owned roads grew slightly between 1997 and 2006, increasing from 75.3 percent. During that same period, the share of State-owned mileage remained mostly constant and Federally owned road mileage decreased from 4.3 percent in 1997 to 3.2 percent in 2006.

Highway Mileage by Jurisdiction, 2006



In 2006, 50.5 percent of bridges were locally owned, 47.6 percent were owned by States, 1.4 percent were owned by the Federal government, and 0.5 percent were either privately owned (including highway bridges owned by railroads) or had unknown or unclassified owners. About 46.8 percent of all bridges were built before 1966.

The 163,462-mile National Highway System (NHS) includes the Nation's key corridors and carries much of its traffic. In 2006, NHS included only 4.0 percent of the Nation's total route mileage, but its roads carried 44.6 percent of VMT.

The Interstate System is the core of NHS and includes the most-traveled routes. All Interstates are part of the NHS, as are 83.5 percent of rural other principal arterials, 87.2 percent of urban other freeways and expressways, and 36.3 percent of urban other principal arterials. Interstate travel represented the fastest-growing portion of VMT between 1997 and 2006.

Chapter 2

System Characteristics: Transit

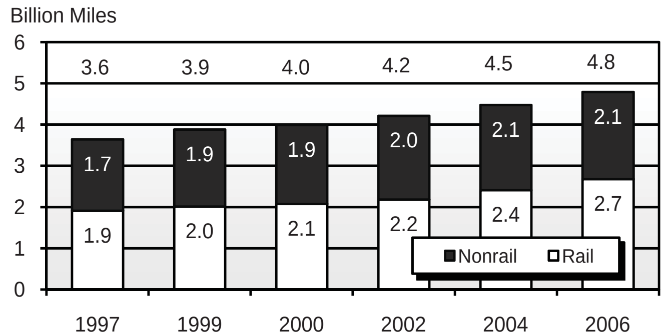
Transit system coverage, capacity, and use in the United States continued to increase between 2004 and 2006. In 2006, there were 657 agencies in urbanized areas reporting to the National Transit Database (NTD), of which 588 were public agencies, including seven State Departments of Transportation. Of the 657 reporting agencies, 83 received either a temporary reporting waiver or a reporting exemption for operating nine or fewer vehicles. The remaining 575 reporting agencies provided service on 1,398 different modal networks; 162 agencies operated a single mode and 495 transit agencies operated more than one mode. In 2006, there were an additional 1,327 transit operators serving rural areas.

In 2006, urban transit systems, excluding special service providers, operated 128,132 vehicles compared with 120,659 vehicles in 2004, an increase of 6.2 percent. In 2006, transit providers operated 11,796 miles of track and served 3,053 stations, compared with 10,892 miles of track and 2,961 stations in 2004. In 2006, there were 813 maintenance facilities for all transit modes in urban areas, compared with 793 in 2004. In 2006, the first year for which rural data are available through the NTD, there were 1,327 rural transit operators, a significant increase over 1,215 in 2000. In 2006, 80 percent of all transit vehicles reported to the NTD were compliant with the Americans with Disabilities Act (ADA). In 2006, 72 percent of total transit stations were ADA-compliant.

In the United States in 2006, 223,489 urban route miles were provided by nonrail modes, which is consistent with 2004 data (at 216,619 urban route miles). Rail modes provided 10,865 urban route miles, an increase from 9,782 in 2004.

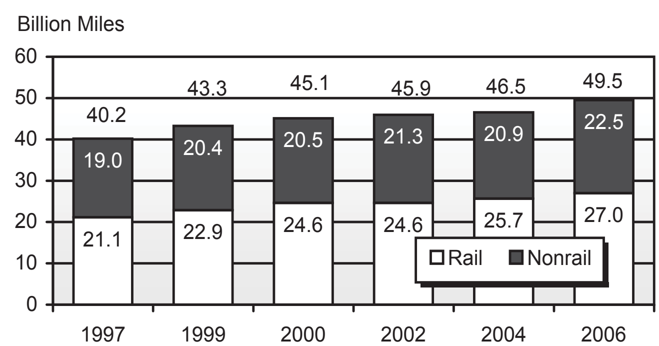
For all modes, capacity-equivalent vehicle revenue miles (VRMs) increased at an average annual rate of 3.5 percent between 1997 and 2006 and 3.5 percent between 2004 and 2006. Rail capacity-equivalent VRMs provided 2.7 billion capacity-equivalent miles, and nonrail provided 2.1 billion miles in 2006.

Urban Capacity-Equivalent Revenue Vehicle Miles



Transit passenger miles traveled (PMT) increased by 6.4 percent between 2004 and 2006, from 46.5 billion to 49.5 billion. PMT traveled on nonrail modes increased from 20.9 billion to 22.5 billion, or 7.9 percent. PMT on rail transit modes increased from 25.7 billion in 2004 to 27.0 billion in 2006, or by 5.1 percent.

Urban Passenger Transit Miles



Approximately 56.2 percent of unlinked trips were on motor buses, 31.2 percent were on heavy rail, 4.7 percent were on commuter rail, 4.3 percent on light rail, and 3.5 percent categorized as other. By comparison, 41.2 percent of PMT in 2006 were on motor bus, 29.7 percent were on heavy rail, 20.9 percent were on commuter rail, and 3.8 and 4.4 percent respectively were on light rail and other. Percentages across modes can differ as average trip length can vary by mode. While unlinked passenger trips and PMT both increased by approximately 6 percent, the allocation across the modes remained relatively unchanged.

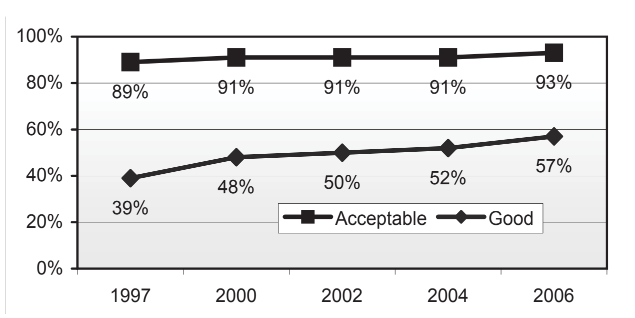
Chapter 3

System Conditions: Highways and Bridges

Poor pavement condition imposes economic costs on highway users in the form of increased wear and tear on vehicle suspensions and tires, delays associated with vehicles slowing to avoid potholes, and crashes resulting from unexpected changes in surface conditions. While transportation agencies consider many factors when assessing the overall condition of highways and bridges, surface roughness most directly affects the ride quality experienced by drivers.

On NHS, the percentage of VMT on pavements with good ride quality has risen sharply over time, from approximately 39 percent in 1997 to about 57 percent in 2006. The VMT on NHS pavements meeting the acceptable standard of ride quality grew more slowly, from approximately 89 percent in 1997 to approximately 93 percent in 2006.

Percentage of VMT on NHS Pavements With Acceptable Ride Quality



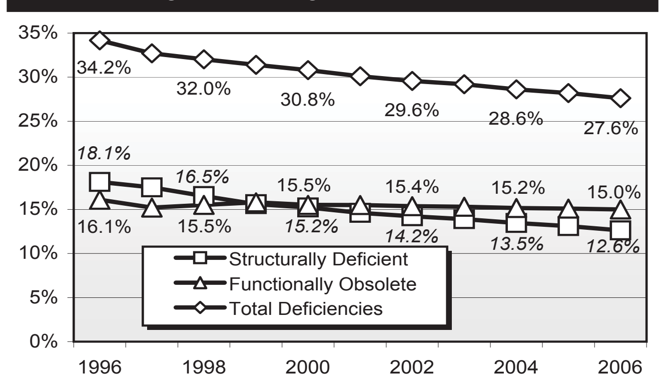
Rural NHS routes tend to have better pavement conditions than urban NHS routes. In 2006, for example, about 98 percent of all VMT on rural pavements was traveled on routes with acceptable ride quality. By contrast, the portion of urban NHS VMT on acceptable pavements was 90 percent that same year.

For Federal-aid highways as a whole, including the NHS and other arterials and collectors eligible for Federal funding, the VMT on pavements with good ride quality increased from 39.4 percent in 1997 to 47.0 percent in 2006. The VMT on pavements meeting the less stringent standard of acceptable ride quality decreased slightly from 86.4 percent in 1997 to 86.0 percent.

Most bridges are inspected every 24 months and receive ratings based on the condition of various bridge components. Two terms used to summarize bridge deficiencies are "structurally deficient" and "functionally obsolete." Structural deficiencies are characterized by deteriorated conditions of significant bridge elements and reduced load-carrying capacity. A "structurally deficient" designation does not imply that a bridge is unsafe, but such bridges typically require significant maintenance and repair to remain in service, and would eventually require major rehabilitation or replacement to address the underlying deficiency. A bridge is considered functionally obsolete when it does not meet current design standards, either because the volume of traffic carried by the bridge exceeds the level anticipated when the bridge was constructed and/or the relevant design standards have been revised. Addressing functional deficiencies may require the widening or replacement of the structure. Rural bridges tend to have a higher percentage of structural deficiencies, while urban bridges have a higher incidence of functional obsolescence due to rising traffic volumes.

The share of bridges classified as deficient fell from 34.2 percent in 1996 to 27.6 percent in 2006. Most of this decline was the result of reductions in the percent of structurally deficient bridges.

Percentage of All Bridges Classified as Deficient



Chapter 3

System Conditions: Transit

The overall physical condition of the U.S. transit system can be evaluated by examining the age and condition of the various components of the Nation's infrastructure. This infrastructure includes vehicles in service, maintenance facilities, the equipment they contain, and other supporting infrastructure such as guideways, power systems, rail yards, stations, and structures (bridges and tunnels). Since the 2006 C&P Report, asset data for approximately 71 percent of the Nation's transit assets have been updated.

Definitions of Transit Asset Conditions

Rating	Condition	Description
Excellent	5	No visible defects, near new condition.
Good	4	Some slightly defective or deteriorated components.
Adequate	3	Moderately defective or deteriorated components.
Marginal	2	Defective or deteriorated components in need of replacement.
Poor	1	Seriously damaged components in need of immediate repair.

The Federal Transit Administration (FTA) has undertaken extensive engineering surveys and collected a considerable amount of data on the U.S. transit infrastructure to evaluate transit asset conditions. FTA uses a rating system of 1, "poor," to 5, "excellent," to describe asset conditions. The Rail Modernization study, released by FTA in April 2009, considered an asset to be in a **state of good repair** when the physical condition of that asset is at or above a specific condition rating value of 2.5 (the mid-point between adequate and marginal). This replaces the over-age criteria used in previous C&P reports, which were based on FTA's minimum vehicle replacement ages.

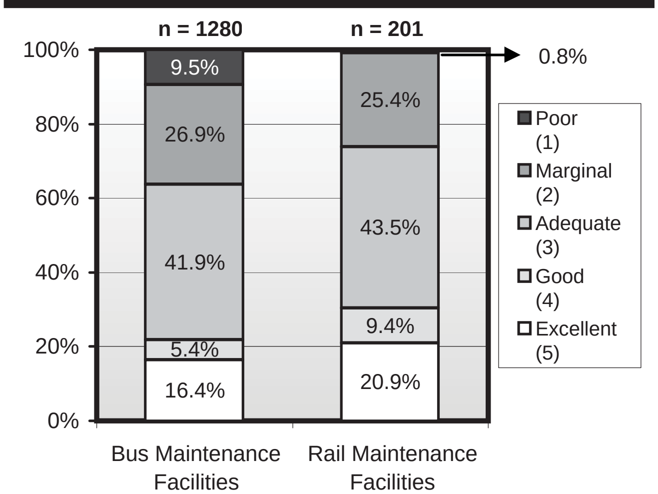
The estimated average condition rating of urban bus vehicles declined slightly from a rating of 3.08 in 2004 to 3.01 in 2006. The average age of urban bus vehicles remained constant at 6.1 years, with 21.8 percent of the fleet considered over-age. The average estimated condition of bus maintenance facilities declined from 3.41 in 2004 to 3.26 in 2006. In 2006, 63.7 percent of bus maintenance facilities were in adequate, good, or excellent condition, a decline from 68.1 percent in 2004.

The estimated average condition rating of rail vehicles continued to increase from 3.50 in 2004 to 3.51 in 2006. The average age of rail vehicles remained relatively consistent at 19.8 years in 2006 compared with 19.7 years in 2004, with 32.1 percent of the fleet defined as over-age. The estimated average condition of rail maintenance facilities decreased from 3.82 in 2004 to 3.68 in 2006. In 2006, 73.8 percent of rail maintenance facilities were estimated to be in adequate, good, or excellent condition.

The estimated average condition rating of rail stations improved from 3.37 in 2004 to 3.53 in 2006. In 2006, 99.3 percent of communications systems, 80.2 percent of train control systems, and 88.5 percent of traction power systems were in adequate, good, or excellent condition. The estimated average conditions of elevated structures, underground tunnels, and track declined from 2004 and 2006; however, the condition of vehicle storage yards improved slightly.

The total value of the U.S. transit infrastructure was estimated at $607.2 billion in 2006. Of this total, rail assets comprise $500.8 billion, with nonrail and joint assets comprising the remaining $106.4 billion. The data collected for these efforts represent a significant improvement in data availability and are significantly more comprehensive in comparison to previous C&P reports.

Condition of Bus and Rail Maintenance Facilities, 2006



Chapter 4

Operational Performance: Highways

Americans continue to grapple with gridlock on the Nation's highways, leading to travel delays, wasted fuel, and billions of dollars in congestion costs. From an economic perspective, travel time accounts for almost half of all costs experienced by highway users (other key components of user costs include vehicle operating costs, and costs associated with crashes).

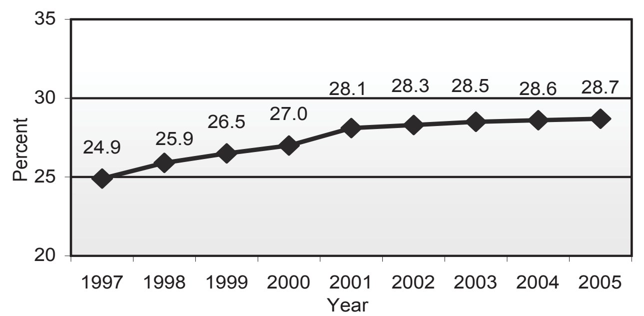
Congestion occurs when traffic demand approaches or exceeds the available capacity of the highway system. Three key aspects of congestion are severity, extent, and duration. **Severity** refers to the magnitude of the problem at its worst. The **extent** of congestion is the geographic area or number of people affected. **Duration** of congestion is the length of time that the traffic is congested.

Since there is no universally accepted definition of exactly what constitutes a congestion "problem," this report uses several metrics to explore different aspects of congestion.

The Texas Transportation Institute (TTI) collects data for 437 urban communities of different sizes across the Nation. The TTI 2007 Urban Mobility Report estimates that drivers experienced over 4.2 billion hours of delay and wasted approximately 2.9 billion gallons of fuel in 2005. The total congestion cost for these areas was $78.2 billion.

The average daily percentage of VMT under congested conditions is a metric that indicates the portion of daily traffic on freeways and other principal arterials in an urbanized area that moves at less than free-flow speeds. The measure increased by 3.8 percentage points from 24.9 percent in 1997 to 28.7 percent in 2005 for all urbanized areas combined. However the increase between 2004 and 2005 was only 0.1 percentage point, which suggests the growth of congestion is slowing. **The largest increase during this period was in medium-sized urbanized areas with population between 500,000 and 999,999.**

Average Daily Percent of VMT Under Congested Conditions for All Urbanized Areas, 1997–2006



Another metric, the Travel Time Index, measures the amount of additional time required to make a trip during the congested peak travel period. Using the year 1987 as the base for comparison, the Travel Time Index for all urbanized areas increased from 1.16 to 1.28 in 2005. In 1997, a trip that would take 20 minutes during off-peak non-congested periods would take 4.6 minutes longer during the peak period. The same trip in 2005 would require 25.6 minutes during the peak period. The largest increase between 1997 and 2005 was experienced in medium-sized urbanized areas.

Travel Time Index by Urbanized Area Size, 1997–2005

Urbanized Area Population	Base Year 1987	Year 1997	Year 2005
Less Than 500,000	1.04	1.09	1.13
500,000 to 999,999	1.09	1.15	1.21
1,000,000 to 3,000,000	1.15	1.21	1.27
Over 3,000,000	1.26	1.33	1.40
All Urbanized Areas	**1.16**	**1.23**	**1.28**

The measure of annual hours of delay per capita represents the average amount of time lost due to congested conditions per urbanized area resident. The annual person-hours of delay per capita for all urbanized areas grew from 17.1 hours in 1997 to 21.8 hours in 2005.

The average length of congested conditions is a measure of the amount of time during a 24-hour period when traffic is operating under congested conditions. The average congested travel period increased from 5.9 hours in 1997 to 6.4 hours in 2005, although it has stabilized since 2002.

Chapter 4

Operational Performance: Transit

Transit operational performance can be measured and evaluated using a number of different factors, including the speed of passenger travel, vehicle utilization, and service frequency.

Average operating speed in 2006 remained consistent with 2004 levels at 20.0 miles per hour across all transit modes. Average operating speed is an approximate measure of the speed experienced by transit riders and is affected by dwell times and the number of stops. The average speed of nonrail modes was 14.4 miles per hour in 2006, improved from 14.0 miles per hour in 2004. Conversely, rail mode operating speeds decreased from 25.0 miles per hour in 2004 to 24.8 miles per hour in 2006.

Average vehicle occupancy levels increased across all rail and nonrail modes (excluding demand response and other rail) between 2004 and 2006 on an adjusted basis. The most significant increases were realized in light rail and ferryboat, at 7.5 and 9.0 percent, respectively.

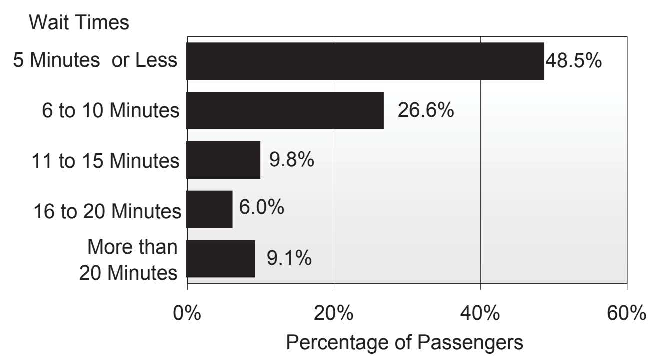
With the exception of light rail, motorbus and trolleybus, average vehicle utilization levels were lower in 2006 than in 2004. Vehicle utilization is measured as passenger miles per vehicle operated in maximum service, adjusted to reflect differences in the passenger-carrying capacities of transit vehicles. On average, rail vehicles operate at a higher level of utilization than nonrail vehicles. Commuter rail has consistently had the highest vehicle utilization rate, and demand response the lowest.

Vehicle Utilization Passenger Miles per Capacity-Equivalent Vehicle

(Thousands of Passenger Miles)

Mode	Utilization 2004	Utilization 2006
Commuter Rail	754.8	658.3
Heavy Rail	652.4	632.4
Vanpool	501.7	490.1
Light Rail	467.7	543.4
Motorbus	373.5	402.9
Ferryboat	328.4	287.8
Trolleybus	236.7	246.2
Demand Response	180.7	162.6

Passengers by Waiting Times



Most passengers who ride transit wait in areas that have frequent service. The 2001 National Household Travel Survey found that 49 percent of all passengers who ride transit wait for 5 minutes or less for a vehicle to arrive, and 75 percent wait 10 minutes or less. Nine percent of passengers wait for more than 20 minutes. To some extent, waiting times are correlated with incomes. Passengers with annual incomes above $65,000 are more likely to wait less time for a transit vehicle than passengers with incomes lower than $30,000. Higher-income passengers are more likely to be choice riders; passengers with lower incomes are more likely to use transit for basic mobility and to have more limited alternative means of travel.

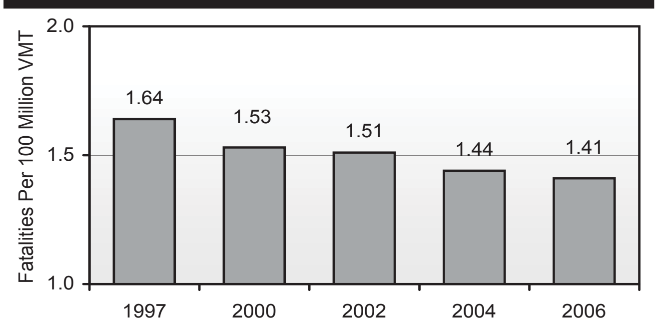
Chapter 5

Safety: Highways

There has been considerable progress in reducing the number of highway fatalities since 1966, when Federal legislation first addressed highway safety. Since that time, the highest number of traffic deaths was 54,589 in 1972, while the lowest was 39,250 in 1992. Highway fatalities decreased from 42,836 in 2004 to 42,642 in 2006.

The fatality rate per 100 million vehicle miles traveled (VMT) has declined over time, as the number of VMT has increased. In 1966, the fatality rate per 100 million VMT was 5.50; this figure dropped to 1.64 in 1997, 1.44 in 2004, and 1.41 in 2006.

Change in Fatality Rate Between 1997 and 2006



Fatality rates declined on every urban functional system between 1997 and 2006. Urban Interstate highways were the safest functional system, with a fatality rate of 0.55 per 100 million VMT in 2006. Urban minor arterials, however, recorded the sharpest decline in fatality rates. The fatality rate for urban minor arterials in 2006 was about 21.7 percent lower than in 1997.

There are many ways to examine the total number of highway-related crashes. One way is to look at roadway departure fatalities, where a vehicle leaves its lane and crashes. In 2006, there were 24,806 of these fatalities. About 43.1 percent involved the rollover of a passenger vehicle.

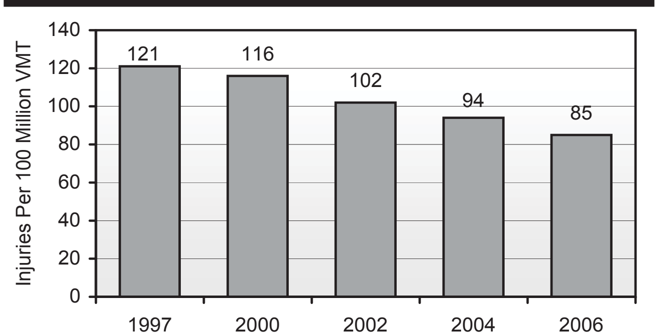
Another way is to examine fatalities that occur at intersections. Of the 42,642 fatalities that occurred in 2006, 19.6 percent—or 8,797—were related to intersections. Older drivers and pedestrians are particularly at risk at intersections. Half of the fatal crashes for drivers aged 80 or older and about one-third of the pedestrian deaths among people aged 70 or older occurred at intersections.

Another way to evaluate crashes is to analyze data related to crashes and fatalities caused by speeding. The National Highway Traffic Safety Administration estimates that 13,543 lives were lost in speed-related crashes in 2006.

Despite intense education and enforcement efforts, alcohol-impaired driving remains a serious public safety problem in the United States. In 2006, 17,602 Americans were killed in alcohol-related crashes on the Nation's highways. Alcohol was involved in 41 percent of fatal crashes and 9 percent of all crashes in 2006.

The overall number of traffic-related injuries has decreased over time, from about 3.4 million in 1988 to about 2.6 million in 2006. In 1988, the injury rate was 169 per 100 million VMT; by 2006, the number had dropped to 85 per 100 million VMT.

Change in Injury Rate Between 1997 and 2006



In terms of vehicle type, the number of occupant fatalities that involved passenger cars decreased from 22,199 in 1997 to 17,800 in 2006. Occupant fatalities involving light and large trucks, motorcycles, and other vehicles all increased.

In recent years, much attention has been focused on the safety of drivers at either extreme of the age spectrum. Motor vehicle crashes are the leading cause of death for Americans between the ages of 15 and 20 years old, and drinking is often a factor. Americans aged 65 and older, however, are among the safest drivers. They tend to be some of the most experienced drivers, and they are also less likely to drive while intoxicated.

Chapter 5

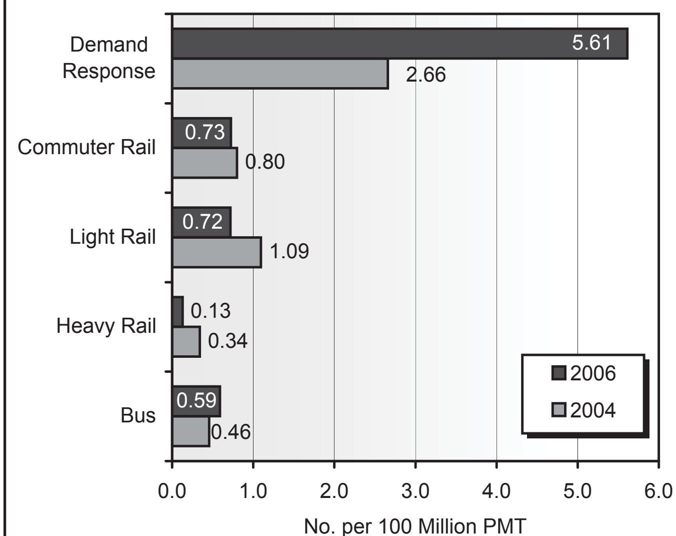
Safety: Transit

Public transit in the United States has been and continues to be a highly safe mode of transportation, as evidenced by the statistics on incidents, injuries, and fatalities that have been reported by transit agencies for the vehicles they operate directly. Reportable safety incidents include collisions and any other type of occurrence that results in death, a reportable injury, or property damage in excess of a threshold. Injuries and fatalities include those suffered by riders as well as by pedestrians, bicyclists, and people in other vehicles. Reportable security incidents include a number of serious crimes (robberies, aggravated assaults, etc.), as well as arrests and citations for minor offenses (fare evasions, trespassings, other assaults, etc.). Injuries and fatalities may occur not only while traveling on a transit vehicle, but also while boarding, alighting, or waiting for a transit vehicle or as a result of a collision with a transit vehicle or on transit property.

The definition of fatalities has remained the same. Fatalities decreased from 217 in 2004 to 213 in 2006, and fell from 0.52 per 100 million passenger miles travelled (PMT) in 2004 to 0.49 per 100 million PMT in 2006. Fatalities, adjusted for PMT, are lowest for heavy rail systems and motorbuses. Fatality rates for commuter and light rail have, on average, been higher than fatality rates for heavy rail. Commuter rail has frequent grade crossings with roads and shares track with freight rail vehicles; light rail is often at grade level and has minimal barriers between streets and sidewalks. Fatalities on demand response vehicles have consistently been the highest across all modes, increasing from 2.66 fatalities per 100 million PMT in 2004 to 5.61 in 2006.

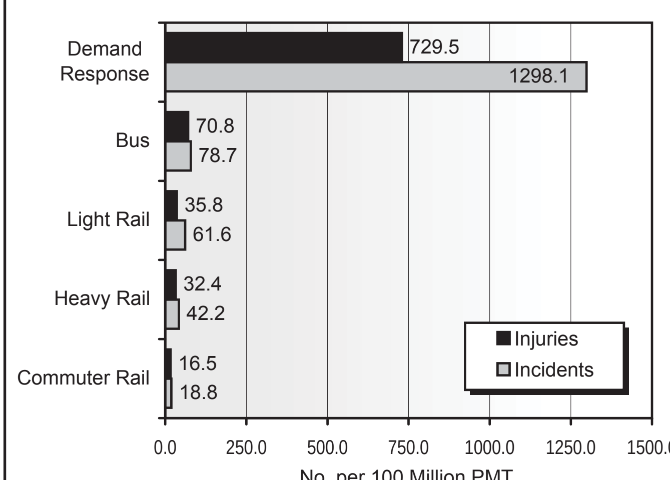
Incidents (safety and security combined) and injuries per 100 million PMT increased for all modes combined from 2004 to 2006. Incidents and injuries, when adjusted for PMT, are consistently the lowest for commuter rail and highest for demand response systems.

Fatalities per 100 Million PMT, 2004 and 2006



While commuter rail has a very low number of incidents per PMT, these incidents are more likely to result in a fatality than incidents occurring on any other mode at 3.85 fatalities per 100 incidents. Further, while light rail and motor bus have similar rates of incidents per PMT, an incident on light rail is more likely to produce a fatality (1.17 fatalities per 100 incidents for light rail compared with 0.75 for motor bus in 2006).

Incidents and Injuries per 100 Million PMT, 2006



Chapter 6

Finance: Highways

In recent years, governments throughout the United States have experimented with new ways of financing transportation projects. As costs have increased, officials have often tried to replicate some of the most successful strategies of the private sector.

Public-Private Partnerships (PPPs) are increasingly applied to a large range of transportation functions across all modes. These functions may include project conceptualization, design, finance, construction, toll collection, and maintenance. Among the broad spectrum of PPP models, the most traditional is the private contract-fee services approach, where an agency transfers limited functions to a private company. In more advanced PPP models, a private company may control some or all of these functions through a lease of an asset over some period. Outright private ownership of highway assets remains rare.

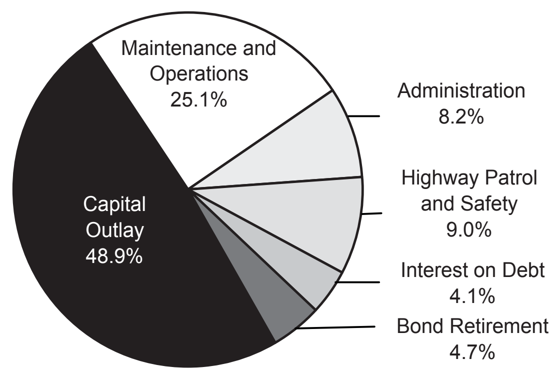
Another innovative finance tool is the use of credit assistance. The Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) provides Federal credit assistance for major transportation projects of national importance. So far, 17 projects have received commitments of TIFIA credit assistance. In addition, the State Infrastructure Bank Pilot Program offers direct loans and loan guarantees. As of June 2007, 33 States had taken advantage of this program.

Federal legislation has introduced additional ways to take advantage of debt financing. A Grant Anticipation Revenue Vehicle (GARVEE) generates up-front capital for major highway projects that the State may otherwise be unable to build in the near term. As of December 2007, the amount of GARVEE debt issued nationally had reached over $7.3 billion.

The trend toward tolling as an innovative finance technique has continued. Not only is there renewed emphasis on existing programs, such as the Congestion Pricing Pilot Program, but SAFETEA-LU also established several new innovative programs.

Governments throughout the United States spent $161.1 billion on highways in 2006. About $78.7 billion (48.8 percent) of this total was spent on capital projects. Another $40.4 billion was targeted toward maintenance (25.1 percent), while $14.5 billion (9.0 percent) was used for highway patrol and safety activities and $13.2 billion (8.2 percent) was spent on administrative costs; $14.2 billion (8.8 percent) was used for interest and bond retirement.

Highway Expenditure by Type, 2006



Of the $78.7 billion of capital spending in 2006, $40.4 billion was spent for rehabilitating the existing system; $16.2 billion was used to construct new roads and bridges; $13.8 billion was used for widening existing facilities; and $8.2 billion supported system enhancements such as safety, operational, and environmental enhancements. The portion of total capital outlay funded by the Federal government rose from 41.6 to 44.0 percent between 1997 and 2006; Federal support for capital projects climbed from $20.1 billion to $34.6 billion, while State and local capital investment increased from $28.3 billion to $44.1 billion. However, recent sharp increases in the prices of construction materials have reduced the purchasing power of this investment; in constant dollar terms, capital spending fell by 4.4 percent over this period.

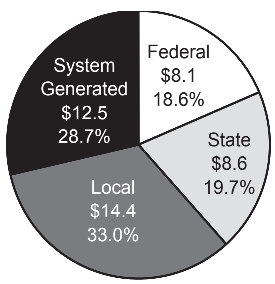
In 2006, user charges including motor fuel taxes, motor-vehicle fees, and tolls were the source of 56.3 percent of all highway funding. The remaining 43.7 percent of revenues came from other sources, such as general fund appropriations, property taxes, assessments, and bond sales.

Chapter 6

Finance: Transit

In 2006, $43.4 billion was available from all sources to finance transit capital investments and operations, compared with $39.5 billion in 2004. Transit funding comes from *public funds* allocated by Federal, State, and local governments and *system-generated revenues* earned by transit agencies from the provision of transit services. In 2006, Federal funds accounted for 18.6 percent of all transit revenue sources, State funds for 19.7 percent, local funds for 33.0 percent, and system-generated funds for 28.7 percent.

2006 Transit Revenue Sources (Billions of Dollars)

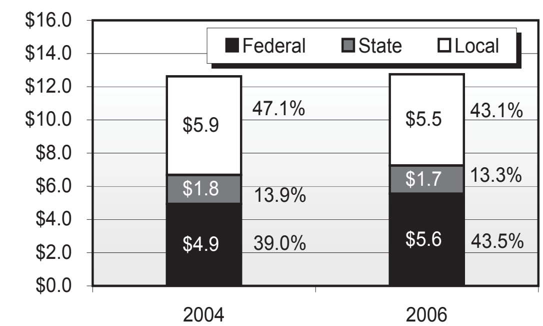


Eighty percent of the Federal funds allocated to transit are from a dedicated portion of the Federal motor-fuel tax receipts, and 20 percent are from general revenues. Federal funding for transit increased from $7.0 billion in 2004 to $8.1 billion, and State and local funding increased from $21.5 billion in 2004 to $22.8 billion in 2006.

In 2006, $12.75 billion, or 29.4 percent of total available transit funds, was spent on capital investment. Federal capital funding was $5.6 billion, or 43.5 percent of total capital expenditures; State capital funding was $1.7 billion, or 13.3 percent of total capital expenditures; and local capital funding was $5.5 billion, or 43.1 percent of total capital expenditures. The share of those funding sources shifted slightly from 2004 to 2006, with Federal funds increasing to 43.5 percent from 39.0 percent in 2004, and local funding declining from 47.1 percent to 43.1 percent during that same time period.

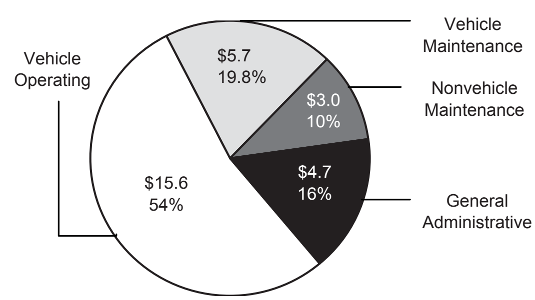
In 2006, $4.5 billion (35.3 percent) of total capital expenditures was for guideway, $3.1 billion (24.3 percent) of the total was for rolling stock, and $2.2 billion (17.2 percent) of the total was for stations.

Transit Capital Investment Funding Sources, 2004 and 2006 (Billions of Dollars)



In 2006, actual operating expenditures were $29.0 billion. Vehicle operating expenses were $15.6 billion, 53.7 percent of total operating expenses and 35.9 percent of total expenses; vehicle maintenance expenses were $5.7 billion, 19.8 percent of total operating expenses and 13.2 percent of total expenses; nonvehicle maintenance expenses were $3.0 billion, or 10.4 percent of total operating expenses and 6.9 percent of total expenses; and general administrative expenses were $4.7 billion, or 16.2 percent of total operating expenses and 10.8 percent of total expenses.

2006 Transit Operating Expenditures (Billions of Dollars)



In 2006, $30.6 billion was available for operating expenses, accounting for 70.6 percent of total available funds; the Federal government provided $2.5 billion, or 8.2 percent of total operating expenses; State governments $6.9 billion, or 22.5 percent of total operating expenses; local governments $8.9 billion, or 29.0 percent of total operating expenses; and system-generated revenues $12.3 billion, or 40.3 percent of total operating expenses.

Part II

Investment/Performance Analysis

Traditional engineering-based analytical tools focus mainly on estimating transportation agency costs and the value of resources required to maintain or improve the conditions and performance of infrastructure. This type of analytical approach can provide valuable information about the cost effectiveness of transportation system investments from the public agency perspective, including the optimal pattern of investment to minimize life-cycle costs. However, this approach does not fully consider the potential benefits to users of transportation services from maintaining or improving the conditions and performance of transportation infrastructure.

The investment/performance analyses presented in Chapters 7 through 10 of this report were developed using the Highway Economic Requirements System (HERS), the National Bridge Investment Analysis System (NBIAS), and the Transit Economic Requirements Model (TERM). Each of these tools has a broader focus than traditional engineering-based models and takes into account the value of services that transportation infrastructure provides to its users as well as some of the impacts that transportation activity has on non-users.

An economics-based approach will likely result in different decisions about the catalog of desirable improvements than would be made using a purely engineering-based approach. For example, if a highway segment, bridge, or transit system is greatly underutilized, benefit-cost analysis might suggest that it would not be worthwhile to fully preserve its condition or to address its engineering deficiencies. Conversely, a model based on economic analysis might recommend additional investments to expand capacity or improve travel conditions above and beyond the levels dictated by an analysis that simply minimized engineering life-cycle costs, if doing so would provide substantial benefits to the users of the system.

An economics-based approach also provides a more sophisticated method for prioritizing potential improvement options when funding is constrained. By identifying investment opportunities in order of the net benefits they offer, economic analysis helps provide guidance in directing limited resources toward those improvements that provide the largest benefits to transportation system users. Projects are ranked in order by their benefit-cost ratios, then successively implemented until the funding constraint is reached. Projects that produce lesser net benefits are deferred for reconsideration in the future.

For purposes of computing a benefit-cost ratio for a transportation project, the "costs" would reflect only the direct capital costs associated with that project. As defined in this report, the "benefits" would include reductions in costs of (1) transportation agencies (such as for maintenance), (2) users of the transportation system (such as savings in travel time or vehicle operating costs, or reductions in crashes), and (3) others who are affected by the operation of the transportation system (such as reductions in environmental or other societal costs). Increases in any of these costs would be treated as a negative benefit.

HERS, NBIAS, and TERM each use benefit-cost analysis as part of their decision-making process, but their approaches are very different. Each model relies on separate databases, making use of specific data available for only one part of the transportation network and addressing issues unique to that particular mode. The procedures for developing the investment scenario estimates have evolved over time, to incorporate new research, new data sources, and improved estimation techniques relying on economic principles. The methodologies used to analyze investment for highways, bridges, and transit are discussed in greater detail in Appendices A, B, and C.

While some new analysis has been added to this edition indirectly linking certain transit scenarios to specific highway scenarios involving shifts of peak period travelers between modes, **the models have not evolved to the point where direct multimodal analysis is possible for the full range of scenarios.**

Chapter 7 analyzes the projected impacts of different levels of future capital investment on a

Part II

Investment/Performance Analysis (continuation)

series of measures of physical condition, operational performance, and other benefits to system users. These levels are based on alternative annual rates of increase or decrease in constant dollar investment over 20 years.

The highway investment/performance analyses also examine the impacts of alternative financing mechanisms. Parallel analyses were constructed for each funding level assuming that any increases in investment above 2006 levels would be funded from non-user sources, user charges imposed on a fixed-rate per-mile basis (such as a VMT charge), or user charges imposed on a variable rate basis (such as congestion pricing). Any excess revenues stemming from decreases in highway and bridge investment below 2006 levels were assumed to be rebated to users in the form of reductions to existing fixed rate user charges.

Chapter 8 presents a set of **illustrative** 20-year capital investment scenarios building upon the analyses presented in Chapter 7. **The Department does not endorse or recommend any particular scenario.** Some of these scenarios are oriented toward maintaining different aspects of system conditions and performance, while others would improve the system to varying degrees. **The investment levels associated with each scenario represent combined public and private capital spending; the scenarios do not identify how much might be contributed by each level of government to support such spending.**

Chapter 9 provides supplemental analyses aimed at putting the scenarios presented in Chapter 8 into their proper context. It compares historic capital funding levels to recent conditions and performance trends and relates historic system use patterns to State and metropolitan planning organization (MPO) forecasts of future system use. The chapter also discusses the potential impacts of inflation, the timing of investments, and carbon dioxide emissions.

As in any modeling process, assumptions have been made in the models to make analysis practical and meet the limitations of available data. Chapter 10 explores the impact that varying some of these key assumptions would have on the overall results projected by HERS, NBIAS, and TERM. These include alternative assumptions regarding future deployments of operations technology, future levels of travel demand, the elasticity of travel demand to changes in user costs, future capital costs, discount rates, the valuation of nonmonetary benefits such as travel time savings, and the expected life span of pavements and structures.

While the economics-based approach applied in HERS, NBIAS, and TERM would suggest that projects be implemented in order based on their benefit-cost ratios (BCRs) until the funding available under a given scenario is exhausted, **the reality is that other factors influence Federal, State, and local decisionmaking**. If some projects with lower BCRs were carried out in favor of projects with higher BCRs, then the actual amount of investment required to achieve any given level of performance would be higher than the amount predicted in this report. Consequently**, increasing spending to the level specified for one of the "maintain" scenarios would not guarantee that the targeted measures of conditions and performance would actually be sustained at base year levels.**

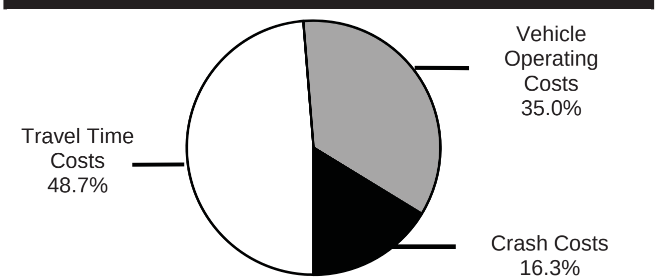
Similarly, while the HERS, NBIAS, and TERM models all screen out potential improvements that are not cost-beneficial from the "improve" scenarios, simply increasing spending to the level associated with that scenario would not in itself guarantee that these funds would be expended in a cost-beneficial manner. There may also be some projects that, regardless of economic merits, may be infeasible as a practical matter due to factors beyond those considered in the models. Because of this, the supply of feasible cost-beneficial projects could be exhausted at a lower level of investment than indicated by these scenarios. Consequently, **the improvements to future conditions and performance projected under the "improve" scenarios may not be fully obtainable in practice.**

Chapter 7

Potential Capital Investment Impacts: Highways and Bridges

Chapter 7 explores the potential impacts of 24 alternative levels of future highway capital investment on various measures of conditions and performance. Each level is expressed as an annual percent change in constant dollar spending relative to 2006 levels. The NBIAS economic bridge investment backlog metric represents the level of potential bridge investments that would be cost-beneficial to implement. The HERS adjusted average highway user costs metric quantifies the impact that changes in system conditions and performance have on travel time costs (estimated to comprise 48.7 percent of total user costs in 2006), vehicle operating costs (35.0 percent), and crash costs (16.3 percent).

Estimated Distribution of Highway-User Costs, 2006

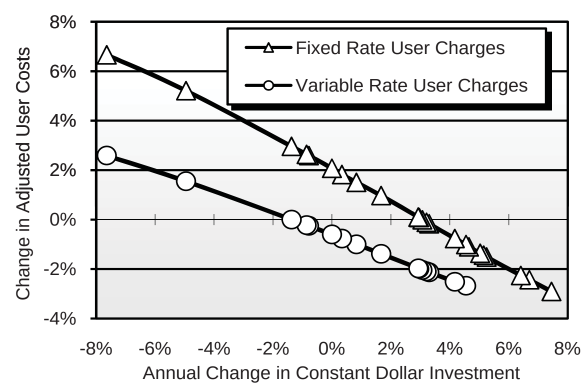


Of the $78.7 billion of total capital outlay in 2006, $48.2 billion was used for types of capital improvements modeled in HERS, including pavement resurfacing and reconstruction, and system expansion investments. Chapter 7 presents parallel analyses of alternative investment levels based on alternative financing mechanisms including funding from fixed rate user charges, and funding from variable rate user charges (direct pricing systems on congested highways).

Assuming variable rate user financing, adjusted average user costs are projected to decrease if spending were sustained at 2006 levels; if constant dollar spending were to decrease by 0.86 percent per year, this metric would still be sustained at 2006 levels through 2026. An increase of 4.55 percent per year in constant spending would yield a reduction in adjusted user costs of 5.1 percent; spending above this level would not be cost-beneficial. By 2026, each one percent reduction in user costs would translate into user savings of approximately $40 billion annually.

Regardless of the level of investment being analyzed, average user costs associated with fixed rate user financing would always be higher than if a variable rate user charge had been applied. Maintaining adjusted average user costs would require a 3.07 percent annual increase in spending assuming fixed rate user financing.

Projected Changes in 2026 Adjusted Average User Costs Compared with 2006 Levels for Different Spending Growth Rates and Financing Mechanisms



In 2006, $10.1 billion was spent by all levels of government on types of capital improvements modeled in NBIAS, including bridge repair, rehabilitation, and replacement actions. If combined public and private spending for the types of capital improvements modeled in NBIAS were sustained at 2006 levels in constant dollars, the economic bridge investment backlog is projected to rise from an initial level of $98.9 billion to a level of $112.6 billion, stated in 2006 dollars. This metric could be maintained at the 2006 base year level assuming annual spending growth of 0.83 percent per year in constant dollar terms; eliminating the backlog would require a 5.15 percent annual increase in constant dollar expenditures.

Chapter 7

Potential Capital Investment Impacts: Transit

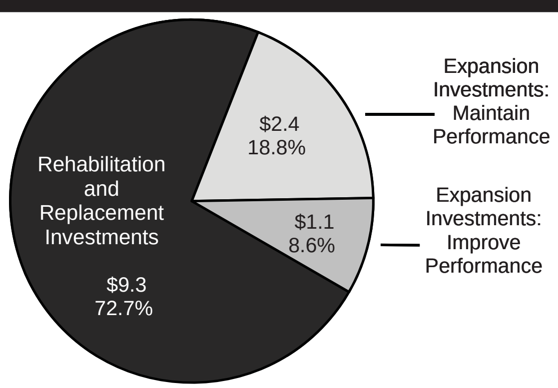
Chapter 7 analyzes how different types and levels of annual capital spending would affect different future measures of transit system condition and performance.

U.S. transit agencies spent $9.3 billion in 2006 to rehabilitate and replace antiquated and/or worn equipment. To maintain current average transit asset conditions into the future, providers of transit services would need to spend $11.4 billion annually on rehabilitation and replacement projects. (Note that this estimate is not comparable to the estimate shown in Chapter 8 because it includes capital investments in safety and other forms of capital spending not modeled by the Transit Economic Requirements Model [TERM].)

Transit operators expended $2.4 billion in 2006 on investments intended to maintain existing performance levels. If continued annually, this level of expenditure would cause crowding on transit vehicles to increase. To maintain current performance levels, U.S. transit operators would need to allocate $4.3 billion on performance maintenance (asset expansion) investments on a yearly basis.

In an effort to improve existing performance levels, U.S. transit agencies expended $1.1 billion in 2006. To improve performance through 2026, as defined by TERM, providers of transit services would need to increase annual capital spending on performance improving investments to $6.1 billion.

2006 Transit Capital Expenditures (Billions of Dollars)



In addition to reviewing investment needs on a national basis, Chapter 7 identifies capital spending requirements for different segments of urbanized areas.

In large urbanized areas with heavy rail transit systems, transit agencies collectively spent $6.5 billion on rehabilitation and replacement investments in 2006. To maintain average conditions into the future, agencies in these cities would need to spend $8.0 billion annually. Agencies in large urbanized areas without heavy rail transit systems jointly spent $1.3 billion on these types of investments but would need to spend $1.6 billion annually to maintain average conditions. Finally, public transportation service providers in small cities and rural areas invested $0.7 billion rehabilitating and replacing transit assets. These agencies, however, would need to increase capital spending to $1.3 billion to maintain existing conditions.

Transit agencies also make investments intended to accommodate growth in demand for transit services.

Agencies operating in large metropolitan areas with heavy rail transit systems spent $0.2 billion in 2006 to expand service capacity. To keep pace with demand, however, agencies in these cities would need to increase capital expenditures on service-expanding investments to $3.3 billion annually.

In large cities without heavy rail transit systems, agencies invested $2.0 billion to expand capacity. If continued annually, this level of investment would allow agencies in these cities to maintain and even improve existing performance levels into the future.

Transit agencies in small cities and rural areas spent $0.1 billion to expand capacity in 2006. To maintain performance levels, however, agencies would need to increase annual capital spending on expansion projects to $0.3 billion.

Select analyses in this chapter include a **Replace at Condition 2.5** scenario to help readers of the Rail Modernization Study that FTA released in April, 2009, place that study in the context of this report. The Rail Modernization Study considered seven select large transit rail agencies, a significant subset of the large urbanized areas with heavy rail transit systems discussed in this chapter.

Chapter 8

Selected Highway Capital Investment Scenarios

Chapter 8 presents a set of illustrative highway capital investment scenarios, building on the HERS and NBIAS analyses presented in Chapter 7, and taking into account other types of capital spending that are not currently modeled. The scenario criteria were applied separately to the Interstate System, the NHS, and the highway system as a whole. For each scenario, there is one version that assumes funding would be derived solely from fixed rate user based sources, and another that assumes funding would come from variable rate user based sources such as congestion pricing. **This report does not endorse any of these scenarios as a target level of funding**, nor does it make any recommendations concerning future levels of Federal funding.

The **Sustain Current Spending scenario** assumes that capital spending is maintained in constant dollar terms at base year 2006 levels between 2007 and 2026. (In other words, spending would rise by exactly the rate of inflation over that period). Of the $78.7 billion spent by all levels of government for highway capital improvements in 2006, $16.5 billion was directed to the Interstate System and $37.1 billion was directed to the NHS.

The **Sustain Conditions and Performance scenario** assumes that capital investment gradually changes in constant dollar terms over 20 years to the point at which adjusted average user costs and the economic bridge investment backlog in 2026 are maintained at their base year 2006 levels. Assuming fixed rate user financing, the average annual investment levels associated with meeting these goals are estimated to be $24.8 billion for the Interstate System, $38.7 billion for the NHS, and $105.6 billion for all roads. Assuming variable rate user financing, the average annual investment levels under this scenario would be $11.6 billion for the Interstate System, $19.6 billion for the NHS, and $71.3 billion for all roads. These values are lower than the amounts currently being spent on these systems, as the analysis indicates that current spending would be more than adequate to maintain system conditions and performance if congestion charges were widely applied.

Three scenarios are presented that would improve overall system conditions and performance. The **MinBCR=1.5 scenario** assumes that investment gradually increases in constant dollar terms over 20 years up to the point at which all potential capital improvements with a benefit-cost ratio of 1.5 or higher are funded by 2026 and the economic backlog for bridge investment is reduced to zero. The **MinBCR=1.2** and **MinBCR=1.0 scenarios** make the same assumptions, but apply benefit-cost ratio cutoffs of 1.2 and 1.0, respectively. Assuming fixed rate user financing, the average annual investment level for all roads for the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios**, respectively, were estimated to be $137.4 billion, $157.1 billion, and $174.6 billion; assuming variable rate user financing, the comparable levels would be $101.8 billion, $117.2 billion, and $131.3 billion. (The MinBCR=1.0 scenario is equivalent to the Cost to Improve Highways and Bridges described in previous editions of this report).

Summary of Selected Highway Capital Investment Scenarios for 2007 to 2026 (Billions of 2006 Dollars)

Functional System	Interstate	NHS	All Roads
Scenarios Assuming Fixed Rate User Financing			
Sustain Current Spending	$16.5	$37.1	$78.7
Sustain Conditions and Performance	$24.8	$38.7	$105.6
Invest up to MinBCR=1.5	$39.0	$60.7	$137.4
Invest up to MinBCR=1.2	$43.5	$69.2	$157.1
Invest up to MinBCR=1.0	$47.0	$76.1	$174.6
Scenarios Assuming Variable Rate User Financing			
Sustain Current Spending	$16.5	$37.1	$78.7
Sustain Conditions and Performance	$11.6	$19.6	$71.3
Invest up to MinBCR=1.5	$24.0	$38.9	$101.8
Invest up to MinBCR=1.2	$27.5	$44.9	$117.2
Invest up to MinBCR=1.0	$30.4	$50.1	$131.3

The fixed rate user financing and variable rate user financing versions of the **Sustain Current Spending scenario** for all roads are associated with benefit-cost ratio cutoffs of 2.89 and 1.90, respectively. The comparable values for the fixed rate user financing and variable rate user financing versions of the **Sustain Conditions and Performance scenario** for all roads are 1.98 and 2.25, respectively.

Chapter 8

Selected Transit Capital Investment Scenarios

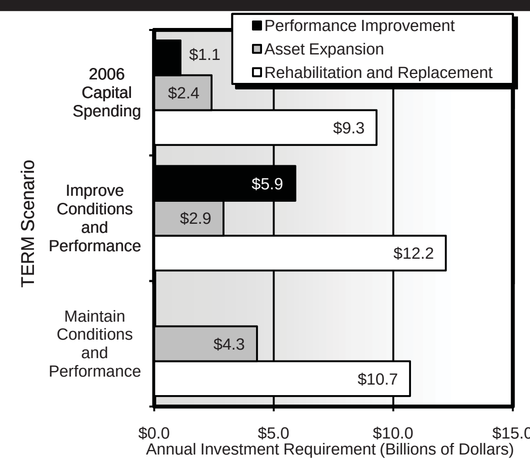
Chapter 8 provides a more in-depth analysis of specific investment scenarios. This chapter assesses the expected impact of maintaining current transit capital expenditure levels on future transit asset conditions and service performance, as well as considers how variations in the pass-fail threshold for TERM's benefit-cost ratio impact investment forecasts. In addition to consideration of the maintain and improve scenarios for transit asset conditions and service performance as considered in prior year reports, this section also considers the level of transit investment required to serve ridership potentially diverted from automobile usage due to the influence of congestion pricing. Current investment estimates are for the period 2007 to 2026 and are stated in 2006 constant dollars.

If current funding levels of $9.3 billion per year on rehabilitation and replacement were maintained over 2007 to 2026, TERM estimates that the average condition would decline from 3.72 in 2006 to 3.36 in 2026. Further, the percent of assets in operation in excess of their useful life would increase from 14.7 percent in 2006 to 26.9 percent in 2026.

If the funding level for expansion and performance improvement investments of an additional $3.5 billion per year were maintained through 2026, funding levels would be insufficient to maintain performance in aggregate across rail transit modes and compound existing overcrowding problems for some high demand operators.

Since 1997, the C&P report has included a consistent set of TERM investment scenarios that assess the level of investment required to attain specific asset conditions and performance targets. The levels of investment required to attain these targets have been combined to construct a range of investment scenarios. The **Maintain Conditions and Performance scenario** projects the level of investment to maintain current average asset conditions over the 20-year period and to maintain current vehicle occupancy levels as transit passenger travel increases. In looking at the **Maintain Conditions and Performance scenario**, with a benefit-cost ratio of 1.0, a total of $15.1 billion per year is required. The **Improve Conditions and Performance scenario** projects the level of investment to raise the average condition of each major transit asset type to at least a level of "good," reduce average vehicle occupancy rates, and increase average vehicle speeds. In this scenario, annual requirements for rehabilitation and replacement are projected to be $12.2 billion, with asset expansion and performance improvements estimated at $2.9 and $5.9 billion respectively to total an annual estimate of $21.1 billion.

TERM Investment Scenarios



The variable rate user financing scenarios examined in the highway analysis assume a reduction in peak period VMT, a portion of which could be diverted to transit. The level of expansion investment required to support this increase in transit ridership while maintaining current transit performance at today's levels is examined. To do so, the analysis assumes that between 25 percent and 50 percent of diverted auto users shift to transit as their preferred modal choice, based on the projected VMT for the highway "Sustain Current Spending" (SCS) and "Maximum Economic Investment" (MEI) scenarios. Annual investment requirements modeled in TERM are significantly impacted by the increase in PMT on transit under all investment scenarios.

Chapter 9

Scenario Implications: Highways and Bridges

Chapter 9 provides supplemental discussion and analysis of key issues to assist in the interpretation of the selected capital investment scenarios presented in Chapter 8.

All of the investment/performance analyses in the C&P report are presented in constant 2006 dollars. It is difficult to predict inflation rates, and adjusting the constant dollar figures to nominal dollar values would add to the uncertainty of the overall results, particularly if inflation assumptions later proved incorrect. However, when applying these analytical findings in other contexts, such as comparing a particular scenario with nominal dollar revenue projections, it is sometimes necessary to adjust for inflation to ensure an accurate comparison.

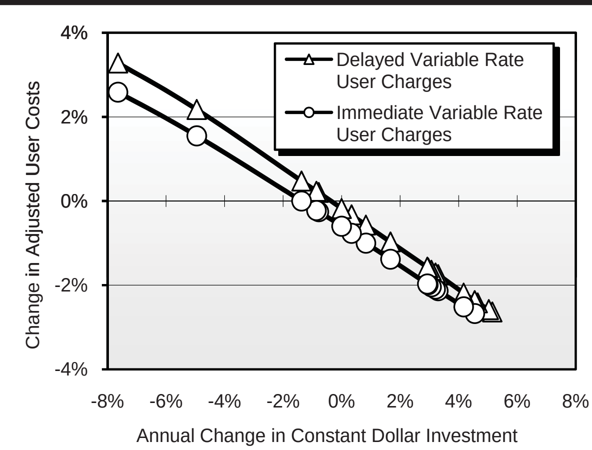
Capital spending by all levels of government increased by 62.7 percent between 1997 and 2006, but did not keep pace with the 69.4 percent increase in the FHWA Composite Bid Price Index (BPI) over this period, due to a sharp increase in the cost of construction materials between 2004 and 2006.

The fixed rate financing version of the Sustain Conditions and Performance scenario implies that $40.0 billion per year of system expansion investment would be needed to achieve the scenario's goals; actual spending in 2006 by all levels of government for these types of improvements was only $30.0 billion. This finding is consistent with declines in operational performance noted in Chapter 4. The annual investment level identified for the system rehabilitation component of this scenario is $40.4 billion, which is close to the $43.5 billion of actual system rehabilitation spending in 2006. However, this gap is not evenly distributed across all types of roads and is wider for lower-ordered urban functional systems; this appears consistent with the decline in pavement conditions in recent years noted for these systems in Chapter 3.

The analyses in Chapters 7 and 8 assume gradual changes in investment at a fixed annual rate over time. Previous editions of the C&P had either assumed that investment would immediately jump to the average annual investment levels associated with each investment scenario or assumed that investment in any given year would be driven solely by benefit-cost ratio criteria. The latter approach frequently resulted in a significant front-loading of capital investment in the early years as the existing backlog of cost-beneficial improvements was addressed. The HERS model identifies $523.5 billion of cost-beneficial investments that could be made based on the current conditions and operational performance of the system, without regard to future travel growth; this is in addition to the $98.9 billion bridge backlog identified by NBIAS. If resources were available to immediately reduce the backlog in this fashion, HERS projects that there would be significant savings to users, even if annual investment later dropped off.

The variable rate financing analyses in Chapters 7 and 8 assume the immediate imposition of congestion pricing on a widespread basis. If the imposition of such charges were delayed by 10 years, HERS estimates that a higher level of investment would be needed to sustain adjusted annual average user costs, but that this could be achieved without increasing spending above the 2006 base year level in constant dollar terms. Regardless of the level of investment being analyzed, the projected average user costs associated with a delayed implementation of variable rate user charges would be higher than if such a financing mechanism were to be applied immediately.

Projected Changes in 2026 Adjusted Average User Costs Compared With 2006 Levels for Different Spending Growth Rates and Timing of Variable Rate User Charges



Chapter 9

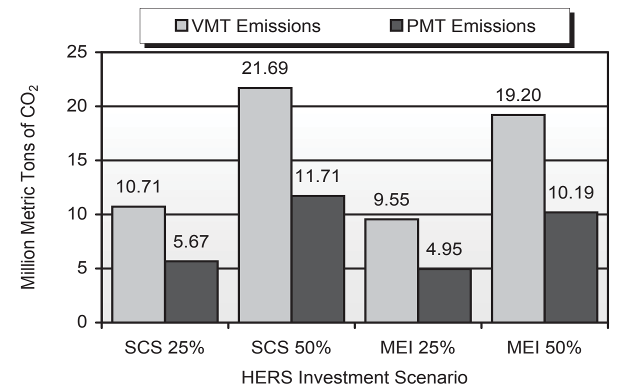
Scenario Implications: Transit

Chapter 9 considers a number of potential implications and limitations of the transit scenario analyses presented in Chapters 7 and 8. The intention is to provide a more comprehensive understanding of the assumptions used in scenario development as well as some alternative interpretations of the scenario results. Specifically, this section includes discussion of the following topics: ridership response to TERM investments; the potential impact of highway congestion pricing on CO_2 emissions from both autos and transit vehicles; a comparison of PMT growth rates used by TERM's asset expansion module with the recent, actual PMT growth rates; and the potential impact of recent construction commodity price increases on transit investment costs.

Each of the three investment types considered by TERM—including the rehabilitation and replacement of existing assets, asset expansion, and performance improving investments—may draw varying levels of new transit ridership. First, the rehabilitation and replacement of aging transit assets results in improving the quality and reliability of transit services, improvements that are believed to attract new transit riders. At present, the responsiveness of ridership to changes in asset conditions is not well understood and, for this reason, these impacts are not currently modeled within TERM. Second, for TERM's annual asset expansion investments, given the weighted-average annual national growth rate of 1.5 percent, it is estimated that TERM's $4.7 billion investment in annual transit expansion (i.e., Maintain Performance) would support an additional 3.3 billion annual boardings by 2026, roughly 35 percent more than the current 9.5 billion annual boardings. Third, for the Improve Performance scenario, the estimate of $6.1 billion would generate 4.4 billion annual transit boardings by 2026, or 46 percent over current ridership levels.

Continuing with the presentation of congestion pricing in Chapter 8, Chapter 9 examines the impact that the portion of highway VMT that would shift away from peak period highway travel to transit alternatives in response to congestion pricing initiatives would have on CO_2 emissions. This analysis indicates there is significant potential to reduce CO_2 emissions by almost half for the assumed commuters diverting to transit from highways.

Annual CO_2 Emissions Comparison of Highway VMT Diverted to Transit PMT



SCS: Sustain Current Spending
MEI: Maximum Economic Investment

The "Transit Travel Growth" section describes how observed recent changes in PMT (historic growth rates) have diverged from the long-range demand forecasts used by TERM. The variance in PMT rates of change can be attributed to a variety of factors, including the strength of the U.S. economy, the prevalence of public transportation, and the price of gasoline. From 1997 to 2006, annual transit PMT increased from 39.2 billion to 49.5 billion, growing at an average annual rate of 2.6 percent.

Forecasting demand for public transportation services is an inexact science. TERM's projections of investments required to support the projected, natural growth in transit ridership are driven entirely by ridership and PMT forecasts provided by a sample of the nation's metropolitan planning organizations (MPOs). The average rate of PMT growth for 1991 to 2005 was 1.7 percent. The actual rate of increase for 2006 to mid-2008 well exceeds the forecast rate based on MPO projections of 1.5 percent on average for 2009 to 2026.

Pricing for materials and labor used in the construction industry have increased significantly in recent years, pushing the costs for constructing all types of capital projects upward. A discussion of construction material and labor inflation is also provided in Chapter 9.

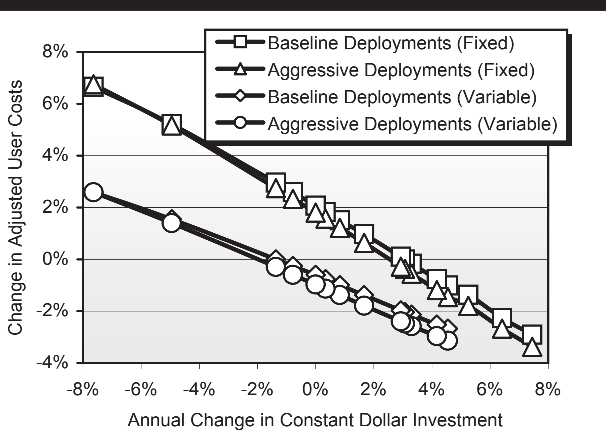
Chapter 10

Sensitivity Analysis: Highways and Bridges

The usefulness of any investment scenario analysis depends on the validity of the underlying assumptions used to develop the analysis. Since there may be a range of appropriate values for several of the model parameters used in the HERS and NBIAS analyses presented in Chapter 7, this section explores the impacts of changing some of these assumptions pertaining to technology, travel growth, economic assumptions, the valuation of non-monetary benefits, and life span of bridges.

The baseline investment/performance analyses reflect the impacts of a continuation of existing trends in the deployment of operations strategies and intelligent transportation systems (ITS) technologies on highway performance. If a portion of the spending for system expansion in the baseline analyses were redirected to cover the capital and operating costs associated with a more aggressive rate of operations/ITS deployments, HERS projects that adjusted average user costs would be reduced for most of the investment levels analyzed. The baseline existing deployment trends assumption would result in superior performance outcomes only if total capital spending were to decrease significantly relative to 2006 levels. This analysis suggests that, if combined public and private investments were to be sustained at current levels or increased above those levels, serious consideration should be given to accelerating the rate of operations deployments.

Projected Changes in 2026 Adjusted Average User Costs Compared With 2006 Levels for Different Spending Growth Rates, Operations Deployment Rates, and Financing Mechanisms



Pavement technology can greatly extend the lifetime of a highway system. Assuming a one-third increase in typical pavement lives, HERS recommends directing a larger share of total funding to capacity expansion because pavement actions would not be needed as frequently. This would allow for improvements in both average pavement roughness and average traveler delay for most of the investment levels analyzed.

HERS assumes that the State-provided forecast for each sample highway segment represents the level of travel that will occur if a constant level of service is maintained on that facility. As noted in Chapter 4, however, the level of service has generally declined over time. Modifying the forecasts to match actual travel growth for the past 20 years would increase both overall congestion and the rate of pavement deterioration, both of which would cause the adjusted average highway user costs associated with any given level of capital investment to rise. Assuming fixed rate user financing, annual constant dollar spending would need to increase by between 6.41 percent and 7.45 percent to maintain average user costs in 2026 at base year 2006 levels, significantly higher than the 3.07 percent rate in the baseline analyses. Assuming variable rate user financing, spending would need to increase between 1.67 percent and 2.93 percent annually. Alternatively, if the trends that have caused travel growth per capita to rise over time were to cease and VMT were to grow only by the projected rate of increase in the total population, then current funding levels would be more than adequate to maintain adjusted user costs at base year levels.

The baseline investment/performance analyses are tied to the Energy Information Agency's reference case values for fuel prices; substituting in their high price forecast would result in lower projections for 2026 travel for all funding levels, regardless of the financing mechanism. This would lead to lower levels of average delay and average pavement roughness for any given funding level than were computed for the baseline analyses.

Chapter 10

Sensitivity Analysis: Transit

Chapter 10 examines the sensitivity of projected transit investment estimates by the Transit Economic Requirements Model (TERM) to variations in the values of exogenously determined model inputs including passenger miles traveled (PMT), capital costs, the value of time, and user travel cost elasticities.

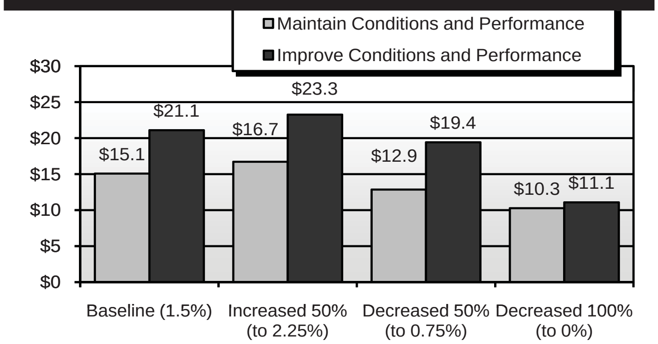
TERM relies on forecasts of PMT in large urbanized areas to determine estimates of projected investment in the Nation's transit systems for the Maintain Performance scenario (i.e., current levels of passenger travel speeds and vehicle utilization rates) as ridership increases and the Improve Performance scenario (i.e., increase passenger travel speeds and reduce crowding).

PMT forecasts are generally made by metropolitan planning organizations (MPOs) in conjunction with projections of VMT. **The average annual growth rate in PMT of 1.5 percent used in this report is a weighted average of the most recent MPO forecasts available.** Transit investment estimates in the 2004 report were based on a projected PMT growth rate of 1.57 percent, from 92 of the Nation's largest metropolitan areas. PMT has increased at an average annual rate of 2.3 percent between 1997 and 2006 and by 3.1 percent between 2004 and 2006.

Varying the assumed rate of growth in PMT affects estimated transit investment both for the Maintain and Improve scenarios. A 50-percent change in growth will impact the cost to Maintain Conditions and Performance by an 11.0 percent increase or a 14.6 percent decrease, and the cost to Improve Conditions and Performance by a 10.2 percent increase or an 8.0 percent decrease. Investment estimated by both the Maintain and Improve scenarios would decrease significantly if PMT was assumed to remain constant.

Given the uncertainty of capital costs, a sensitivity analysis was performed to examine the effect of higher capital costs on the projected transit investment. A 25-percent increase in capital costs increases the investment estimated by the **Maintain Conditions and Performance scenario** by 9.9 percent and decreases the investment estimated by the **Improve Conditions and Performance scenario** by 20.7 percent. With this increase in costs, fewer investments are economically viable under this scenario compared with the **Maintain Conditions and Performance scenario.**

The Effect of Variations in PMT Growth on Transit Annual Investment Scenario Estimates (Billions of 2006 Dollars)



The value of time is used to determine the total benefits accruing to transit users from transit investments that reduce passenger travel time. Three scenarios were examined in relation to the base value of time of $11.20 per hour: (1) value of time is double, (2) value of time is half, and (3) value of time in constant 2006 dollars. Variations in the value of time were found to have a limited effect on the investment estimates because changes in the value of time have inverse effects on the demand for transit services. An increase in the value of time was found to reduce projected investment in modes with relatively slower transit services and to increase projected investment in modes with relatively faster transit services. The opposite occurs in response to a decrease in the value of time.

TERM considers user cost elasticities to estimate the changes in ridership, fare, and travel time costs resulting from infrastructure investment to increase speeds, decrease vehicle occupancy levels, and increase frequency. A doubling or halving of these elasticities was found to have a minimal effect (an increase of 0.4 percent and decrease of 6.5 percent, respectively) on projected investment.

Chapter 11

NHS Bridge Performance Projections

All bridges are important to the communities along the Nation's transportation system; however, the National Highway System (NHS) bridge network is extremely important because of the amount of traffic it carries.

Chapter 11 examines the impact of combining several bridge management strategies with different funding alternatives over a period of 50 years. The analyses presented in this chapter do not directly correspond to the 20-year capital investment scenarios referenced in other chapters.

Several metrics are considered: the bridge's average Sufficiency Rating (a composite measure taking into account factors such as a bridge's structural adequacy, functionality, and essentiality, on a scale of 0 to 100), the average Health Index (a measure of the structural integrity of individual bridge elements, on a scale of 0 to 100); and the percentage of NHS bridges with condition ratings of 5 or greater for deck, superstructure, and substructure (a measure of the general condition of major bridge components, on a scale of 0 to 9).

The **Sufficiency Rating 50 strategy** assumes that structures that reach a sufficiency rating of 50 or less are selected for replacement. The **Age 50 strategy** assumes that any structure that becomes 50 years or older during the analysis period will be replaced. The **Health Index 75 strategy** assumes that any structure with a health index equal to or less than 75 during the analysis period will be replaced. The **Health Index 80 strategy** assumes that any structure with a health index equal to or less than 80 during the analysis period will be replaced. **The Health Index 85 strategy** assumes that any structure with a health index equal to or less than 85 during the analysis period will be replaced.

An additional management strategy was included in the analysis to reflect selection of actions on bridges based on any action having a benefit-cost ratio of 1.0 or greater. This is the **No Special Rules strategy.**

Four funding alternatives were combined with one or all of the proposed management strategies – the **Maximum Flat Funding** alternative, the **Maximum Ramped Funding** alternative, the **Unconstrained Funding** alternative, and the **Current Funding** alternative.

The **Maximum Flat Funding** alternative provides funding at the maximum annual amount at which all allocated funds will be expended during the analysis period. The **Maximum Ramped Funding** alternative assumes an increase in spending at a fixed annual rate over 50 years. The **Unconstrained Funding** alternative assumes spending will be allocated on the management criteria in use and there is no limit to annual spending. The **Current Funding** alternative assumes funding will remain at the amount allocated for 2006. All amounts are in 2006 dollars.

In general, when comparing the various strategies, those that yield the higher values of the individual metrics both over the long term and the short term will provide a more desirable system.

The **Sufficiency Rating 50 – Current Funding** combination yielded the lowest values for all metrics except for substructure condition rating. The **Age 50 – Maximum Flat Funding** combination yielded the lowest substructure value in 2056. The remaining approaches provide much higher metric levels in 2056 and, depending on the minimum acceptable performance levels selected, yield a much higher performance level for the total NHS bridge network.

It is critical to understand the funding stream needed to implement any of the approaches. The ramped spending approach gradually increases investment, addressing an increasing number of needs each year. The flat spending approach may not provide enough funding to reduce the backlog. The **No Special Rules** approach projects a large influx of funding in 2007, followed by relatively flat funding.

Chapter 12

Transportation Serving Federal and Indian Lands

Federal and Indian lands have many uses. These include recreation, range and grazing, timber, minerals, watersheds, fish and wildlife, and wilderness. In recent years, recreational use has significantly increased, while resource extraction and cutting of timber have declined. These lands are also managed to protect their natural, scenic, scientific, and cultural value.

Roads on Indian lands provide access and mobility for residents and provide access to regional and national transportation systems. Tribal roads are essential for economic development and community development on reservations, providing critical access between housing and education, emergency centers, and places of employment.

Transportation plays a key role in the way people access and enjoy Federal lands. Approximately 329,000 miles of public roads are located on Federal lands, including 93,000 miles of State and local roads that provide access to and within these lands. Use of roads by private vehicles and tour buses continues to be the primary method of travel to and within Federal and Indian lands.

Although the Federal Highway Administration (FHWA) and its predecessors have worked to improve access to Federal lands for over a century, the Federal Lands Highway Program (FLHP) was only created in 1983. Today's FLHP is subdivided into four core areas: the Indian Reservation Roads, Park Roads and Parkways, Refuge Roads, and Public Lands Highway (Forest Highway and the Public Lands Highway Discretionary) Programs.

The primary purpose of the FLHP is to provide financial resources and technical assistance to support a coordinated program of public roads that service the transportation needs of Federal and Indian lands. The SAFETEA-LU authorizations for 2005 through 2009 for the FLHP total over $4.5 billion. During the past five fiscal years, the FLHP has improved, on average, about 1,000 miles of roads and 35 to 40 bridges per year.

The FHWA works with numerous Federal Land Management Agencies (FLMAs) while overseeing the FLHP. The four FLMAs that are most directly involved in the core areas of the FLHP are known as core partners; these include the U.S. Forest Service (USFS), the National Park Service (NPS), the Bureau of Indian Affairs (BIA), and the U.S. Fish and Wildlife Service (FWS).

The USFS estimates that, of the 29,200 miles of paved National Forest System Roads in 2006, approximately 39 percent were in good condition, compared with 29 percent in fair condition and 32 percent in poor condition. The NPS estimates that, of 5,450 miles of paved Park Roads and Parkways, approximately 11 percent were in good condition, while 48 percent were rated as fair and 41 percent were considered poor. The condition ratings estimated by the BIA for nearly 37,000 paved miles of Indian Reservation Roads are 16 percent good, 39 percent fair, and 45 percent poor. The FWS estimates that, of 415 miles of paved Refuge Roads, approximately 39 percent were in good condition, 32 percent were in fair condition, and 30 percent were in poor condition.

The FLHP supports the FLMAs beyond design and construction oversight by also providing funding and expertise for integrated transportation planning, road and bridge inspections, and other technical assistance activities. FLHP funds can be used for transportation planning, research, engineering, and construction of highways, roads, parkways, and transit facilities.

SAFETEA-LU established a $97 million Alternative Transportation in Parks and Public Lands Program. This program authorizes FTA grants for projects that improve mobility in parks and public lands. Eligible projects include the purchase of buses for new transit service, replacement of old buses and trams, construction of bicycle and pedestrian pathways, ferry dock replacement, intelligent transportation system components, and planning studies.

Chapter 13

Freight Transportation

The economy of the United States depends on freight transportation to link businesses with suppliers and markets. The transportation system in the United States moved an average of 53 million tons of freight worth $36 billion per day in 2002. Over the next three decades, the tonnage of goods to be moved is expected to increase by 2.0 percent each year, almost doubling between now and 2035.

Demands on the Transportation System

Most of the Nation's freight transportation infrastructure was developed before 1960. This older system moved goods from farm to market and from fort to port, and served industrial and population centers concentrated in the Northeast and the Midwest. Since 1960, however, population and manufacturing have grown in the South and on the West Coast, and international trade has changed the complexion of traditional corridors. Railroads and steamship companies accommodate enormous numbers of containers—a technological novelty five decades ago. Trucks serve new inland distribution centers beyond the urban fringe. Air carriers deliver parcels between any locations in the country over night.

The freight system must serve an economy that is increasingly decentralized and organized around just-in-time delivery. Much of this delivery is done by truck. The Interstate System carries half of truck travel and three-fourths of freight-hauling truck traffic that serves places at least 50 miles apart.

Freight and Congestion

As freight demand grows, it often creates congestion. Congested freight hubs include international gateways such as ports, airports, and border crossings, as well as domestic terminals and transfer points such as Chicago's rail yards. On the Nation's road network, the top 10 highway interchange bottlenecks cause an average of 1.5 million annual truck hours of delay each, compared to less than 250,000 annual hours of truck delay for other truck bottlenecks. Trucks are also a source of congestion when space and time for pickups and deliveries are limited. An estimated 947,000 hours of vehicle delay is attributable to delivery trucks parked curbside in dense urban areas.

Safety and Environmental Concerns

Freight transportation is not just an issue of throughput and congestion. Policymakers are increasingly focused on how freight transportation impacts air quality, and how hazardous materials can be safely moved. Policymakers are deliberating how to move the Nation's increasing volume of goods without compromising public safety and the quality of the environment.

The Economic Costs of Freight Transportation

Freight transportation has become cheaper over the past quarter century, contributing significantly to the Nation's economic productivity and growth. Several forces, however, are combining to increase costs in the years ahead. Congestion, higher fuel prices, and a shortage of labor in some sectors has increased the costs to carriers, and impacted the prices of goods. Over the three years ending in 2006, prices increased 13 percent for truck transportation, 27 percent for rail transportation, and 8 percent for scheduled air freight.

The Freight Challenge

SAFETEA-LU included several provisions designed to improve freight infrastructure. Among other provisions, SAFETEA-LU authorized $4.6 billion for certain freight-oriented investments, expanded eligibility under the Transportation Infrastructure Finance and Innovation Act (TIFIA) for freight projects, and modified the tax code to encourage investment through private activity bonds. Still, meeting the freight challenge is difficult due to the high cost of many improvements and the fact that much of the Nation's freight infrastructure is privately owned.

Chapter 14

Congestion Reduction Strategies

Congestion generally reflects a fundamental imbalance of supply and demand. Economists have long understood that such an imbalance stems from inefficient pricing, where the true costs of use are not reflected in the prices paid by users. This imbalance is also affected by the absolute volume of traffic (demand) on a given facility relative to its physical capacity (supply).

There are four broad ways to reduce congestion: add more capacity, use capacity more productively, reduce system demand, and create an efficient transportation market.

Strategic Addition of Capacity

Traditionally, transportation officials have dealt with congestion by expanding the capacity of the road network. Today, however, concerns about air pollution, noise, and urban sprawl often stand in the way of capacity additions. Equally significant, adding new capacity can be enormously expensive and physically challenging. Despite these challenges, major projects that reduce bottlenecks, add lanes, or modify traffic patterns can often provide system performance benefits that outweigh these costs.

System Operations and Management

Another approach is to use the transportation system more productively. Transportation officials can increase productivity by maximizing system performance in the first place and being prepared to recover as quickly as possible when disruptions occur.

Several tools are greatly improving system operations and management. **Real-time traveler information** allows travelers to decide how they will (or will not) use the transportation system. **Traffic incident management** is a planned and coordinated process to detect, respond to, and remove traffic incidents and restore capacity as safely and quickly as possible.

Work zones are second only to incidents as a source of delay from temporary capacity loss, and more effective management can minimize disruptions to the traveling public. **Better monitoring of weather conditions** and **improved traffic signal timing and coordination** can also enhance the productivity of the highway network.

Providing Better Transportation Choices

Another effective way to reduce the level of demand for using highways is to ensure that travelers have a variety of high-quality alternatives to choose from that meet their transportation needs. Travel Demand Management (TDM) increases the use of travel alternatives; spreads the timing of travel to less-congested periods; reduces the need for travel; and shifts the routing of vehicles to less-congested facilities. A more robust public transportation system, high-occupancy vehicle lanes, better bicycling and pedestrian facilities, flexible work schedules, and telecommuting are a few of the other alternatives to traditional highway transportation.

Road Pricing

Although the building of new facilities and better management and operation of roads are effective strategies in relieving congestion, they do not address one of its root causes: that most travelers do not pay the full cost of receiving transportation services. Congestion pricing—charging a price that will bring supply and demand into balance—relies on market forces and recognizes that trip values vary by individual.

Congestion pricing can take many forms. At the present time, variable pricing is typically applied on a limited access facility, such as a bridge, or in a congestion charging zone around a central business district. In the future, charging systems that use special technology may make it feasible to efficiently price entire road networks. Congestion pricing may also be applied to parking, encouraging travelers to alter their travel habits during peak periods.

Chapter 15

National Household Travel Survey

Since 1969, the National Household Travel Survey (NHTS) and related studies have provided key information on how the American public uses the Nation's highway system. The NHTS provides detailed data on the characteristics of travelers, trips, and vehicles. Data collection for the 2008 survey is currently underway. This Chapter includes selected findings from the 2001 survey.

Long-Distance Travel

Overall, about 2.6 billion long distance trips are taken by U.S. residents every year. These are trips of 50 miles or more away from home; in any given year, 169 million people (61 percent of the population) do not make any trips of this length. Business trips comprise nearly 30 percent of the long distance trips. Another 25 percent of trips involve visiting friends and relatives, while leisure trips, sight-seeing, and vacations make up another 25 percent.

Older Drivers

Americans aged 65 and older represent the fastest-growing segment of the U.S. population. The total mileage driven by these older Americans is projected to increase by 50 percent by 2020 and more than double by 2040. While older drivers tend to drive far fewer miles than younger drivers, they are more vulnerable to severe injuries. Per mile driven, elderly drivers (those over 80 years old) are more likely to die in a crash than any other age group.

Rising Fuel Cost

Almost 70 percent of all petroleum used in the United States goes for transportation. Recent increases in fuel costs have raised questions about the impact of higher fuel prices on driver behavior. In 2001, the average household spent $1,461 a year on motor fuel; by 2006, this cost had risen to an estimated $3,261. Despite higher fuel prices, passenger travel has continued to grow. This is due to population growth; the increased purchasing power of American households; and the continued dispersion of housing, workplace, and recreational locations.

Travel Characteristics of New Immigrants

For the first time since the early 1900s, immigrants comprise more than 10 percent of the American population, a total of 32 million people. Immigrants will provide a larger share of the labor force in the future, requiring agencies to rethink transportation options. Immigrants are five times more likely to take transit to work than native-born Americans. There is also a high use of carpools by Hispanic commuters, especially men.

Commuting

One in 12 American workers spent an hour or more commuting each way per day in 2001, up from one in 20 in 1995. The number of hour-long commutes has skyrocketed not only because workers are taking jobs farther from home, but because the same commutes are taking longer. More than one-quarter of workers with commutes of one hour or longer leave before 6 a.m. for their trip to work.

Travel Time and Congestion

Commuting is a major factor in metropolitan congestion. According to the 2001 NHTS, two-thirds of all commuters usually leave for work between 6:00 and 9:00 a.m., and more than 88 percent of these workers travel in private vehicles.

A significant number of non-work vehicle trips, however, are made during peak periods. From 1990 to 2001, morning peak period non-work trips on Mondays through Thursdays increased by 100 percent. Shopping trips (including those for the purpose of getting a meal) adds 31 billion VMT to morning peak volumes.

Travel to School

The percentage of children ages 6 to 12 driven to school in a private vehicle rose from 15 percent in 1969 to 50 percent in 2001. This change in travel behavior has led many transportation professionals to consider policies and programs that encourage walking and biking to school, especially for grade school children.

PART I

Description of Current System

Introduction

Chapters 1 through 6 are designed to provide a broad overview of the current status of the Nation's highway and transit systems, as well as to describe historic trends. These retrospective analyses serve as a foundation for the prospective analyses contained in Part II and other sections of the C&P report.

Chapter 1, **An Introduction to Highways and Transit**, provides a broad overview of the functions served by the Nation's highways and transit systems. The basic concepts introduced here are expanded upon in other chapters of this report. This chapter also explores the evolving Federal role in highway and transit infrastructure.

Chapter 2, **System Characteristics**, describes the extent of the Nation's highways, bridges, and transit systems and provides information on the usage of these systems.

Chapter 3, **System Conditions**, describes the current physical condition of the Nation's highways, bridges, and transit systems and how the overall physical condition of this infrastructure has changed in recent years.

Chapter 4, **Operational Performance**, analyzes how well the highway and transit infrastructure has performed in accommodating increasing demand for travel.

Chapter 5, **Safety**, describes the safety performance of highways and transit systems.

Chapter 6, **Finance**, discusses recent innovations in highway and transit finance as well as more traditional sources of revenue for these modes. This chapter also describes the current levels and types of highway and transit expenditures made by Federal, State, and local governments.

Chapter 1

An Introduction to Highways and Transit

An Introduction to Highways and Transit

There are four principal elements of the Nation's surface transportation network—highways, transit, railroads, and ports and waterways. This chapter examines highways and public transit, which form the foundation of one of the most extensive and complicated transportation networks in the world. It defines the functions these two modes of transportation perform, and the ways they complement one another. Finally, this chapter describes the evolution of the Federal role in providing highway and transit infrastructure.

The Essential Functions of Highway and Transit Infrastructure

There are several critical ways that highways and transit infrastructure interact to provide service for the American people.

Personal Mobility

Highways and public transit provide the American people with a high degree of personal mobility. Convenience and accessibility are the key elements of the surface transportation network in the United States and Americans have come to expect this ease of transportation. Freedom of movement has been a defining theme in American history, and many of the Nation's social, governmental, and legal principles were built around the concept of mobility.

On the highway system, automobiles allow people to travel where they want, when they want, and with whom they want. Automobile travel is the most popular form of personal transportation. The 2001 National Household Travel Survey (NHTS) found that there is nearly one vehicle (0.97) for every person 16 years and older in the United States. The NHTS also found that 87 percent of daily trips were taken by personal vehicle. In the United States, the highway network is the principal mode of choice for the vast majority of personal travel.

Q&A

What are some challenges in ensuring that the Nation's highways, bridges, and tunnels are secure from terrorist threats?

Many of the qualities of the Nation's highway system described in Chapter 2 of this report make it vulnerable to terrorist threats, namely that it is vast, open, and accessible. Additionally, much of the Nation's infrastructure is owned and operated by State and local governments, and a small percentage is privately owned. These owners are primarily responsible for implementing effective security strategies with support from the Federal government. Some of the most effective security strategies—such as retrofitting existing structures—can be very expensive.

The ultimate challenge is to "harden" or retrofit existing structures and design new structures to handle terrorist-induced loadings. Today, the necessary technology either does not exist or is at a very premature stage; further, highway infrastructure varies in design and location. There is no "one size fits all" solution.

Transit also enhances personal mobility. The 2001 NHTS estimates that 43 percent of transit riders live in households with incomes of less than $20,000 and that 44 percent come from households without cars.

Transit helps people without cars take advantage of a wider range of jobs and educational opportunities, and access health care and other vital services.

> **What are some challenges in ensuring that the Nation's transit systems are secure from terrorist threats?** Q&A
>
> Americans take more than 10.3 billion transit trips each year. With such high concentrations of people in small spaces, transit systems in the United States are a target for terrorists as they have been globally. Because transportation systems must remain accessible, convenient, and inexpensive for the traveling public, the transit industry and the Federal government must employ innovative ways to prevent terrorist activity in the Nation's transit systems.

Transit use is not, however, limited to those who cannot afford private automobiles. Many people who use transit are choice riders who come from households that own cars, but prefer transit for certain trips because it offers a more convenient and less expensive alternative. A high-quality transit system, in particular, allows people living in dense urban environments to limit their automobile use without sacrificing their mobility.

Commercial Freight Transportation

The Nation's surface transportation system plays an essential role in moving freight. While railroads move a substantial amount of the country's freight, most goods are moved by truck over the Nation's highways. According to the Federal Highway Administration's (FHWA's) Freight Analysis Framework, trucks carried over 60 percent of the weight and two-thirds the value of all goods shipments in 2006.

American consumers rely on the freight network to receive finished products, and businesses in every sector of the domestic economy depend on raw materials and supplies moved over the Nation's highways. Increasingly, the Nation's international competitiveness is linked to the performance of its freight network—how efficiently goods can be moved between ports and distribution points in the Nation's interior. Since 1970, imports to the United States have tripled and exports have doubled, when measured against the value of the Gross Domestic Product.

The Nation's trade with other countries is changing. While the countries of Western Europe remain strong trading partners, there is increasing commerce with Canada, Japan, Mexico, and rapidly growing Asian nations such as China and India. As commerce grows with more distant countries, the length that shipments must travel between origin and destination also increases. This makes it even more important to efficiently move cargo through seaports and along freight corridors. The Nation's top 20 international freight gateways move more than $2.6 trillion worth of goods, and many are located in the country's fast-growing urban areas, as estimated in the FHWA's Freight Analysis Framework. As development occurs around these freight gateways, trucks must deal with increased traffic, as well as homeland security requirements.

While the Nation's public transit systems move passengers and not goods, transit can affect the efficiency of the freight network. Providing transit as an option for potential drivers can help to reduce overall traffic volume and free up highway capacity for freight movement.

Developing Markets and Communities

Transportation plays an essential role in developing new markets and communities. In the Nineteenth Century, waterways and railroads allowed entrepreneurs to access isolated places like the South and West. During the Twentieth Century, paved roads and Interstate highways extended low-cost automobile and truck transportation across the entire continent. Transit broadened the reach of cities by allowing people to commute to central cities along trolley and rail lines.

Today, new trade corridors have the potential to transform undeveloped parts of the country. In the ten years after the enactment of the North American Free Trade Agreement (NAFTA), the U.S. Department of Commerce estimates that total trade between the United States and Canada and Mexico grew by 111 percent. Trade not only generates jobs in manufacturing plants and distribution centers along these corridors, but also leads to new homes and shopping centers as people move to communities where there are jobs.

Transit plays a critical role in developing new markets and communities. Planners have long recognized that corridors with well-functioning transit systems accommodate retailers, restaurants, theatres, and high-density housing development. Over the past two decades, an increasing number of communities have collected around transit lines, hoping to reduce the need for automobile travel and related congestion and environmental impacts.

National Defense and Homeland Security

Highways and transit systems play an important role in protecting the American public, although in different ways. The Nation's highway system is essential for much of the Nation's military mobilization. During Operations Desert Storm and Desert Shield in the early 1990s, for example, more than 3.5 million tons of combat-related material and supplies for military personnel were moved throughout the United States.

Q&A

What is the Federal Highway Administration's transportation security mission?

In collaboration with the Department of Homeland Security/Transportation Security Administration (DHS/TSA), other Federal agencies, States, local governments, and the private sector, FHWA works to secure highway system integrity and performance by providing subject matter expertise, facilitating communications, and coordinating and conducting research and development, technical assistance, and training.

Q&A

What is the Federal Transit Administration's (FTA's) transportation security mission?

The mission of the FTA Office of Safety and Security is to provide leadership and vision in the development and management of programs and initiatives to continually improve the safety and security of passengers, employees, emergency responders, and all others who come into contact with the public transportation system.

The Office of Safety and Security accomplishes its mission through:

- Developing polices, requirements, and guidelines for transit oversight as authorized by Federal statute
- Implementing two Congressionally mandated regulatory programs: Substance Abuse Management and State Safety Oversight of Rail Fixed Guideway Systems
- Developing and overseeing the implementation of strategic long-term FTA safety, security, and emergency management programs
- Managing national safety, security, and emergency management training programs
- Coordinating safety, security, and emergency management plans, programs, and activities within FTA and DOT and with other Federal partners (including DHS) and the transit industry
- Formulating, overseeing, and managing technical assistance and demonstration programs.

This mission includes coordination with TSA on provisions outlined in the legislation Implementing Recommendations of the 9/11 Commission Act of 2007 (HR1).

Highways and transit routes can save lives in an emergency, whether a natural disaster or a terrorist incident. The highway network must have the capability to accommodate police, fire, and rescue vehicles at a moment's notice. Highways and transit lines must also accommodate evacuations. According to the U.S. Nuclear Regulatory Commission, a large-scale evacuation of at least 1,000 people occurred in the United States every three weeks between 1990 and 2003.

The Complementary Relationship of Highways and Transit

The Nation's surface transportation system is a network of public and private elements that interact to provide service for the American people. Highways and transit are complementary, serving distinct but overlapping markets in the Nation's transportation system. Highways serve both rural and urban communities in the United States, while transit is more widespread in dense urban areas. Investment in both modes of transportation, however, expands travel choices for the American people, allowing them to use the travel options that best meet their needs.

Highway investment not only benefits automobile users, but transit riders as well, since a significant portion of public transportation takes place on the Nation's highways. Buses, vanpools, and demand response services typically share highways with private automobiles, so better pavement quality and traffic conditions benefit transit operations. Conversely, automobile users may decide to use public transit when there is improvement in transit services, freeing up capacity on highways. Automobile users may also choose more frequent use of transit at times when gas prices increase significantly, making transit a more economical option. Transit can also increase the effectiveness of highways by supporting carpools, and by serving as a backup mode for riders when carpools do not meet their needs.

An area served by both a good road network and effective transit service is likely to be more attractive to companies than one served by transit or highways alone. Good highway access to transit stations in outlying areas—such as park-and-ride lots—increases the accessibility of transit and expands its use to a broader group of people than would be possible if access were limited to walking, biking, or other modes of public transportation. According to the 2001 NHTS, over 3.4 billion vehicle trips are made annually to access other modes of transportation.

Chapter 2

System Characteristics

Highway System Characteristics

The Nation's highway system is an extensive network of roadways that facilitates the movement of people and goods and supports the growth of the national economy by providing access to national and international markets. The system supports the defense of the Nation by providing the means for the rapid deployment of military forces and their support systems.

This section examines the characteristics of the Nation's roadways, addressing ownership, purpose, and usage. This information is presented for the National Highway System (NHS), including its Interstate highway system component, and for the overall highway system.

Subsequent sections within this chapter explore the characteristics of bridges and transit systems. These are followed by a section comparing key statistics from the highway, bridge, and transit sections with the information presented in the previous edition of this report.

Roads by Ownership

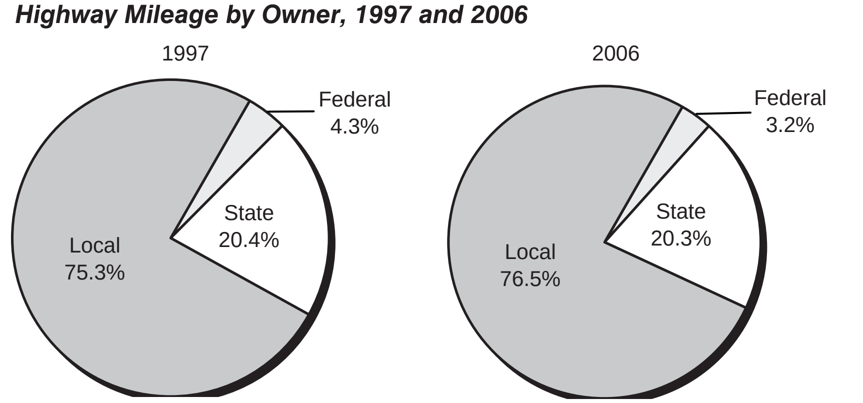
Ownership is largely split among the Federal, State, and local governments. Roads owned by these governments are considered "public." States own slightly over 20 percent of the Nation's public road mileage. The Federal government controls approximately 3.2 percent, primarily in National Parks and Forests, on Indian reservations, and on military bases. In 2006, approximately 76.5 percent of American roads were locally owned. In general, owners construct and maintain the roads with the aid of substantial financial assistance from other levels of government; some intergovernmental agreements authorize States to directly construct and maintain locally owned highways under certain conditions.

As *Exhibit 2-1* demonstrates, the share of locally owned roads grew slightly over the past decade. The share of local public road mileage increased from 75.3 to 76.5 percent between 1997 and 2006. During that same period, the share of State-owned public road mileage remained mostly constant at 20.4 percent in 1997 and 20.3 percent in 2006.

The share of Federally owned public road mileage declined from 4.3 percent in 1997 to 3.2 percent in 2006. This drop can be attributed to the decision not to count country forest development roads as public roads in 1998. As such, Federal, rural area road mileage decreased significantly between 1997 and 2000. Federal road mileage reached a peak in 1984, when 7 percent of all public roads were owned by the Federal government, and has steadily decreased since then. Much of the change occurred as the result of Federal land management agencies reclassifying some of their mileage from public to nonpublic status.

Exhibit 2-1

Highway Mileage by Owner, 1997 and 2006



Source: Highway Performance Monitoring System.

Roads by Ownership and Size of Area

All roads are designated as urban or rural. Urban areas have two subsets, the small urban areas that include populations of 5,000 to 49,999 and urbanized areas that include populations over 50,000. All other areas outside of a population's urban or small urban areas are designated rural.

In 2006, the highway system in the Nation was composed of over 4.03 million miles, compared with slightly less than 4 million miles in 2004. Highway mileage in urban areas has continued to increase in recent years, accompanied by a decrease in rural mileage. This trend is depicted in *Exhibit 2-2,* which shows that total mileage in small urban areas grew by an average annual rate of 0.9 percent between 1997 and 2006. In larger urbanized areas, 50,000 or more in population, the annual growth was 2.6 percent between 1997 and 2006. In rural areas, however, highway miles decreased at an average annual rate of 0.4 percent over the same time period.

Two factors contributed to the apparent increase in urban highway mileage, in addition to the construction of new roads. First, the ramifications of the redefinition of urban boundaries based on the 2000 decennial census continued to have an impact as States continue the work to establish new urban boundaries. This work resulted in an expansion of urban areas, and thus some mileage formerly classified as rural is now contained in urban areas. Second, greater focus has been placed on Federal agencies to provide a more complete reporting of Federally owned mileage. As a result, Federal mileage in urban areas increased significantly based on more accurate reporting of Department of Defense mileage on military bases within urban areas.

Exhibit 2-2

Highway Miles by Owner and by Size of Area, 1997–2006

	1997	2000	2001	2002	2004	2006	Annual Rate of Change 2006/1997
Rural Areas (under 5,000 in population)							
Federal	167,368	116,707	119,291	117,775	118,866	123,393	-3.3%
State	661,473	663,763	665,095	664,814	683,789	669,678	0.1%
Local	2,280,042	2,308,842	2,294,691	2,295,006	2,200,786	2,197,410	-0.4%
Subtotal Rural Areas	**3,108,883**	**3,089,312**	**3,079,077**	**3,077,595**	**3,003,441**	**2,990,482**	**-0.4%**
Small Urban Areas (5,000–49,999 in population)							
Federal	482	458	662	980	723	831	4.6%
State	27,455	27,596	27,347	27,639	30,719	36,893	1.3%
Local	143,848	148,094	152,651	154,869	155,406	160,009	0.9%
Subtotal Small Urban Areas	**171,785**	**176,148**	**180,660**	**183,488**	**186,848**	**197,733**	**0.9%**
Urbanized Areas (50,000 or more in population)							
Federal	980	1,026	1,573	1,840	2,847	4,157	17.4%
State	83,428	83,944	83,134	84,135	101,881	113,160	3.4%
Local	587,426	597,837	618,821	632,025	702,446	727,476	2.4%
Subtotal Urbanized Areas	**671,834**	**682,807**	**703,527**	**718,000**	**807,173**	**844,794**	**2.6%**
Total Highway Miles							
Federal	168,830	118,191	121,525	120,595	122,436	128,381	-3.0%
State	772,356	775,303	775,576	776,588	816,388	819,731	0.7%
Local	3,011,316	3,054,773	3,066,163	3,081,900	3,058,638	3,084,896	0.3%
Total	**3,952,502**	**3,948,267**	**3,963,264**	**3,979,083**	**3,997,462**	**4,033,008**	**0.2%**
Percentage of Total Highway Miles							
Federal	4.3%	3.0%	3.0%	3.0%	3.1%	3.2%	
State	19.5%	19.6%	19.6%	19.5%	20.4%	20.3%	
Local	76.2%	77.4%	77.4%	77.5%	76.5%	76.5%	
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	

Source: Highway Performance Monitoring System as of January 2008.

Highways by Purpose

Another way to categorize roads is by purpose, which is commonly called functional classification. The Highway Functional Classification System (HFCS) is the basic organization used for most of this report. *Exhibit 2-3* shows the hierarchy of the HFCS pictorially.

Review of Functional Classification Concepts

The functional classification system results from grouping highways by the type of service they provide and recognizing that each road or street doesn't stand alone, but is interconnected, as a network for travel between other roads. Each segment of road other than the lowest classification (local) should connect at both ends only to another segment functionally classified at an equal or higher level. Exceptions to this principle typically occur because of unusual geographic or traffic conditions (e.g., connections to international borders, coastal cities, waterports, and airports).

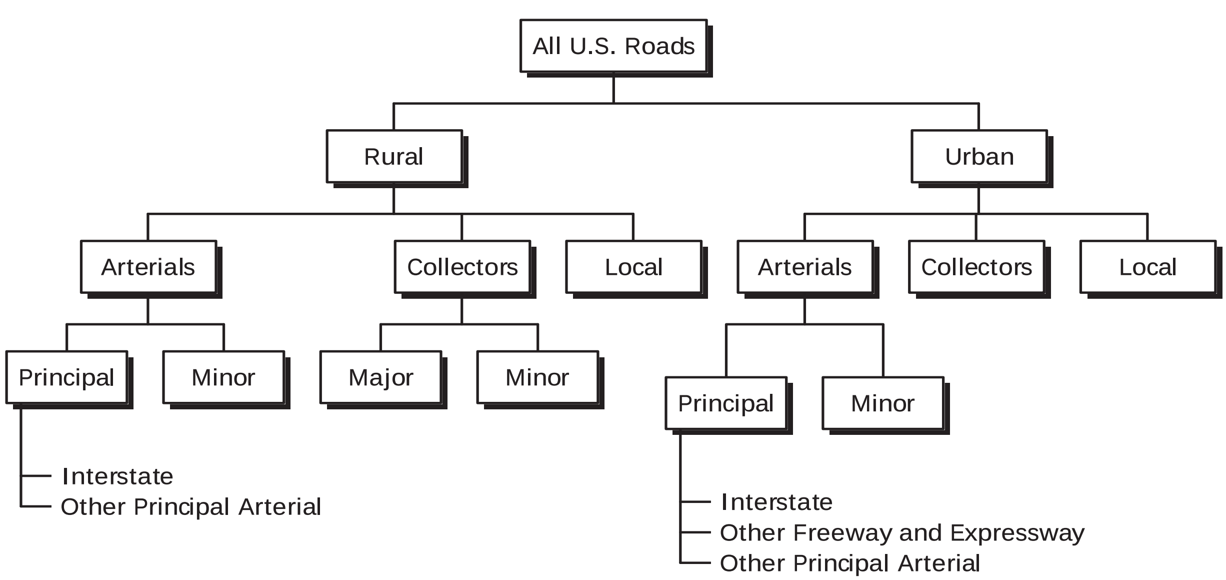
Roads serve two important functions: access and mobility. The better any individual segment is serving one of these functions, the worse it is at serving the other. Thus, routes on the Interstate Highway System allow a driver to travel long distances in a relatively short time, but do not allow the driver to enter each farm field or business along the way. Contrarily, a subdivision street allows a driver access to any address along its length, but does not allow the driver to travel at a high rate of speed and is frequently interrupted by intersections, often containing traffic control devices.

Arterials provide the highest level of mobility, at the highest speed, for long and uninterrupted travel. Arterials typically have higher design standards than other roads. They often include multiple lanes and have some degree of access control.

The rural arterial system provides interstate and intercounty service so that all developed areas are within a reasonable distance of an arterial highway. This system is broken down into principal and minor routes, of which principal roads are more significant. Virtually all urbanized areas with more than 50,000 people, and most urban areas with more than 25,000 people, are connected by rural principal arterial highways. **The rural principal arterial system is divided into two subgroups: Interstate highways and other principal arterials.**

Exhibit 2-3

Highway Functional Classification System Hierarchy



Source: FHWA Functional Classification Guidelines.

Similarly, in urban areas the arterial system is divided into principal and minor arterials. **The urban principal arterial system is the most important group; it includes (in descending order of importance) Interstate highways, other freeways and expressways, and other principal arterials.** The urban principal arterial system serves major metropolitan centers, corridors with the highest traffic volume, and those with the longest trip lengths. It carries most trips entering and leaving metropolitan areas and provides continuity for rural arterials that cross urban boundaries. Urban minor arterial routes provide service for trips of moderate length at a lower level of mobility. They connect with the urban principal arterial system and other minor arterial routes.

Collectors provide a lower degree of mobility than arterials. They are designed for travel at lower speeds and for shorter distances. Generally, collectors are two-lane roads that collect travel from local roads and distribute it to the arterial system.

The rural collector system is stratified into two subsystems: major and minor collectors. Major collectors serve larger towns not accessed by higher-order roads, and important industrial or agricultural centers that generate significant traffic but are not served by arterials. Rural minor collectors are typically spaced at intervals consistent with population density to collect traffic from local roads and to ensure that a collector road serves all small urban areas.

In urban areas, the collector system provides traffic circulation within residential neighborhoods and commercial and industrial areas. Unlike arterials, collector roads may penetrate residential communities, distributing traffic from the arterials to the ultimate destination for many motorists. Urban collectors also channel traffic from local streets onto the arterial system. Unlike rural collectors, the urban collector system has no subclassification.

Local roads represent the largest element in the American public road system in terms of mileage. For rural and urban areas, all public road mileage below the collector system is considered local. Local roads provide basic access between residential and commercial properties, connecting with higher-order highways.

Federal-Aid Highways

The term "Federal-aid highways" is defined as highways on the Federal-aid highway systems and all other public roads not functionally classified as rural minor collector, rural local, or urban local. Federal-aid highway systems are defined as the Dwight D. Eisenhower National System of Interstate and Defense Highways (the "Interstate System") and the NHS, which includes the Interstate System as a subset.

While the system characteristics information presented in this chapter is available for all functional classes, some data pertaining to system conditions and performance presented in other chapters are not collected from States through the Highway Performance Monitoring System (HPMS) for roads classified as rural minor collector, rural local, or urban local. Consequently, some data presented in other chapters apply to Federal-aid highways only.

Q&A

Are the 2006 HPMS data cited in this report fully consistent with those reported in the *Highway Statistics 2006* publication?

No. As the HPMS data submitted by the States are reviewed for omissions or inconsistencies, revisions are submitted by the States. The statistics reflected in this report are based on the latest available 2006 HPMS data as of the date the chapters were written, and include revisions that were not reflected in the *Highway Statistics 2006* publication.

The HPMS database is subject to further change on an ongoing basis if other States identify a need to revise their data. Such changes will be reflected in the next edition of the C&P report.

Additional information on HPMS is available at: http://www.fhwa.dot.gov/policy/ohpi/hpms/index.htm.

System Characteristics for All Functional Classes

Exhibit 2-4 summarizes the percentage of highway miles, lane miles, and vehicle miles traveled (VMT) for 2006 stratified by functional system and by population area. There are three categories for population areas: rural, small urban, and urbanized. Rural areas have populations of less than 5,000, small urban areas have populations between 5,000 and 49,999, and urbanized areas have populations of 50,000 or more. Urbanized areas are further divided into four segments, including small urbanized, 50,000 to 499,999 in population; medium urbanized, 500,000 to 999,999; large urbanized, 1 million to 3 million; and very large urbanized, over 3 million.

In 2006, 74.2 percent of the Nation's highway mileage and 72.3 percent of lane miles were located in rural areas. In contrast, only 33.7 percent of the VMT occurred in rural areas.

Small urban and small urbanized functional system areas made up only 4.9 percent and 7.7 percent of the highway mileage in the Nation, but carry 8.2 and 16.2 percent of the VMT. In 2006, medium urbanized areas consisted of 2.8 percent of the highway mileage, 3.0 percent of the lane miles, and 7.9 percent of the VMT.

In the Nation's most populated areas, the large urbanized and very large urbanized areas, highway mileage accounted for only 4.4 percent and 6.0 percent of the Nation's total highway mileage, but carried an overwhelming 13.2 and 20.8 percent of the Nation's VMT, respectively.

Exhibit 2-5 shows the total public road route mileage in the United States. In 2006, there were slightly more than 4.03 million route miles in the United States. Route miles are the length of a roadway. Approximately 74.2 percent of this mileage, or just over 2.99 million route miles, was in rural areas.

Exhibit 2-4

Percentage of Highway Miles, Lane Miles, and VMT by Functional System and by Size of Area, 2006

Functional System	Miles	Lane Miles	VMT
Rural Areas (less than 5,000 in population)			
Interstate	0.8%	1.5%	8.4%
Other Principal Arterial	2.4%	2.9%	7.5%
Minor Arterial	3.4%	3.3%	5.3%
Major Collector	10.4%	10.0%	6.3%
Minor Collector	6.5%	6.2%	1.9%
Local	50.8%	48.4%	4.3%
Subtotal Rural Areas	74.2%	72.3%	33.7%
Small Urban Areas (5,000–49,999 in population)			
Interstate	0.1%	0.1%	1.5%
Other Freeway and Expressway	0.0%	0.1%	0.7%
Other Principal Arterial	0.3%	0.5%	2.2%
Minor Arterial	0.5%	0.6%	1.7%
Collector	0.6%	0.6%	0.9%
Local	3.3%	3.2%	1.2%
Subtotal Small Urban Areas	4.9%	5.0%	8.2%
Small Urbanized Areas (50,000–499,999 in population)			
Interstate	0.1%	0.3%	3.3%
Other Freeway and Expressway	0.1%	0.2%	1.5%
Other Principal Arterial	0.5%	0.8%	4.1%
Minor Arterial	0.8%	0.9%	3.3%
Collector	0.8%	0.8%	1.6%
Local	5.5%	5.2%	2.5%
Subtotal Small Urbanized Areas	7.7%	8.2%	16.2%
Medium Urbanized Areas (500,000–999,999 in population)			
Interstate	0.1%	0.2%	2.3%
Other Freeway and Expressway	0.0%	0.1%	0.7%
Other Principal Arterial	0.1%	0.3%	1.6%
Minor Arterial	0.3%	0.3%	1.5%
Collector	0.3%	0.3%	0.7%
Local	2.0%	1.9%	1.2%
Subtotal Medium Urbanized Areas	2.8%	3.0%	7.9%
Large Urbanized Areas (1 million–3 million in population)			
Interstate	0.1%	0.2%	3.9%
Other Freeway and Expressway	0.1%	0.1%	1.7%
Other Principal Arterial	0.2%	0.4%	2.6%
Minor Arterial	0.4%	0.6%	2.4%
Collector	0.4%	0.5%	1.1%
Local	3.2%	3.1%	1.5%
Subtotal Large Urbanized Areas	4.4%	4.8%	13.2%
Very Large Urbanized Areas (more than 3 million in population)			
Interstate	0.1%	0.3%	5.3%
Other Freeway and Expressway	0.1%	0.2%	2.9%
Other Principal Arterial	0.4%	0.7%	4.9%
Minor Arterial	0.6%	0.8%	3.7%
Collector	0.6%	0.6%	1.6%
Local	4.3%	4.1%	2.4%
Subtotal Very Large Urbanized Areas	6.0%	6.6%	20.8%
Total	100.0%	100.0%	100.0%

Source: Highway Performance Monitoring System.

The remaining 25.8 percent of route mileage, or approximately 1.04 million miles, was in small urban and urbanized communities.

Overall route mileage increased by an average annual rate of about 0.2 percent between 1997 and 2006. On an average annual basis, mileage decreased by 0.5 percent in rural America and increased by 1.6 percent in small urban communities and by 2.6 percent in urbanized areas from 1997 to 2006.

Between 2004 and 2006, route mileage decreased in rural areas by 13,177 miles. Route mileage in small urban and urbanized areas during the same period increased by 10,788 miles and 36,938 miles, respectively. **It must be noted that the results of the 2000 census are still impacting the reporting of the distribution of mileage, lane miles, and VMT in all population areas (rural, small urban, and urbanized). The adjustment of the boundaries for these areas, rather than the construction of new roads, is the primary reason for the changes in the reported data.**

Exhibit 2-5

Highway Route Miles by Functional System and by Size of Area, 1997–2006

Functional System	1997	2000	2002	2004	2006	Annual Rate of Change 2006/1997
Rural Areas (less than 5,000 in population)						
Interstate	32,919	33,152	33,107	31,477	30,615	-0.8%
Other Principal Arterial	98,358	99,023	98,945	95,998	95,009	-0.4%
Minor Arterial	137,791	137,863	137,855	135,683	135,589	-0.2%
Major Collector	433,500	433,926	431,754	420,293	419,289	-0.4%
Minor Collector	273,043	272,477	271,371	268,088	262,966	-0.4%
Local	2,141,111	2,115,293	2,106,725	2,051,902	2,046,796	-0.5%
Subtotal Rural Areas	**3,116,722**	**3,091,733**	**3,079,757**	**3,003,441**	**2,990,264**	**-0.5%**
Small Urban Areas (5,000–49,999 in population)						
Interstate	1,744	1,794	1,808	2,088	2,211	2.7%
Other Freeway and Expressway	1,253	1,219	1,227	1,218	1,207	-0.4%
Other Principal Arterial	12,477	12,474	12,590	13,532	14,048	1.3%
Minor Arterial	19,635	19,800	19,926	19,956	21,245	0.9%
Collector	21,338	21,535	21,813	23,706	25,209	1.9%
Local	115,420	119,342	126,140	126,348	133,716	1.6%
Subtotal Small Urban Areas	**171,867**	**176,163**	**183,503**	**186,848**	**197,636**	**1.6%**
Urbanized Areas (50,000 or more in population)						
Interstate	11,651	11,729	11,832	13,270	14,066	2.1%
Other Freeway and Expressway	7,864	7,977	8,150	9,087	9,610	2.3%
Other Principal Arterial	40,993	41,084	41,090	46,556	49,132	2.0%
Minor Arterial	70,050	70,502	70,996	78,491	82,433	1.8%
Collector	67,312	67,263	68,033	79,680	84,430	2.5%
Local	474,044	484,650	518,309	580,088	604,440	2.7%
Subtotal Urbanized Areas	**671,914**	**683,205**	**718,409**	**807,173**	**844,111**	**2.6%**
Total Highway Route Miles	**3,960,503**	**3,951,101**	**3,981,670**	**3,997,462**	**4,032,011**	**0.2%**

Source: Highway Performance Monitoring System.

Exhibit 2-6 shows the number of highway lane miles by functional system and by population area. Highway lane miles are the length of the roadway multiplied by the number of lanes on that roadway section. In 2006, there were 8.46 million lane miles in the United States. Lane miles have grown at an average annual rate of about 0.2 percent since 1997, mostly in urban areas (lane miles in rural areas decreased overall by 0.5 percent per year during the same time period). Between 1997 and 2006, lane miles grew annually by 1.6 percent in small urban areas and by 2.6 percent in urbanized areas.

Exhibit 2-6

Highway Lane Miles by Functional System and by Size of Area, 1997–2006

Functional System	1997	2000	2002	2004	2006	Annual Rate of Change 2006/1997
Rural Areas (less than 5,000 in population)						
Interstate	133,573	135,000	135,032	128,012	124,506	-0.8%
Other Principal Arterial	248,921	253,586	256,458	249,480	248,334	0.0%
Minor Arterial	288,872	287,750	288,391	283,173	282,397	-0.3%
Major Collector	875,393	872,672	868,977	845,513	843,262	-0.4%
Minor Collector	546,085	544,954	542,739	536,177	525,932	-0.4%
Local	4,282,222	4,230,588	4,213,448	4,103,804	4,093,592	-0.5%
Subtotal Rural Areas	**6,375,066**	**6,324,550**	**6,305,044**	**6,146,159**	**6,118,023**	**-0.5%**
Small Urban Areas (5,000–49,999 in population)						
Interstate	7,365	7,626	7,776	8,890	9,309	2.6%
Other Freeway and Expressway	4,747	4,627	4,685	4,754	4,714	-0.1%
Other Principal Arterial	37,618	37,806	38,275	41,015	42,896	1.5%
Minor Arterial	44,982	45,212	45,682	45,335	48,380	0.8%
Collector	44,216	44,525	45,095	48,977	51,985	1.8%
Local	230,839	238,684	252,279	252,697	267,433	1.6%
Subtotal Small Urban Areas	**369,767**	**378,482**	**393,793**	**401,667**	**424,717**	**1.6%**
Urbanized Areas (50,000 or more in population)						
Interstate	65,603	67,020	68,088	75,127	79,727	2.2%
Other Freeway and Expressway	36,655	37,428	38,782	43,016	45,491	2.4%
Other Principal Arterial	146,585	149,224	150,250	169,491	178,726	2.2%
Minor Arterial	185,273	184,199	187,512	205,434	221,532	2.0%
Collector	145,927	145,313	147,020	171,201	183,255	2.6%
Local	948,087	969,300	1,036,619	1,160,175	1,208,881	2.7%
Subtotal Urbanized Areas	**1,528,130**	**1,552,484**	**1,628,271**	**1,824,444**	**1,917,612**	**2.6%**
Total Highway Lane Miles	**8,272,963**	**8,255,516**	**8,327,108**	**8,372,270**	**8,460,352**	**0.2%**

Source: Highway Performance Monitoring System.

Highway Travel

This section describes highway infrastructure use, which is typically defined by VMT. During the last decade, Americans traveled at record levels, a phenomenon prompted by the booming economy, population growth, and other socioeconomic factors. As *Exhibit 2-7* shows, VMT grew at an average annual rate of 1.9 percent between 1997 and 2006. By the end of that period, Americans were traveling just over 3 trillion vehicle miles annually. Slightly over 1 trillion vehicle miles were on rural highways, and almost 2.0 trillion vehicle miles were in small urban and urbanized areas.

While highway mileage is mostly rural, a majority of highway travel (approximately 65.7 percent) occurred in urban areas in 2006. The average annual rate of change for rural travel was 0.4 percent between 1997 and 2006. For the same period, the average annual rate of change in small urban areas was 1.7 percent and in urbanized areas was 2.9 percent. **Again, it must be noted, that portions of these increases are the**

result of the expansion of the boundaries of these areas due to the results of the 2000 census and the inclusion of travel that was previously recorded in the rural category.

Exhibit 2-7 shows from 2004 to 2006, in rural areas, travel grew slightly on local roadways but the highest VMT in rural areas was still on the Interstate System. During the same period, the highest growth in travel in small urban areas was on collectors with an increase of 9.9 percent between 2004 and 2006. The greatest amount of travel was on other principal arterials in small urban areas. For urbanized areas, the greatest percentage of growth was on collectors with an increase of 6.3 percent from 2004 to 2006, followed by Interstates, 5.1 percent, and other freeways and expressways, 4.9 percent. The most travel in urbanized areas was on the Interstate System.

Exhibit 2-7

Vehicle Miles Traveled (VMT) and Passenger Miles Traveled (PMT), 1997–2006

	(Millions of Miles)					Annual Rate of Change
Functional System	**1997**	**2000**	**2002**	**2004**	**2006**	**2006/1997**
Rural Areas (less than 5,000 in population)						
Interstate	241,451	269,533	281,461	267,397	258,324	0.8%
Other Principal Arterial	229,133	249,177	258,009	241,282	232,224	0.1%
Minor Arterial	164,129	172,772	177,139	169,168	162,889	-0.1%
Major Collector	202,588	210,595	214,463	200,926	193,423	-0.5%
Minor Collector	52,809	58,183	62,144	60,278	58,229	1.1%
Local	113,248	127,560	139,892	132,474	133,378	1.8%
Subtotal Rural Areas	**1,003,358**	**1,087,820**	**1,133,107**	**1,071,524**	**1,038,467**	**0.4%**
Small Urban Areas (5,000–49,999 in population)						
Interstate	18,393	21,059	22,578	25,784	26,448	4.1%
Other Freeway and Expressway	9,251	9,892	10,442	10,245	9,753	0.6%
Other Principal Arterial	55,359	58,170	59,490	61,426	63,172	1.5%
Minor Arterial	40,845	43,035	44,566	41,961	44,643	1.0%
Collector	19,749	20,412	21,492	21,761	23,915	2.1%
Local	30,368	33,277	34,241	33,439	34,759	1.5%
Subtotal Small Urban Areas	**173,965**	**185,845**	**192,808**	**194,616**	**202,691**	**1.7%**
Urbanized Areas (50,000 or more in population)						
Interstate	346,376	376,116	389,903	433,982	456,229	3.1%
Other Freeway and Expressway	151,231	168,293	180,199	198,840	208,658	3.6%
Other Principal Arterial	332,448	343,186	351,436	392,442	407,250	2.3%
Minor Arterial	263,296	283,854	297,393	323,846	335,426	2.7%
Collector	111,874	116,596	122,129	142,569	151,600	3.4%
Local	176,268	202,774	207,480	224,178	233,635	3.2%
Subtotal Urbanized Areas	**1,381,495**	**1,490,819**	**1,548,540**	**1,715,857**	**1,792,799**	**2.9%**
Total VMT	**2,558,818**	**2,764,484**	**2,874,455**	**2,981,998**	**3,033,957**	**1.9%**
Total PMT	**4,089,366**	**4,390,076**	**4,667,038**	**4,832,394**	**4,933,689**	**2.1%**

Sources: VMT data from Highway Performance Monitoring System; PMT data from Highway Statistics, Table VM-1, various years.

Exhibits 2-9 and *2-10* expand on the information in *Exhibit 2-7*. They depict highway travel by functional classification and vehicle type. Three types of vehicles are identified: passenger vehicles which include buses and light trucks (2-axle, 4-tire models); single-unit trucks having 6 or more tires; and combination trucks, including trailers and semitrailers. The totals in *Exhibit 2-9* include all vehicles, whereas those in *Exhibit 2-10* exclude motorcycles.

What has happened to highway travel since 2006?

The December 2007 Traffic Volume Trends (TVT) report showed a decline of 0.4 percent in highway travel between 2006 and 2008. Travel dropped from 3,014.0 billion vehicle miles of travel (VMT) in 2006 to 3,003.2 billion VMT in 2007.

The decline in VMT has continued in 2008. The June 2008 TVT report describes the percentage change in cumulative monthly travel for all highway systems for the first half of 2007 compared with the first half of 2008. This report shows a 2.8 percent decline.

Exhibit 2-8 , which is shown below, compares the traffic volume for different elements of the road network at comparable points in 2006 and 2008. The greatest decline occurred on lower-level rural roads.

For additional information on ongoing traffic trends, visit http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm.

Exhibit 2-8

Cumulative Travel on Public Roads During the First Two Quarters of 2006 and 2008 (Million Miles)

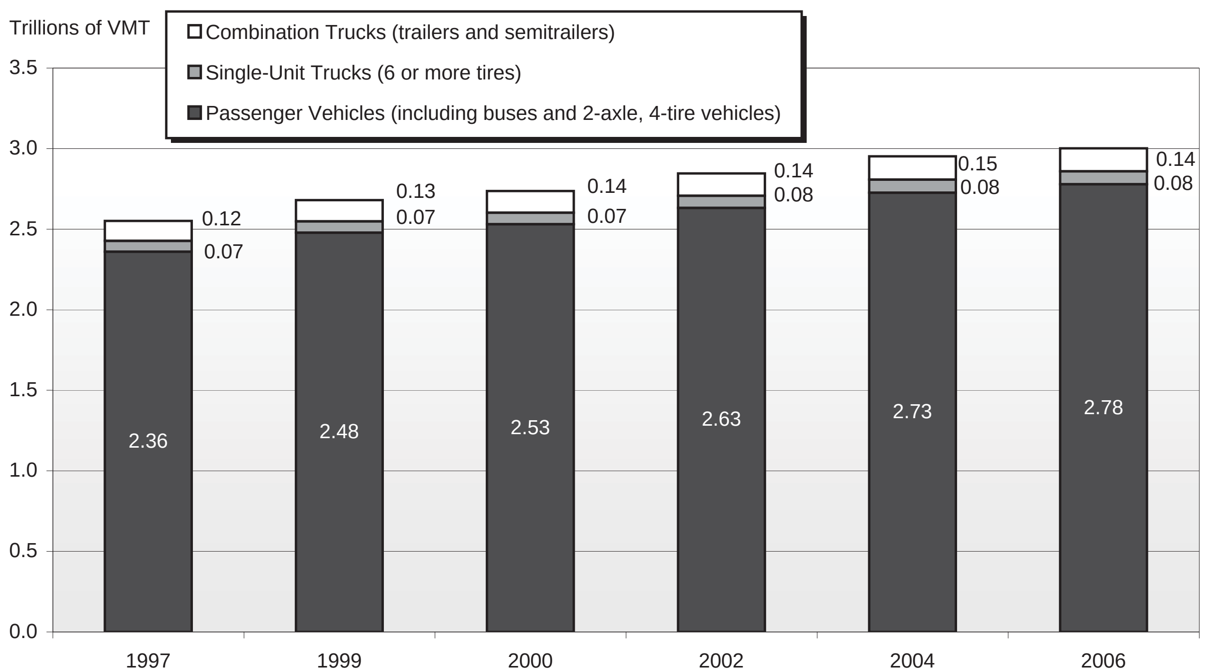
	Urban			Rural			
Year	**Interstates**	**Other Arterials**	**Other Roads**	**Interstates**	**Other Arterials**	**Other Roads**	**Total**
2006	238,072	528,047	216,528	124,508	190,993	189,866	**1,488,014**
2008*	231,122	510,728	211,543	120,585	185,127	179,618	**1,438,723**
% Change from 2006	-2.9	-3.3	-2.3	-3.2	-3.1	-5.4	**-3.3**

** Preliminary data.*

Source: Travel Monitoring Analysis System (TMAS).

Exhibit 2-9

Highway Travel by Vehicle Type, 1997 – 2006



Source: Highway Statistics, Table VM-1, various years.

From 1997 to 2006, travel among all vehicle types and on all functional classifications grew fastest among single-unit trucks, at an average annual rate of 2.1 percent. Passenger vehicle travel grew by 1.8 percent per year, and combination truck traffic grew by 1.5 percent per year over the same period. While vehicle travel by single-unit and combination trucks is small compared with passenger vehicle travel across all highways, trucks account for 12.5 percent of vehicle travel on the Interstate System and 20 percent on rural Interstates.

Exhibit 2-10

Highway Travel by Functional System and by Vehicle Type, 1997–2006

Functional System Vehicle Type	(Millions of Miles) 1997	2000	2002	2004	2006	Annual Rate of Change 2006/2004	Annual Rate of Change 2006/1997
Rural Interstate							
PV	189,869	214,532	224,375	211,369	205,103	-1.5%	0.9%
SU	7,671	8,236	8,745	8,548	7,674	-5.3%	0.0%
Combo	41,665	44,248	45,633	45,754	43,711	-2.3%	0.5%
Other Arterial							
PV	351,313	377,270	389,758	365,951	353,245	-1.8%	0.1%
SU	13,688	13,644	14,606	14,771	13,835	-3.2%	0.1%
Combo	25,505	28,005	27,818	27,817	25,791	-3.7%	0.1%
Other Rural							
PV	341,323	366,433	383,724	361,080	353,886	-1.0%	0.4%
SU	13,698	13,722	14,963	15,611	15,084	-1.7%	1.1%
Combo	12,471	12,555	14,090	15,035	13,990	-3.5%	1.3%
Total Rural							
PV	882,505	958,235	997,857	938,400	912,234	-1.4%	0.4%
SU	35,057	35,602	38,314	38,930	36,593	-3.0%	0.5%
Combo	79,641	84,808	87,541	88,606	83,492	-2.9%	0.5%
Urban Interstate							
PV	331,343	359,592	373,957	415,254	435,043	2.4%	3.1%
SU	7,906	8,716	9,106	10,512	10,301	-1.0%	3.0%
Combo	20,643	23,465	23,887	26,481	29,430	5.4%	4.0%
Other Urban							
PV	1,146,289	1,213,109	1,259,859	1,372,307	1,431,401	2.1%	2.5%
SU	23,930	26,182	28,467	31,665	33,436	2.8%	3.8%
Combo	24,300	26,747	27,215	30,310	29,784	-0.9%	2.3%
Total Urban							
PV	1,477,632	1,572,701	1,633,816	1,787,561	1,866,444	2.2%	2.6%
SU	31,836	34,898	37,573	42,177	43,737	1.8%	3.6%
Combo	44,943	50,212	51,102	56,791	59,214	2.1%	3.1%
Total							
PV	**2,360,137**	**2,530,936**	**2,631,673**	**2,725,961**	**2,778,678**	**1.0%**	**1.8%**
SU	**66,893**	**70,500**	**75,887**	**81,107**	**80,330**	**-0.5%**	**2.1%**
Combo	**124,584**	**135,020**	**138,643**	**145,397**	**142,706**	**-0.9%**	**1.5%**

PV = Passenger Vehicles (including buses and 2-axle, 4-tire vehicles)

SU = Single-Unit Trucks (6 or more tires)

Combo = Combination Trucks (trailers and semitrailers).

Source: Highway Statistics, Table VM-1, various years.

National Highway System

The NHS is an important portion of the total highway system. It includes the Interstate System as well as other routes most critical to national defense, mobility, and commerce. The NHS consisted of 163,462 route miles and approximately 566,000 lane miles in 2006.

With the Interstate System essentially complete, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) revised the Federal-aid highway program for the post-Interstate era. The legislation authorized designation of an NHS that would focus Federal resources on roads that are the most important to interstate travel, economic expansion, and national defense; that connect with other modes of transportation; and that are essential to the country's role in the international marketplace.

The legislation required the U.S. Department of Transportation (DOT) to submit a list and description of proposed NHS routes. This list was submitted in December 1993. Based on the Department's proposals, the National Highway System Designation Act of 1995 identified a 160,955-mile network. The Transportation Equity Act for the 21st Century (TEA-21) authorized a maximum mileage on the NHS of 178,250.

The NHS was designed to be a dynamic system able to change in response to future travel and trade demands. The DOT may approve modifications to the NHS without congressional approval. States must cooperate with local and regional officials in proposing modifications. In metropolitan areas, local and regional officials must act through metropolitan planning organizations and the State transportation department when proposing modifications. A number of such modifications are proposed and approved each year.

The NHS has five components. The first, the Interstate System, is the core of the NHS and includes the most traveled routes. The second component includes selected other principal arterials deemed most important for commerce and trade. The third is the Strategic Highway Network (STRAHNET), which consists of highways important to military mobilization. The fourth is the system of STRAHNET connectors that provide access between major military installations and routes that are part of STRAHNET. The final component consists of intermodal connectors, which were not included in the 1995 Act but are eligible for NHS funds. These roads provide access between major intermodal passenger and freight facilities and the other four subsystems making up the NHS.

While not one of the components of the NHS, the National Network is a system with significant overlap with the NHS. The National Network is 210,000 miles of highways that provides geographic access for interstate commerce and include highways that are not included on the NHS. The National Network primarily serves trucks, while the 163,462-mile NHS primarily serves passenger vehicles and may even exclude trucks in some sections. Additional information on the National Network can be found in Chapter 13, *Freight Transportation.*

The NHS was not envisioned as a new Interstate construction program. The non-Interstate portions of the NHS will be upgraded to the standards appropriate for improved safety and operational efficiency. In ISTEA and subsequent legislation, Congress authorized funds for this and other purposes aimed at preserving and improving the NHS.

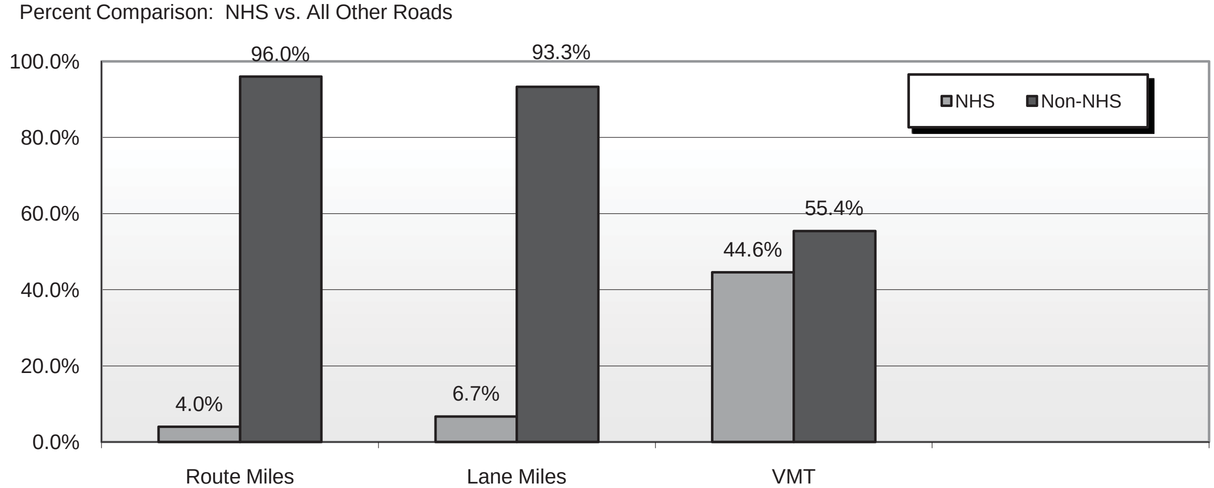
NHS System and Use Characteristics

Exhibit 2-11 summarizes NHS route miles, lane miles, and VMT for the NHS components. The NHS is overwhelmingly concentrated on higher functional systems. All Interstates are part of the NHS, as are 83.5 percent of rural other principal arterials, 87.2 percent of urban other freeways and expressways, and 36.3 percent of urban other principal arterials. The share of minor arterials, collectors, and local roads on the NHS is relatively small. There are currently 163,462 route miles on the NHS, excluding some sections not yet open to traffic.

In 2006, while only 4.0 percent of the Nation's total route mileage and 6.7 percent of the total lane miles are on the NHS, these roads carried 44.6 percent of VMT. This represents a slight increase since 1997, when 43.5 percent of total VMT were on the NHS.

Exhibit 2-11

Highway Route Miles, Lane Miles, and VMT on the NHS Compared With All Roads, by Functional System, 2006



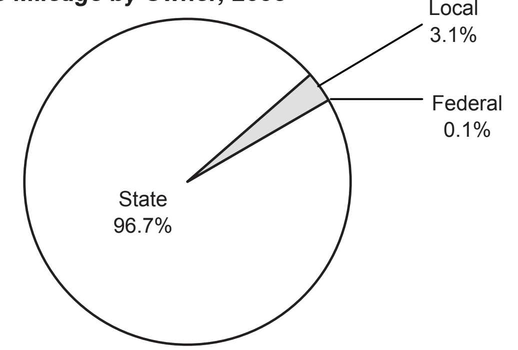
	Route Miles		Lane Miles		VMT (Millions)	
	Total on NHS	Percent of Functional System	Total on NHS	Percent of Functional System	Total on NHS	Percent of Functional System
Rural NHS						
Interstate	30,617	100.0%	124,503	100.0%	258,326	100.0%
Other Principal Arterial	79,349	83.5%	212,753	85.7%	203,235	87.5%
Minor Arterial	2,233	1.6%	5,269	1.9%	4,583	2.8%
Major Collector	734	0.2%	1,621	0.2%	1,319	0.7%
Minor Collector	21	0.0%	45	0.0%	10	0.0%
Local	37	0.0%	76	0.0%	37	0.0%
Subtotal Rural NHS	**112,991**	**3.8%**	**344,146**	**5.6%**	**467,463**	**45.0%**
Urban NHS						
Interstate	16,276	100.0%	89,035	100.0%	482,611	100.0%
Other Freeway and Expressway	9,426	87.2%	44,516	88.7%	201,663	92.4%
Other Principal Arterial	22,928	36.3%	84,840	38.3%	193,583	41.1%
Minor Arterial	1,342	1.3%	4,161	1.6%	6,748	1.8%
Collector	378	0.3%	1,014	0.4%	1,452	0.8%
Local	121	0.0%	241	0.0%	238	0.1%
Subtotal Urban NHS	**50,471**	**4.8%**	**223,566**	**9.5%**	**886,295**	**44.4%**
Total NHS	**163,462**	**4.0%**	**567,712**	**6.7%**	**1,353,758**	**44.6%**

Source: Highway Performance Monitoring System.

Exhibit 2-12 describes the ownership of NHS mileage. Approximately 96.7 percent of route miles were State-owned in 2006. Only 3.1 percent were locally owned, and the Federal government owned the remaining 0.1 percent. By comparison, 20.3 percent of all route miles in the United States were State-owned, 76.5 percent were locally owned, and the Federal government owned 3.2 percent. Since the NHS is concentrated on higher functional systems, the percentage of locally owned NHS routes is relatively small.

Exhibit 2-12

NHS Mileage by Owner, 2006



Source: Highway Performance Monitoring System.

Interstate System

The Interstate System dates to the late 1930s when the United States was completing its first "Interstate System," a two-lane paved network of highways generally designated by U.S. highway numbers (such as U.S. 1 and U.S. 66). Its safety and operational deficiencies for the growing traffic volumes of the day prompted consideration of the next stage of highway development.

In a 1939 report to Congress titled *Toll Roads and Free Roads*, the U.S. Bureau of Public Roads (BPR) described the need for a toll-free network of express highways. A 1944 report to Congress, *Interregional Highways*, prompted Congress to incorporate the concept into the Federal-Aid Highway Act of 1944. The legislation authorized designation of a 40,000-mile "National System of Interstate Highways" that would connect principal metropolitan areas, cities, and industrial centers; serve the national defense; and provide suitable connections with Canada and Mexico.

On August 2, 1947, the Public Roads Administration designated the first 37,681 miles of principal highways, including 2,882 miles carrying the routes through urban areas. The agency reserved the remaining 2,319 miles for urban circumferential and distributing routes that would be designated at a later date (1955 as it turned out). As the announcement of the designation pointed out:

> Although the new interstate system follows, in general, the principal routes in the present Federal-aid system, it may be necessary in many instances to relocate existing highways or build alternate routes for express traffic in order to meet essential standards of width, grade, alignment, and control of access.

Although the 1944 Act was a major step forward, it did not authorize special funds for the Interstate System. The assumption was that the State highway agencies would use their annual apportionment of Federal-aid highway funds on Interstate projects. Although some progress was made, the pace was slow and the lack of progress frustrating.

President Eisenhower took office on January 20, 1953, with a keen understanding of the value of roads. As a young officer in 1919, he had been an observer on the U.S. Army's first transcontinental convoy—a 2-month trek from Washington, D.C., to San Francisco over roads that often challenged the sturdiest military vehicles. During and after World War II, he had seen the *autobahn* express highway network Germany had built in the 1930s and understood the network's military and civilian value. As he would say in his memoirs, "The old convoy had started me thinking about good, two-lane highways, but Germany had made me see the wisdom of broader ribbons across the land."

With the President's strong support, the Federal-Aid Highway Act of 1956 declared that the completion of the "National System of Interstate and Defense Highways" was essential to the national interest. It made a national commitment to Interstate completion within the Federal-State partnership of the Federal-aid highway program, with the State responsible for construction to approved standards. In addition, the legislation authorized Interstate Construction funds for what was expected to be the entire construction period (through FY 1969, with completion in 1971). Most importantly, the 1956 Act resolved the challenging issue of how to pay for construction by establishing the Highway Trust Fund to ensure that revenue from highway user taxes, such as the gas tax, would be dedicated to the Interstate System and other Federal-aid highway and bridge projects.

President Eisenhower wrote in his memoirs that "more than any single action by the government since the end of the war, this one would change the face of America. Its impact on the American economy . . . was beyond calculation." A look back on the 50th anniversary of the 1956 Act reveals that his prediction proved true. Although the Interstate System accounts for slightly more than 1 percent of the Nation's total public road mileage, it carries over 24 percent of all highway travel. The Dwight D. Eisenhower National System of Interstate and Defense Highways, as it is now called, accelerated interstate and regional commerce, enhanced the country's competitiveness in international markets, increased personal mobility, facilitated military transportation, and accelerated metropolitan development throughout the United States.

Interstate System Characteristics

The route miles of the Interstate System in the United States increased from 46,314 in 1997 to 46,835 in 2004 and to 46,892 in 2006. About 65.3 percent (30,615 route miles) were in rural areas, 4.7 percent (2,211 route miles) were in small urban areas, and 30.0 percent (14,066 route miles) were in urbanized areas. A breakdown of Interstate route miles is available in *Exhibit 2-5*.

The number of Interstate route miles in rural areas declined from 31,477 in 2004 to 30,615 in 2006. During the same period, the number of Interstate System miles increased from 2,088 to 2,211 in small urban areas and from 13,270 to 14,066 in urbanized areas. **Rural Interstate route miles declined due to the expansion of small urban and urbanized boundaries resulting from the 2000 decennial census, causing some formerly rural areas to be reclassified as urban.** Note that some States are typically faster than others in modifying their data reporting to correspond to new decennial census information; therefore, while many of the States have submitted modified information to HPMS, some changes may still be forthcoming. The next edition of the C&P report may still show some minor additional rural Interstate mileage having been reclassified as urban.

Between 1997 and 2006, rural Interstate route miles decreased by approximately 0.8 percent annually, small urban Interstate route miles increased 2.7 percent annually, and Interstate route miles in urbanized areas increased 2.1 percent annually. The annual growth rate of Interstate route miles from 1997 to 2006 is approximately 0.14 percent, which is slightly less than the overall annual growth rate for all roads during that time period.

The total number of Interstate lane miles is shown in *Exhibit 2-6*. In 2006, there were 213,542 lane miles of Interstates in the United States. Approximately 58.3 percent were in rural communities, 4.4 percent were in small urban areas, and slightly less than 37.3 percent were in urbanized areas.

Interstate Use Characteristics

VMT on Interstate highways for 1997 to 2006 are shown in *Exhibit 2-7*. In 2006, Americans traveled more than 258 billion vehicle miles on rural Interstates, 26.4 billion vehicle miles on small urban Interstates, and in excess of 456 billion vehicle miles on urban Interstates. Interstate travel continued to represent the fastest-growing portion of VMT between 1997 and 2006. Interstate VMT grew at an average annual rate of approximately 2.3 percent during this period, while VMT on all roads grew by about 1.9 percent annually.

In *Exhibit 2-13*, Interstate highway travel by vehicle type is shown for 1997 to 2006. In 2006, 80.0 percent of travel on rural Interstates was by passenger vehicle; 3.0 percent was by single-unit truck; and 17.0 percent was by combination truck. About 91.6 percent of urban Interstate travel was by passenger vehicle; 2.2 percent was by single-unit truck; and 6.2 percent was by combination truck. By contrast, passenger vehicle travel represented approximately 92.6 percent of travel on all roads in 2006. Single-unit truck travel was just above 2.7 percent of travel, and combination truck travel represented slightly less than 4.8 percent.

From 1997 to 2006, combination truck travel grew by 4.0 percent annually on urban Interstates, single-unit truck travel grew by 3 percent, and passenger vehicle travel grew by 3.1 percent. However, from 2004 to 2006 on rural Interstates, combination truck travel decreased by an average annual rate of 2.3 percent, single-unit truck travel decreased by an average annual rate of 5.3 percent, and passenger vehicle travel decreased by an average annual rate of 1.5 percent.

Exhibit 2-13

Interstate Highway Travel by Vehicle Type and Population Area

	(Millions of VMT)												Annual Rate of Change 2006/ 2004	Annual Rate of Change 2006/ 1997
	1997		1999		2000		2002		2004		2006			
Rural	**VMT**	**%**	**VMT**	**%**	**VMT**	**%**	**VMT**	**%**	**VMT**	**%**	**VMT**	**%**	**%**	**%**
Interstate														
PV	189,869	79.4%	208,017	80.3%	214,532	80.3%	224,375	80.5%	211,369	79.6%	205,103	80.0%	-1.5%	0.9%
SU	7,671	3.2%	8,073	3.1%	8,236	3.1%	8,745	3.1%	8,548	3.2%	7,674	3.0%	-5.3%	0.0%
Combo	41,665	17.4%	42,976	16.6%	44,248	16.6%	45,633	16.4%	45,754	17.2%	43,711	17.0%	-2.3%	0.5%
Urban														
Interstate														
PV	331,343	92.1%	349,283	91.5%	359,592	91.8%	373,957	91.9%	415,254	91.8%	435,043	91.6%	2.4%	3.1%
SU	7,906	2.2%	8,494	2.2%	8,716	2.2%	9,106	2.2%	10,512	2.3%	10,301	2.2%	-1.0%	3.0%
Combo	20,643	5.7%	23,792	6.2%	23,465	6.0%	23,887	5.9%	26,481	5.9%	29,430	6.2%	5.4%	4.0%
All Roads														
PV	2,360,137	92.5%	2,477,784	92.4%	2,530,936	92.5%	2,631,673	92.5%	2,725,961	92.3%	2,778,678	92.6%	1.0%	1.8%
SU	66,893	2.6%	70,304	2.6%	70,500	2.6%	75,887	2.7%	81,107	2.7%	80,330	2.7%	-0.5%	2.1%
Combo	124,584	4.9%	132,384	4.9%	135,020	4.9%	138,643	4.9%	145,398	4.9%	142,706	4.8%	-0.9%	1.5%

Source: Highway Statistics, Table VM-1, various years.

Strategic Highway Network

Strategic Highway Network (STRAHNET) is a network of highways critical to the Department of Defense's (DoD) domestic operations providing access, continuity, and emergency transportation for defense purposes. STRAHNET Connectors are roads and highways that provide links or connections between major military installations and the STRAHNET highways. All STRAHNET highways and STRAHNET Connectors are part of the NHS.

The STRAHNET is a 61,976-mile system of roads deemed necessary for moving personnel and equipment during a mobilization or deployment and the peacetime movement of heavy armor, fuel, ammunition, repair parts, food, and other commodities to support U.S. military operations. *Exhibit 2-14* identifies STRAHNET mileage by functional class. Even though DoD primarily deploys heavy equipment by rail, highways play a critical role. Links to over 200 important military installations and ports are provided by approximately 1,700 miles of roadways designated as STRAHNET Connectors.

Exhibit 2-14

STRAHNET Miles by Functional Class, 2006

	Miles
Rural	
Interstate	30,620
Other Principal Arterial	10,165
Minor Arterial	707
Major Collector	197
Minor Collector	1
Local	18
Subtotal Rural	**41,708**
Urban	
Interstate	16,278
Other Freeway and Expressway	1,571
Other Principal Arterial	2,161
Minor Arterial	198
Collector	48
Local	12
Subtotal Urban	**20,268**
Total	**61,976**

Source: Highway Performance Monitoring System.

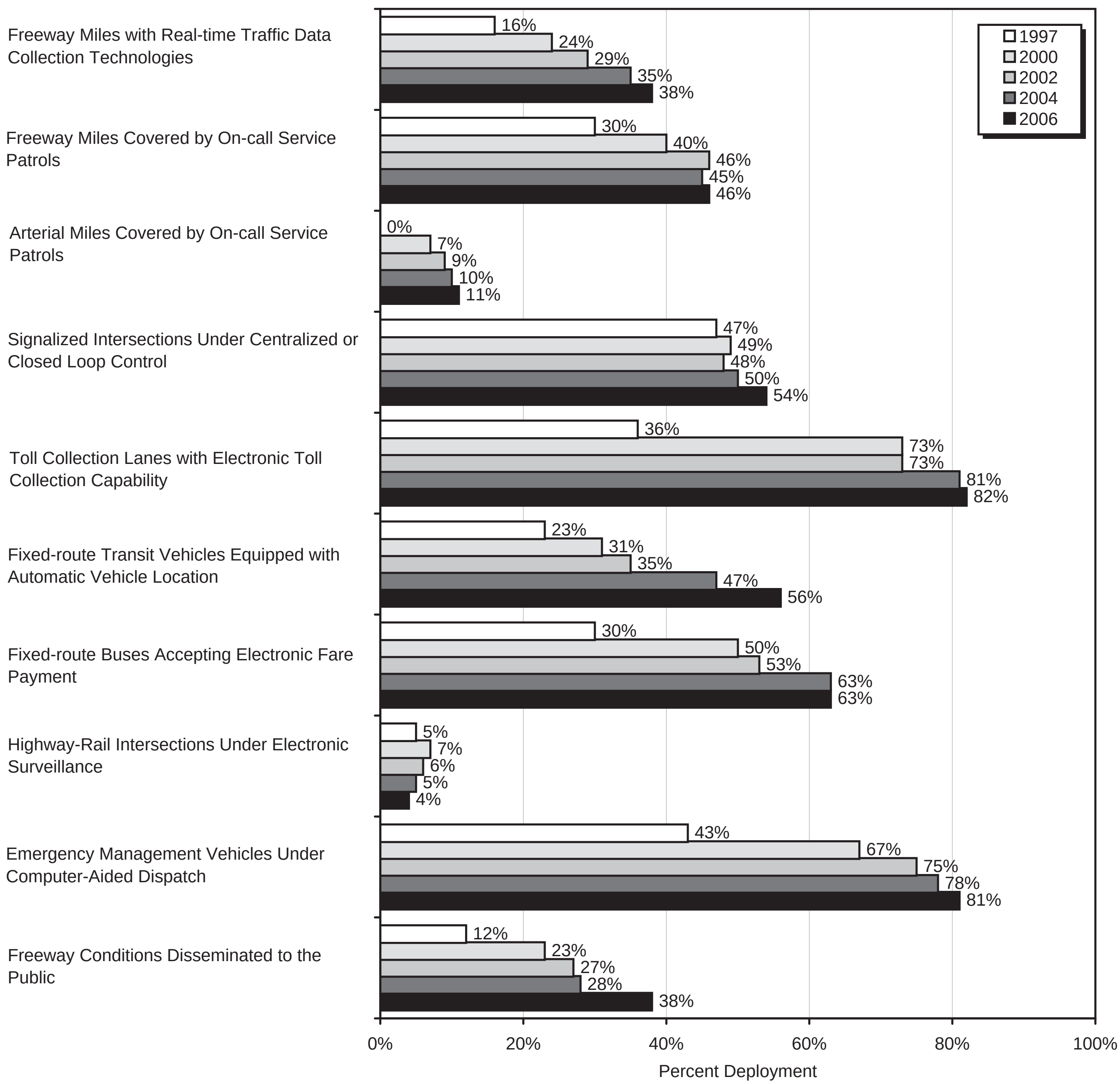
The Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA) is the DoD-designated agent for public highway matters, including STRAHNET and STRAHNET Connectors. The SDDCTEA identified STRAHNET and the Connector routes in coordination with the FHWA, the State transportation departments, the military Services and installations, and the ports. Together, STRAHNET and the Connectors define the total minimum defense public highway network needed to support a defense emergency.

Deployment of Intelligent Transportation Systems

All of the previous exhibits in this chapter represent a traditional look at the highway system. This section looks at the extent of Intelligent Transportation Systems (ITS) deployment and integration in metropolitan areas. The Intelligent Transportation Systems Joint Program Office of the U.S. DOT conducts an annual survey on the deployment of ITS devices in 78 of the largest metropolitan areas in the United States. As shown in *Exhibit 2-15*, results from this survey indicate that freeway deployment has advanced steadily, with real-time data collection sensors deployed on nearly 38 percent of the total freeway mileage and on-call service patrols covering almost 46 percent of the freeway mileage. Arterial deployment of service patrols lags behind that seen on freeways, but is advancing steadily. Traffic control systems have also improved, with over half of them now controlled centrally or through closed loop systems. Transit agencies have advanced rapidly in deployment of ITS, with more than half of all the buses equipped with automatic vehicle location capability by 2006. The dissemination of freeway information to the public showed a particularly large increase between 2004 and 2006. Other well-established ITS technologies include electronic fare payment for transit vehicles, computer-aided dispatch on emergency vehicles, and electronic toll collection.

Exhibit 2-15

Deployment of Intelligent Transportation Systems (ITS) in 78 of the Largest Metropolitan Areas, 1997–2006



Source: ITS Deployment Statistics Database, Research and Innovative Technology Administration.

Bridge System Characteristics

The National Bridge Inventory (NBI) contains nearly 700,000 records, which describe either the features carried by a bridge, termed as "on" records, or the features crossed by the structure, termed as "under" records. Separating the on records from the under records reveals that there were 597,562 bridges over 6.1 meters (20 feet) in total length located on public roads in the United States in 2006. As discussed in Chapter 3, the National Bridge Inspection Standards establishes the frequency of inspection of bridges meeting the definition; as part of these inspections, information is collected concerning both the characteristics and physical conditions of the structures.

Q&A

What were the recommendations of the Blue Ribbon Panel on Bridge and Tunnel Security?

In 2003, a Blue Ribbon Panel on Bridge and Tunnel Security—set up by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO)—developed seven overarching recommendations to improve bridge and tunnel security. These recommendations fall into three areas: institutional, fiscal, and technical.

Institutional Recommendations. The panel recommended greater collaboration between the FHWA, AASHTO, Transportation Security Administration (TSA), and other highway stakeholders. The panel also endorsed better outreach and communication strategies and recommended that FHWA clarify how local transportation agencies act on indications of risk studies for their facilities. Since the publication of the report, collaboration between these groups has become a reality. FHWA, TSA, and AASHTO have conducted Infrastructure Protection Workshops, for instance, and FHWA Division offices share expertise with security officials in the States.

Fiscal Recommendations. The panel endorsed new funding sources for bridge and tunnel security beyond and outside of current Federal-aid sources. The panel also recommended amending Title 23, Sections 144 and 133, to allow for expenditures that could enhance bridge security, as was done for seismic retrofitting. Since these recommendations were made, however, there has been no separate funding for bridge and tunnel security.

Technical Recommendations. The panel endorsed "engineering" security solutions, with the FHWA collaborating with the TSA to prioritize critical bridges and tunnels and administer funding for high security needs. Panelists also endorsed research and development initiatives to better understand bridge and tunnel security. Since the publication of the report, FHWA has worked with TSA on prioritization strategies and other technical efforts.

Bridges by Owner

Exhibit 2-16 shows the number of highway bridges by owner from 1998 to 2006. State and local ownership includes highway agencies; park, forest, and reservation agencies; toll authorities; and other State or local agencies, respectively. The majority of State and local bridges are owned by highway agencies. Federal ownership includes a number of agencies, mostly the Department of Interior and the Department of Defense. A small number (less than 1 percent) of bridges carrying public roadways are owned by other agencies, such as private entities and railroads. Bridges

Q&A

How vulnerable are the Nation's bridges and tunnels to terrorist attacks?

In 2002, it was estimated that about 1,000 of the Nation's almost 600,000 bridges were significant enough that there would be substantial casualties, economic disruption, and other ramifications if these bridges were damaged or destroyed. That was the conclusion of the National Needs Assessment for Ensuring Transportation, Infrastructure Security: Preliminary Estimate, NCHRP Project 20-59(5). Many of the Nation's 337 highway tunnels and 211 transit tunnels are located beneath bodies of water, and many have limited alternative routes due to geographic constraints.

How can bridge and tunnel operators improve the security of their facilities?

Q&A

Federal Emergency Management Agency (FEMA) guidelines require the development of an emergency operations plan that addresses how to respond to a threat involving a bridge. The plan should include, among other items, a sequence of events that should occur for an effective response; a list of potential areas of vulnerability; establishment of a mobile command center; evacuation and shutdown procedures; and identification of emergency evacuation routes.

FEMA and the FHWA have identified numerous countermeasures to reduce the vulnerability of bridges and tunnels. Overgrown vegetation, for example, can be cleared to improve lines of sight to critical areas. Access can be limited to critical areas. Parking spaces below bridges can be restricted, and trash cans and other storage areas that might conceal an explosive device can be removed. Police patrols, guards, and "no fly zones" can create deterrents to suspicious activities.

There are many ways bridges and tunnels can be retrofitted to improve their strength and stability. These measures include reinforcing welds and bolted connections, using energy-absorbing bolts to strengthen connections, and adding stiffeners and strengthening lateral bracing on steel elements.

Exhibit 2-16

Bridges by Owner, 1998–2006

Owner	1998	2000	2002	2004	2006
Federal	7,748	8,221	9,371	8,425	8,355
State	273,897	277,106	280,266	282,552	284,668
Local	298,222	298,889	299,354	300,444	301,912
Private/Railroad	2,278	2,299	1,502	1,497	1,490
Unknown/Unclassified	1,131	415	1,214	1,183	1,137
Total	**583,276**	**586,930**	**591,707**	**594,101**	**597,562**

Source: National Bridge Inventory.

carrying railroads are not included in the database unless they also carry a public road or cross a public road where information of certain features, such as vertical or horizontal clearances, is required for management of the highway system.

Local agencies own 301,912 bridges on the Nation's roadways, or slightly more than 50.5 percent of all bridges. These agencies include cities, counties, townships, and other non-State or non-Federal governmental agencies. State agencies own 47.6 percent, or 284,668 of the Nation's bridges on all functional roadway classifications. State and local agencies, when combined, own 586,580 of the total 597,562 of the Nation's bridges, or approximately 98.2 percent of all bridges on the Nation's roadway system.

How do the bridge ownership percentages compare with the road ownership percentages?

Q&A

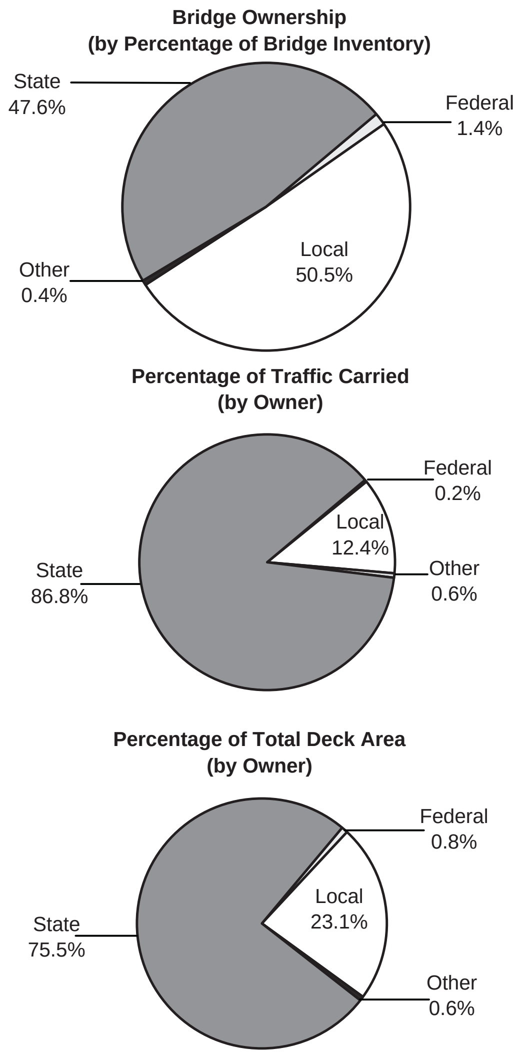
Bridge ownership is nearly equally divided between State (slightly more than 47.6 percent) and local agencies (slightly more than 50.5 percent). The majority of roadways, however, are owned by local agencies (76.5 percent). States tend to own larger, higher-volume structures, such as those on Interstates and expressways. Localities own smaller structures on lower-volume roadways, such as local roads and collectors.

Deeper insight into the condition or composition of bridges can be obtained by considering the size of the structure and/or the traffic carried. Consideration of the structure size can be incorporated using the bridge deck area data. Consideration of the volume of traffic served by the structure can be incorporated using average daily traffic (ADT) data. *Exhibit 2-17* compares the ownership percentages based on the actual number of bridges with percentages based on ADT on bridges and bridge deck area, respectively. Bridges owned by State agencies carry significantly higher cumulative traffic volumes, on average, than bridges owned by local agencies. State-owned bridges also tend to have greater deck area than locally owned bridges.

If an agency owns a bridge, it is responsible for the maintenance and operation of the structure. Interagency agreements may be formed, such as those between State highway agencies and localities. In these cases, a secondary agency (such as the State) performs maintenance and operation work under agreement. This, however, does not transfer ownership and therefore does not negate the responsibilities of the bridge owners for maintenance and operation in compliance with Federal and State requirements.

Exhibit 2-17

Bridge Inventory Characteristics for Ownership, Traffic, and Deck Area



Source: National Bridge Inventory.

Bridges by Functional Classification

Highway functional classifications are maintained by the NBI according to the hierarchy used for highway systems previously described. The number of bridges by functional classification is summarized and compared with previous years in *Exhibit 2-18*. It should be noted the total number of bridges in the Nation in 2006 was 597,562, but the number of bridges listed in *Exhibit 2-18* totals 597,340. The reason for the discrepancy is that functional classifications for 222 bridges were not provided and therefore are not entered into the database.

Overall percentages of each functional classification tend to remain relatively constant over time, although bridges are functionally reclassified as urban boundaries change. **It must be noted that the results of the 2000 census are still impacting the reporting of the distribution of bridges between rural and urban. The adjustments of the boundaries for these areas, in addition to construction of new bridges, are some reasons for the changes in the reported data.** The number of bridges with known functional classifications increased between 2004 and 2006 by 3,265 from 594,075 in 2004 to 597,340 in 2006.

In 2006, a total of 4,916 fewer bridges were classified as rural bridges than in 2004. This reduction was in all functional classes, with 1,015 fewer Interstate bridges, 1,168 fewer bridges on other arterials, 1,222 fewer bridges on the roads classified as collectors, and 1,511 fewer bridges on local roads. In contrast, the number of bridges classified as urban increased by 8,181 in the same time period. The number of urban Interstate

Exhibit 2-18

Number of Bridges by Functional System, 1998–2006

Functional System	1998	2000	2002	2004	2006
Rural					
Interstate	27,530	27,797	27,316	27,648	26,633
Other Arterial	73,324	74,796	74,814	76,456	75,288
Collector	143,140	143,357	144,101	143,470	142,248
Local	210,670	209,415	209,722	208,641	207,130
Subtotal Rural	**454,664**	**455,365**	**455,953**	**456,215**	**451,299**
Urban					
Interstate	27,480	27,882	27,929	27,929	28,637
Other Arterial	60,901	63,177	65,667	66,443	70,278
Collector	14,962	15,038	15,171	15,548	17,618
Local	24,962	25,684	26,609	27,940	29,508
Subtotal Urban	**128,305**	**131,781**	**135,376**	**137,860**	**146,041**
Total	**582,969**	**587,146**	**591,329**	**594,075**	**597,340**

Source: National Bridge Inventory.

bridges increased by 708, bridges on other arterials increased by 3,835, on collectors by 2,070, and on local roads by 1,568.

Exhibit 2-19 shows the relationship between the number of bridges, functional system, ADT carried, and deck area. The deck area for rural bridges is 46.2 percent versus 53.8 percent for urban bridges. The major difference is in the amount of ADT carried by rural bridges versus urban bridges.

Exhibit 2-19

Bridges by Functional System Weighted by Numbers, ADT, and Deck Area

Functional System	Number of Bridges	Percent by Total Number	Percent of Total ADT	Percent of Total Deck Area
Rural				
Interstate	26,633	4.5%	9.7%	7.6%
Other Principal Arterial	35,767	6.0%	6.3%	9.1%
Minor Arterial	39,521	6.6%	3.5%	6.4%
Major Collector	93,609	15.7%	3.5%	9.7%
Minor Collector	48,639	8.1%	0.8%	3.4%
Local	207,130	34.7%	1.5%	9.9%
Subtotal Rural	**451,299**	**75.5%**	**25.2%**	**46.2%**
Urban				
Interstate	28,637	4.8%	35.4%	18.9%
Other Freeways & Expressways	17,988	3.0%	15.3%	9.6%
Other Principal Arterial	26,051	4.4%	12.1%	11.1%
Minor Arterial	26,239	4.4%	7.1%	7.2%
Collector	17,618	2.9%	2.5%	3.2%
Local	29,508	4.9%	2.3%	3.8%
Subtotal Urban	**146,041**	**24.4%**	**74.7%**	**53.8%**
Unclassified	222	0.0%	0.0%	0.0%
Total	**597,562**	**100.0%**	**100.0%**	**100.0%**

Source: National Bridge Inventory.

On the Nation's roadway systems, 75.5 percent of all bridges are located in rural areas and these rural bridges only carry about 25.2 percent of the Nation's daily traffic. This compares with urban bridges which comprise 24.4 percent of the inventory but carry 74.7 percent of all daily traffic. Not surprisingly, urban structures are generally larger in terms of deck area as additional lanes are required to carry larger volumes of traffic. Urban structures constitute 53.8 percent of all total deck area on bridges in the inventory.

Urban Interstate bridges comprise 18.9 percent of the total bridge deck area of bridges on the Nation's roadway system but carry 35.4 percent of the ADT. Bridges on urban other freeways and expressways account for 9.6 percent of the total deck area and carry 15.3 percent of the ADT. Bridges on urban other principal arterials carry 12.1 percent of the ADT and have only 11.1 percent of the total deck area.

While the higher-order functional classifications (including rural and urban Interstate, other freeways and expressways, and other principal arterials) account for only 135,076 bridges, 22.6 percent of the total bridges by number, they carry close to 78.8 percent of all daily traffic and account for approximately 56.3 percent of the deck area for all bridges in the Nation.

Bridges by Traffic Carried

Many bridges carry relatively low volumes of traffic on a typical day. Approximately 318,837 bridges, 53.3 percent of the total bridges in the Nation, have an ADT of 1,000 or less. An additional 177,431 bridges, 29.7 percent of all bridges, have an ADT between 1,000 and 10,000. **Only 16,180 of the Nation's bridges, or 2.7 percent, have an ADT higher than 50,000.** These structures are predominantly in urban environments (approximately 90 percent in terms of numbers, nearly 95 percent in terms of deck area). Over 95 percent of such bridges are located on Interstates or other principal arterials. The remaining 85,114 bridges, 14.3 percent, have an ADT between 10,000 and 50,000. In terms of numbers of bridges, low-volume roadways are predominant. However, the high-volume structures have a significant impact on the user population.

Bridges by Age

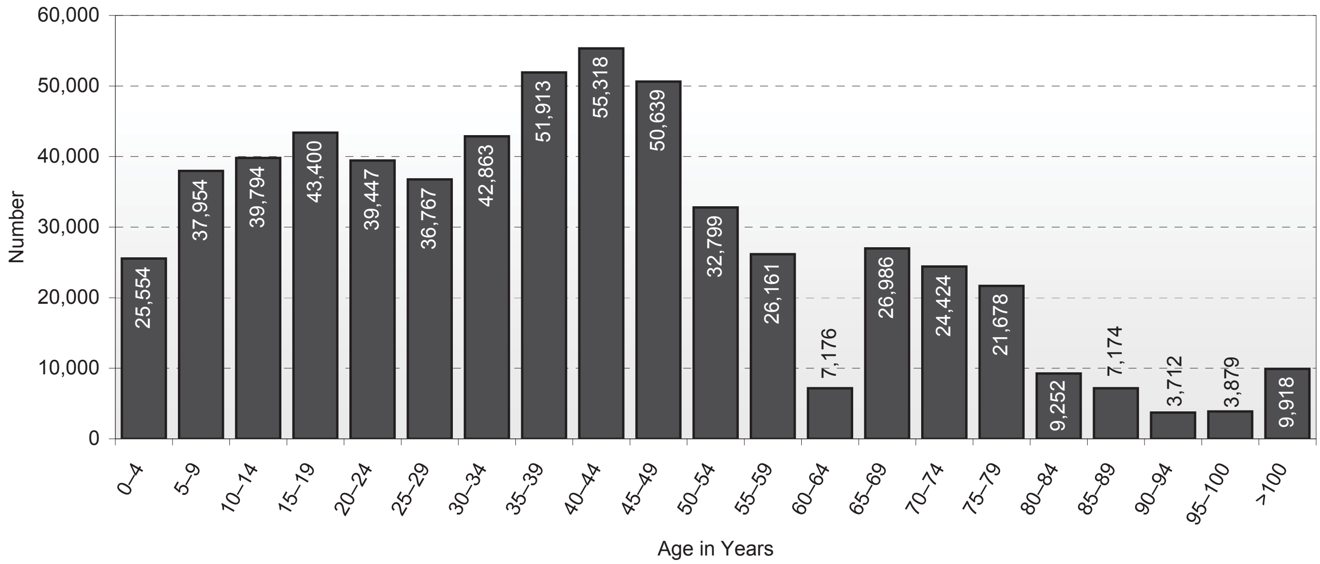
Major construction of bridges began after the end of the Second World War and continued through the construction of the Interstate System. The latter saw an intense period of construction of bridges across the Nation. Approximately 46.8 percent of all bridges were built before 1966; 24.6 percent of all bridges are less than 20 years in age, and 31.2 percent are less than 25 years old.

When broken into 25-year age ranges, 31.2 percent of the bridges are 25 years old or less, 39.8 percent are 26 years to 50 years old, 19.7 percent are 51 to 75 years old, 7.7 percent are 76 years to 100 years old, and 1.7 percent are more than 100 years old. The share of bridges 50 years old or older is 29.0 percent, while the portion of bridges less than 50 years is 71.0 percent. *Exhibit 2-20* shows the distribution of bridges by age.

The age of a bridge structure is only one potential indicator of its physical condition. Several additional factors can affect the physical condition of a structure. These include, but are not limited to: the original type of design; the frequency, timeliness, effectiveness, and appropriateness of the maintenance activities implemented over the life of the structure; the loading the structure has been subject to during its life; the climate of the area where the structure is located; and any additional stresses from events such as flooding to which the structure has been subjected.

Exhibit 2-20

Distribution of Bridges by Age (as of December 2006)



Source: National Bridge Inventory.

NHS Bridges

The NBI shows 115,104 bridges on the NHS. This number represented approximately 19.4 percent of the total bridges on the Nation's roadway system. These bridges had approximately 49.5 percent of the total deck area and carried 71.1 percent of the total travel on bridges in the Nation in 2006. State agencies own over 96 percent of the bridges on the NHS. Local agencies own slightly more than 3 percent of the NHS bridges, with the remaining less than 1 percent being owned by Federal agencies and other groups.

The STRAHNET system is a subset of the NHS. In 2006, approximately 73,528 bridges were on the STRAHNET system. This number represented approximately 12.1 percent of all bridges on the Nation's roadway system.

The Interstate System is a subset of the STRAHNET. The number of bridges on the Interstate System totaled 55,270 structures. The Interstate bridges carried 45.1 percent of ADT and accounted for 26.5 percent of the deck areas for all bridges in the Nation.

Transit System Characteristics

System History

The first transit systems in the United States date to the middle of the 19th century. Initially, the Federal government had little involvement in the public transit sector. Over time, however, leaders at all levels of government began to realize that developing and sustaining transit services was an important national, as well as local, concern. In 1964, Congress passed the Urban Mass Transportation Act, which generated an influx of Federal funding for transit systems. The Act also changed the character of the industry by specifying that Federal funds for transit were to be given to local or metropolitan-level public agencies, and not to private firms. This reinforced the already existing trend of transferring the ownership and operation of most transit systems in the United States from private to public hands. The Act also required local governments to contribute matching funds in order to receive Federal aid for transit services, setting the stage for the multi-level governmental partnerships that characterize the transit sector today.

State governments are also involved in the provision of transit services, generally through financial support and performance oversight. Thirty States have taxes dedicated to transit. In some cases, States have undertaken outright ownership and operation of transit services; five States—Connecticut, Delaware, Maryland, New Jersey, and Rhode Island—own and operate transit systems directly.

Several Federal initiatives from 1962 to 1965, in effect, mandated the creation of metropolitan planning organizations (MPOs) for each of the Nation's urbanized areas, although some of the Nation's largest urbanized areas already had similar organizations. MPOs are composed of local and State officials and address the transportation planning needs of an urbanized area at a regional level. MPO coordination is now an essential prerequisite for Federal funding of many transit projects.

Given the wide array of combinations of governmental involvement in transit, transit agencies may take on a number of different forms. A transit provider may be a unit of a regional transportation agency; be run directly by the State, county, or city government; or be an independent agency with an elected or appointed Board of Governors. Transit operators may provide service directly with their own equipment or they may purchase transit services through an agreement with a contractor. All public transit services must be open to the general public without discrimination and meet the accessibility requirements of the Americans with Disabilities Act of 1990 (ADA).

System Infrastructure

Transit Agencies

In 2006, there were 657 agencies in urbanized areas reporting to the National Transit Database (NTD), of which 588 were public agencies, including seven State departments of transportation. The remaining 69 agencies were either private operators or independent agencies (e.g., non-profit organizations). Of the 657 agencies, 82 received either a reporting exemption for operating nine or fewer vehicles or a temporary reporting waiver. The remaining 575 reporting agencies provided service on 1,398 separate modal networks; 162 agencies operated a single mode and 495 transit agencies operated more than one mode. In 2006, there were an additional 1,327 transit operators serving rural areas.

What is demand response service, when is a demand response service considered to be transit, and who provides demand response service?

Q&A

The term “demand response” refers to transit service dispatched directly in response to customer requests. Demand response services operate passenger cars, vans, or small buses without fixed routes or fixed schedules. Typically, a vehicle is dispatched to pick up multiple passengers at different locations before taking them to their respective destinations. A demand response system is considered to be part of the Nation’s urban transit system (and hence neither a “taxi” system nor a “shared-ride shuttle” system) if the system is run by or under contract to a transit agency. Demand response vehicles are included as “regular vehicles” in *Exhibit 2-21*, both as rural service vehicles and as vehicles in urbanized areas.

Demand response systems are commonly used to meet transit agencies’ obligations under the ADA. Another less common form of demand response service, often called “Kiddie Cabs,” provides service to schoolchildren. Demand response services for the general public may be provided in small towns, rural areas, and some urban neighborhoods with limited transit demand.

The FTA grants funding to certain private entities to provide demand response–type service to the elderly and those with disabilities. These “special services” are not included in the “demand response mode” and are discussed in the section at the end of this chapter.

The Nation’s motor bus and demand response systems are much more extensive than the Nation’s rail transit system. In 2006, there were 622 motor bus systems and 609 demand response systems in urban areas, compared with 16 heavy rail systems, 28 commuter rail systems, and 32 light rail systems. While motor bus and demand response systems were found in every major urbanized area in the United States, only 40 urbanized areas had service on at least one of the three primary rail modes, including 16 urbanized areas with service on the heavy rail mode. In addition to these modes, there were 57 transit vanpool systems, 17 ferryboat systems, 5 trolleybus systems, 4 automated guideway systems, 4 inclined plane systems, and 1 jitney system operating in urbanized areas of the United States and its territories. The transit statistics presented in this report also include the San Francisco Cable Car, the Seattle Monorail, the Roosevelt Island Aerial Tramway in New York, and the Alaska Railroad (which is a combination of long-distance passenger rail transportation, sightseeing services, and freight transportation services.)

What are the differences between heavy rail, light rail, and commuter rail?

Q&A

There are three primary rail modes in the United States’ transit system: heavy rail, light rail, and commuter rail.

Despite their names, the terms “heavy rail” and “light rail” do not refer to the weight of the rail equipment. Although the precise origins of the terms are not known, the most plausible explanation is that they refer to the level of passenger traffic that can be accommodated on the respective systems, with “heavy rail” systems carrying “heavy” passenger loads, and “light rail” systems carrying “light” passenger loads. Modern technologies, however, have somewhat blurred this distinction.

Heavy rail systems are electric railways that always operate on exclusive guideways. These systems usually have high platform loading and are typically powered by a third rail. Heavy rail trains are often six or more cars long to accommodate high passenger loads and are commonly called “metros,” “rapids,” or “subways” (although light rail trains may also operate occasionally in underground tunnels).

Light rail systems are electric railways that operate at least part of the time in a mixed guideway with foot and automobile traffic or have at least some at-grade crossings with foot and automobile traffic. These systems usually have low platform loading and are typically powered by overhead wires. Light rail trains are usually only one or two cars long and are often called “streetcars” or “trolleys.”

Commuter rail systems typically operate on existing or retired freight rail tracks. These systems usually have low platform loading and are often powered by diesel engines (but may also be electric powered). Commuter rail systems provide service from outlying suburbs and small cities to a central downtown area, with only one or two stops in the central downtown area. A commuter rail system must get at least 50 percent of its traffic from persons using the system to commute between home and work at least three days a week to be considered a transit system (as opposed to an intercity rail system).

What are jitney, ‘aiga bus, and público services? Q&A

Jitney systems use personal vehicles, typically passenger cars, modified light trucks, or vans, to provide frequent service on fixed or semi-fixed routes, but with few or no set stops, and typically without a fixed schedule. The vehicles may be owned or leased by the operator, and capacities vary from eight passengers to modified light trucks holding 30 or more passengers. There is only one jitney service in the incorporated areas of the United States, which has been operating in Laguna Beach, California, since 1914. A newspaper reporter coined the name “jitney” because the service charged a “jitney,” or five cents, for a ride. “Público” is simply the name of the jitney service in San Juan, Puerto Rico, while “ ‘aiga bus” is the name of the jitney service that operates on Tutuila Island (the main island) in American Samoa (‘aiga’ is the Samoan word for “family”). ‘Aiga bus data are not reported to the NTD.

Transit Fleet

Exhibit 2-21 provides an overview of the Nation’s transit fleet in 2006 by type of vehicle and size of urbanized area. Although there is a strong correlation between some types of vehicles and certain modes, many vehicles, particularly small buses and vans, are used by different modes of transit. For example, vans may be used to provide vanpool, demand response, público, or motor bus services.

The Nation’s transit system continues to grow. In 2006, urban transit systems, excluding special service providers, operated 128,133 vehicles compared with 120,659 vehicles in 2004, an increase of 6.2 percent.

Exhibit 2-21

Transit Active Fleet by Vehicle Type, 2006

	Areas Over 1 Million in Population		Areas Under 1 Million in Population		Total	
Urbanized Area Regular Vehicles						
Heavy Rail Vehicles	11,126	11.5%	0	0.0%	11,126	8.7%
Self-Propelled Commuter Rail	2,582	2.7%	0	0.0%	2,582	2.0%
Commuter Rail Passenger Cars	3,415	3.5%	105	0.3%	3,520	2.7%
Commuter Rail Locomotives	718	0.7%	79	0.3%	797	0.6%
Light Rail Vehicles	1,812	1.9%	108	0.3%	1,920	1.5%
Motor Buses	51,451	53.2%	21,611	68.7%	73,063	57.0%
Vans	14,315	14.8%	7,667	24.4%	21,982	17.2%
Other Regular Vehicles [1]	11,260	11.6%	1,883	6.0%	13,143	10.3%
Total Urbanized Area Regular Vehicles	**96,679**	100.0%	**31,453**	100.0%	**128,133**	100.0%
Rural Service Regular Vehicles	**0**	-	**20,459**	-	**20,459**	
Total Regular Vehicles	**96,679**	-	**51,912**	-	**148,592**	
Special Service Vehicles [2]	10,107		27,613		37,720	
Total Active Vehicles	**106,786**		**79,525**		**186,312**	

[1] Includes aerial tramway vehicles, Alaska railroad vehicles, automated guideway vehicles, automobiles, cable cars, ferryboats, inclined plane vehicles, jitneys, monorail vehicles, Públicos, taxicabs, and trolleybuses.

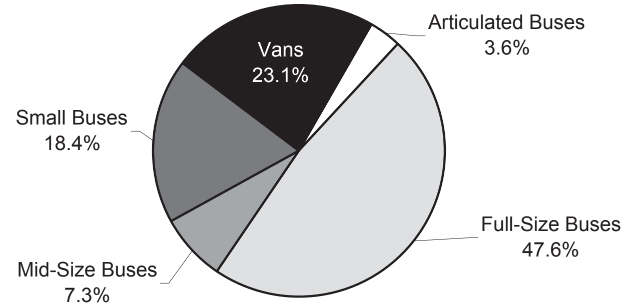
[2] Source: FTA, Fiscal Year Trends Report on the Use of Section 5310 Elderly and Persons with Disabilities Program Funds, 2002.

Source: National Transit Database, except where otherwise noted.

Exhibit 2-22 shows the composition of the Nation's urban transit road vehicle fleet in 2006. The most common type of vehicle is the full-size bus, comprising 47.6 percent of the fleet, followed by vans and small buses, comprising 23.1 percent and 18.4 percent of the fleet, respectively. Articulated buses increased from 3.3 percent in 2004 to 3.6 percent of the total fleet in 2006. Overall, the Nation's urban transit road vehicle fleet has grown by 26.9 percent, which is more than 20,000 vehicles, since 1997. The largest component of growth in the Nation's urban transit road vehicle fleet between 1997 and 2006 has come from small-size buses, which have more than doubled in number since 1997. This is largely driven by an increase in paratransit and demand response vehicles coupled with ADA compliance requirements that would have still been in the early stages of maturity in 1997. The number of full-size buses, by contrast, has remained nearly constant during that same time, and even realized a slight decline over the last reporting period (1.8 percent). For more information on the composition of the Nation's urban transit road vehicle fleet, please see Chapter 3.

Exhibit 2-22

Composition of Urban Transit Road Vehicle Fleet, 2006



Source: Transit Economic Requirements Model and National Transit Database.

Q&A

What are the characteristics of the rural service vehicles and the special service vehicles listed in *Exhibit 2-21*?

Rural service vehicles are vehicles used for regular service that are owned by operators receiving funding from FTA as directed by Title 49—United States Code, Section 5311. These funds are for the provision of transit services in areas with populations of less than 50,000, and these transit operators do not currently report to the NTD.

Special service vehicles are vehicles that are used to provide service to the elderly and disabled, and receive funding from FTA as directed by Title 49—United States Code, Section 5310. Special service vehicle funding is directed toward private nonprofit organizations, although in certain cases specified by law, a public agency may be approved as a grantee. Special service vehicles are not included in the demand response mode (as defined in the fourth Q&A box in this section); recipients of funding for special service vehicles do not report to the NTD. In 2002 (the most recent year available), there were 16,219 special service vehicles in service purchased with FTA funds in both urban and rural areas.

There may be a few rare cases where a single agency receives both rural service vehicle funding and special service vehicle funding, resulting in a few cases of double-counting of vehicles. Additionally, both rural service and special service vehicles include vehicles in American Samoa, Guam, the Northern Marianas, and the Virgin Islands, which do not have urbanized area transit agencies that report to the NTD.

Track, Stations, and Maintenance Facilities

In 2006, there were 813 maintenance facilities for all transit modes in urban areas, compared with 793 in 2004. The number of light rail maintenance facilities increased from 38 in 2004 to 43 in 2006 and the number of heavy rail increased from 55 to 57. Over this same period, the number of bus maintenance facilities increased from 516 to 526, while the number of demand response vehicle maintenance facilities increased only slightly from 103 to 104 [*Exhibit 2-23*].

In 2006, transit providers operated 11,796 miles of track and served 3,053 stations, compared with 10,892 miles of track and 2,961 stations in 2004. For 2006, similar to 2004, a significant portion of the increase in these transit track and station assets was for light rail service. Light rail track increased from 1,321 miles in 2004 to 1,464 miles in 2006, and the light rail stations increased from 723 to 764. The Nation's urban transit rail system infrastructure, however, continues to be dominated by commuter

Exhibit 2-23

Maintenance Facilities for Directly Operated Services, 2006

	Areas Over 1 Million in Population	Areas Under 1 Million in Population	Total
Maintenance Facilities [1]			
Heavy Rail	57	0	57
Commuter Rail	62	0	62
Light Rail	36	7	43
Other Rail [2]	3	4	7
Motor Bus	285	241	526
Demand Response	34	70	104
Ferryboat	6	0	6
Other Nonrail [3]	5	3	8
Total Urban Maintenance Facilities	**488**	**325**	**813**
Rural Transit [4]		**510**	**510**
Total Maintenance Facilities	**488**	**835**	**1,323**

[1] *Includes owned and leased facilities.*

[2] *Alaska railroad, automated guideway, cable car, inclined plane, and monorail.*

[3] *Aerial tramway, jitney, and Público.*

[4] *Vehicles owned by operators receiving funding from FTA as directed by 49 USC Section 5311. These funds are for transit services in areas with populations of less than 50,000. (Section 5311 Status of Rural Public Transportation 2000, Community Transportation Association of America, April 2001.)*

Source: National Transit Database.

rail. In 2006, commuter rail systems accounted for 62.8 percent of transit track miles (7,406 miles) and 38.3 percent of transit rail stations (1,169). This reflects the longer distances generally covered by commuter rail. In 2006, heavy rail accounted for 19.3 percent (2,277 miles) of track miles and 34.1 percent of stations (1,042). Heavy rail typically operates in more densely developed areas than commuter rail, and thus has a higher ratio of stations to track miles *[Exhibit 2-24].*

Exhibit 2-24

Transit Rail Mileage and Stations, 2006

	Urbanized Areas Over 1 Million in Population	Urbanized Areas Under 1 Million in Population	Total
Track Mileage			
Heavy Rail	2,277	0	2,277
Commuter Rail	7,139	267	7,406
Light Rail	1,389	75	1,464
Other Rail and Tramway *	32	617	649
Total Urbanized Area Track Mileage	**10,837**	**959**	**11,796**
Stations			
Heavy Rail	1,042	0	1,042
Commuter Rail	1,141	28	1,169
Light Rail	702	62	764
Other Rail and Tramway *	46	32	78
Total Urbanized Area Transit Rail Stations	**2,931**	**122**	**3,053**

* *Alaska railroad, automated guideway, cable car, inclined plane, monorail, and aerial tramway.*

Source: National Transit Database.

System Coverage: Urban Directional Route Miles

The extent of the coverage of the Nation's transit system is measured in directional route miles, or simply "route miles." Route miles measure the distance covered by a transit route; transit routes that use the same road or track are counted twice. Route miles are not collected for demand response and vanpool modes, since these transit modes do not travel along specific predetermined routes. Route miles are also not collected for jitney services, since these transit modes often have highly variable route structures.

In the United States in 2006, 223,489 urban route miles were provided by nonrail, which is consistent with 2004 data (at 216,619 urban route miles). Rail modes provided 10,865 urban route miles, an increase from 9,782 in 2004 [*Exhibit 2-25*]. Bus modes, which cover a wider area than rail modes, accounted for 94.9 percent of urban route miles in 2006. Rail modes cover smaller areas, typically providing higher-frequency service on the same route and producing fewer directional route miles.

Exhibit 2-25

Transit Urban Directional Route Miles, 1997–2006

							Average Annual Rate of Change	
	1997	1999	2000	2002	2004	2006	2006/1997	2006/2004
Rail	**8,602**	**9,170**	**9,222**	**9,484**	**9,782**	**10,865**	**2.6%**	**5.4%**
Commuter Rail [1]	6,393	6,802	6,802	6,923	6,875	6,972	1.0%	0.7%
Heavy Rail	1,527	1,540	1,558	1,572	1,597	1,623	0.7%	0.8%
Light Rail	659	802	834	960	1,187	1,280	7.7%	3.8%
Other Rail [2]	24	27	29	30	123	989	51.4%	183.9%
Nonrail [3]	**185,164**	**195,984**	**196,858**	**225,820**	**216,619**	**223,489**	**2.1%**	**1.6%**
Bus	184,248	195,022	195,884	224,838	215,571	222,445	2.1%	1.6%
Ferryboat	496	533	505	513	623	620	2.5%	-0.2%
Trolleybus	420	430	469	468	425	424	0.1%	-0.1%
Total	**193,766**	**205,154**	**206,080**	**235,304**	**226,401**	**234,354**	**2.1%**	**1.7%**
Percent Nonrail	95.6%	95.5%	95.5%	96.0%	95.7%	95.4%		

[1] *Includes Alaska Rail.*

[2] *Automated guideway, inclined plane, cable car, and monorail.*

[3] *Excludes jitney, P úblico, and vanpool.*

Source: National Transit Database.

Total route miles increased at an average annual rate of 2.1 percent between 1997 and 2006 and 1.7 percent between 2004 and 2006. Reported motor bus miles increased to 222,445 after reported miles in 2004 were 215,571. Rail route miles increased at an average annual rate of 2.6 percent between 1997 and 2006, and at a 5.4 percent average annual rate from 2004 to 2006. Light rail route miles have grown the most rapidly, reflecting new systems and extensions to existing systems that have become operational. Light rail route miles increased at an average annual rate of 7.7 percent between 1997 and 2006, increasing at a slower pace from 2004 to 2006 of 3.8 percent.

System Capacity

Transit system capacity, particularly in cross-modal comparisons, is typically measured by capacity-equivalent vehicle revenue miles (capacity-equivalent VRMs). Capacity-equivalent VRMs measure the distance traveled by transit vehicles in revenue service, adjusted by the passenger-carrying capacity of each transit vehicle type, with the average carrying capacity of motor bus vehicles representing the baseline.

Exhibit 2-26 provides VRMs, unadjusted by passenger-carrying capacity. These numbers are of interest because they show the actual number of miles traveled by each mode in revenue service. The shares of unadjusted VRMs provided by bus services and rail services are relatively consistent between 1997 and 2006. In 2006, nonrail modes accounted for 72.8 percent and rail modes accounted for 27.2 percent of unadjusted VRMs. As subsequent paragraphs will show, however, the share of VRMs on rail modes, adjusted for capacity, is considerably higher than the share before adjustment.

Exhibit 2-26

Vehicle Revenue Miles, 1997 –2006

Mode	(Millions)						Average Annual Rate of Change	
	1997	1999	2000	2002	2004	2006	2006/ 1997	2006/ 2004
Rail	**811**	**854**	**880**	**925**	**962**	**997**	**2.3%**	**1.8%**
Heavy Rail	540	561	578	603	625	634	1.8%	0.7%
Commuter Rail	230	243	248	259	269	287	2.5%	3.3%
Light Rail	40	47	51	60	67	73	6.9%	4.4%
Other Rail	2	2	2	3	2	3	4.2%	20.1%
Nonrail	**2,042**	**2,257**	**2,322**	**2,502**	**2,586**	**2,674**	**3.0%**	**0.3%**
Motor Bus	1,606	1,719	1,764	1,864	1,885	1,910	1.9%	0.7%
Demand Response	350	418	452	525	561	607	6.3%	4.0%
Vanpool	40	60	62	71	78	110	11.9%	19.0%
Ferryboat	2	2	2	3	3	3	3.6%	-4.2%
Trolleybus	13	14	14	13	13	12	-1.1%	-4.8%
Other Nonrail	31	44	28	26	46	32	0.3%	-16.6%
Total	**2,853**	**3,111**	**3,202**	**3,427**	**3,548**	**3,671**	**2.8%**	**1.7%**
Percent Rail	28.4%	27.4%	27.5%	27.0%	27.1%	27.2%		

Source: National Transit Database

The 2006 capacity-equivalent factors for each mode are shown in *Exhibit 2-27*. Unadjusted VRMs for each mode are multiplied by a capacity-equivalent factor in order to calculate capacity-equivalent VRMs. These factors are equal to the average full-seating and full-standing capacities of vehicles in active service for each transit mode divided by the full-seating and full-standing capacities of all motor bus vehicles in active service. For vehicles that prohibit standing, as is the case of some commuter rail systems, standing capacity is assumed to be zero. The capacity-equivalent factors used in the 2006 and this report differ slightly from those in the 2004 C&P Report. Capacity-equivalent VRMs are now calculated by using a unique capacity-equivalent factor for each year based on the full-seating and full-standing capacities reported for that year to the NTD. The 2004 C&P Report used capacity-equivalent factors based on full-seating and full-standing capacities for an average of the last 3 years of the data used in that report.

Exhibit 2-27

2006 Capacity-Equivalent Factors by Mode

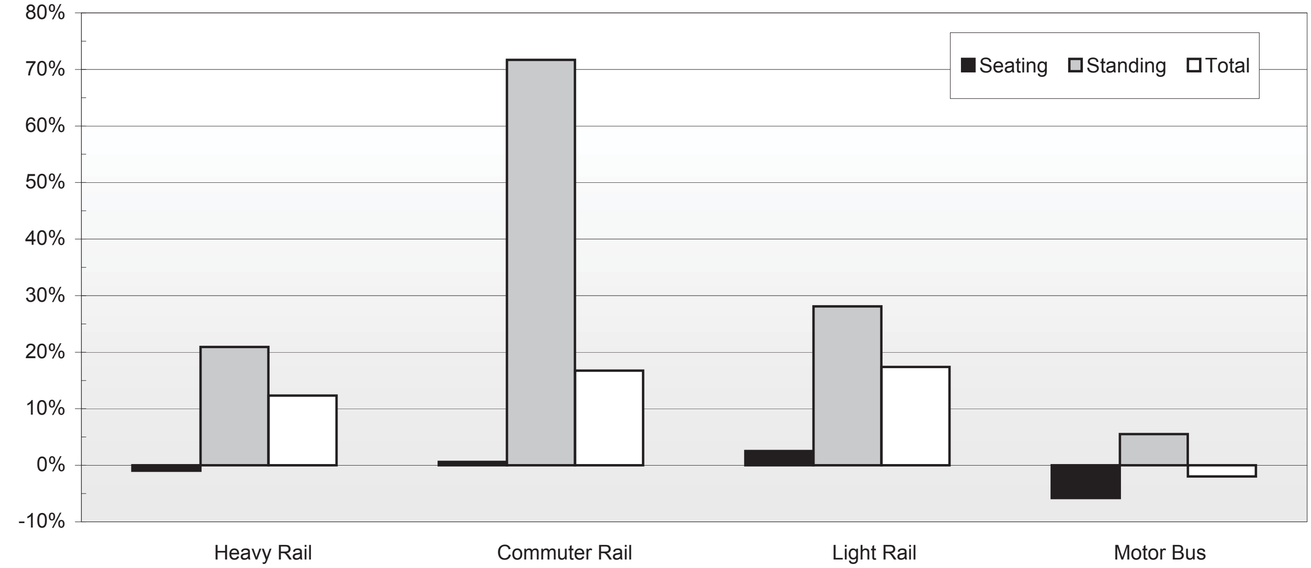
Base = Average Motorbus Vehicle Capacity			
Automated Guideway	1.4	Jitney	NA
Alaska Railroad	1.0	Light Rail	2.7
Cable Car	0.8	Motor Bus	1.0
Commuter Rail	2.9	Monorail	1.9
Demand Response	0.2	Público	0.3
Ferryboat	13.3	Trolleybus	1.6
Heavy Rail	2.6	Aerial Tramway	NA
Inclined Plane	0.9	Vanpool	0.2

Source: National Transit Database.

Since 1997, the capacity-equivalent factors of the major rail modes have increased significantly, largely as a result of increased standing capacity. *Exhibit 2-28* shows the percentage change in seating, standing, and

Exhibit 2-28

Change in Vehicle Capacity, 1997 –2006



Source: National Transit Database.

total capacity for the four largest transit modes since 1997. The average seating capacity for motor bus has declined in part through the addition of many more small buses to the motor bus fleet. At the same time, the capacity of rail mode vehicles has increased through the purchase of larger vehicles, and the removal of seats from existing vehicles for the expansion of standing capacity.

Total capacity-equivalent VRMs are shown in *Exhibit 2-29*. In 2006, nonrail modes accounted for only 44.1 percent of capacity-equivalent VRMs, while rail modes accounted for 54.9 percent of capacity-equivalent VRMs. For all modes, capacity-equivalent VRMs increased at an average annual rate of 3.5 percent between 1997 and 2006 and 3.5 percent between 2004 and 2006. Rail capacity-equivalent

Exhibit 2-29

Capacity-Equivalent Revenue Vehicle Miles, 1997 –2006

	(Millions)						Average Annual Rate of Change	
Mode	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2006/ 1997**	**2006/ 2004**
Rail	**1,801**	**1,936**	**2,046**	**2,274**	**2,413**	**2,681**	**4.5%**	**5.4%**
Heavy Rail	1,183	1,247	1,321	1,469	1,546	1,648	3.8%	3.2%
Commuter Rail	522	572	595	652	685	832	5.3%	10.2%
Light Rail	92	114	127	150	179	197	8.9%	4.9%
Other Rail	4	4	3	3	3	4	-0.5%	18.7%
Nonrail	**1,720**	**1,862**	**1,908**	**2,037**	**2,064**	**2,118**	**2.3%**	**1.3%**
Motor Bus	1,606	1,719	1,764	1,864	1,885	1,910	1.9%	0.7%
Demand Response	56	72	76	100	101	121	8.9%	9.5%
Vanpool	8	11	11	15	15	22	12.6%	21.5%
Ferryboat	24	30	30	32	32	37	4.7%	6.7%
Trolleybus	19	19	20	20	20	19	0.0%	-2.3%
Other Nonrail	8	11	7	7	12	10	2.3%	-9.5%
Total	**3,521**	**3,799**	**3,954**	**4,311**	**4,478**	**4,800**	**3.5%**	**3.5%**

Source: National Transit Database.

VRMs increased at an average annual rate of 4.5 percent between 1997 and 2006 and 5.4 percent between 2004 and 2006. Among the rail modes, light rail capacity-equivalent VRMs have grown the most rapidly, increasing from 92 million capacity-equivalent VRMs in 1997 to 197 million capacity-equivalent VRMs in 2006, an average annual increase of 8.9 percent, and 4.9 percent between 2004 and 2006.

Capacity-equivalent VRMs for nonrail modes increased at an average annual rate of 2.3 percent between 1997 and 2006 and 1.3 percent between 2004 and 2006. The most rapid expansion in capacity-equivalent VRMs has been for vanpools, growing from 8 million in 1997 to 22 million in 2006, at an average annual rate of 12.6 percent, and 21.5 percent between 2004 and 2006.

The ADA spurred a rapid expansion of demand response capacity-equivalent VRMs, which increased at an average annual rate of 8.9 percent from 1997 to 2006 and continued to increase from 2004 to 2006 by 9.5 percent.

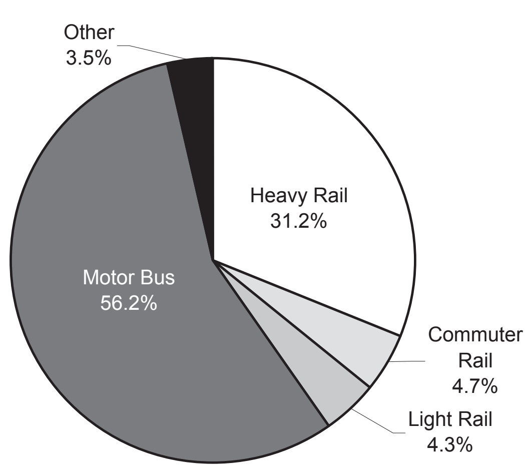
Ridership

There are two primary measures of transit ridership—unlinked passenger trips and passenger miles traveled (PMT). An unlinked passenger trip is defined as a journey on *one* transit vehicle. Passenger miles traveled are calculated on the basis of unlinked passenger trips and estimates of average trip length based on surveys. Either measure provides an appropriate time series since average trip lengths, according to mode, have not changed substantially over time. Cross-modal comparisons, however, may differ substantially depending on which measure is used.

Exhibits 2-30 and *2-31* show the distribution of unlinked passenger trips and PMT by mode. In 2006, there were 9.4 billion unlinked trips and 49.5 billion PMT. Fifty-six and two tenths percent of unlinked trips were on motor buses, 31.2 percent were on heavy rail, 4.7 percent were on commuter rail, 4.3 percent were on light rail, and 3.5 percent were on other. By comparison, 41.2 percent of PMT in 2006 were on motor bus; 29.7 percent were on heavy rail; 20.9 percent were on commuter rail; and 3.8 and 4.4 percent, respectively, were on light rail and other modes. While unlinked passenger trips and PMT both increased by approximately 6 percent, the allocation across the modes remained relatively unchanged.

Exhibit 2-30

Modal Distribution of 9.4 Billion Unlinked Passenger Trips in 2006

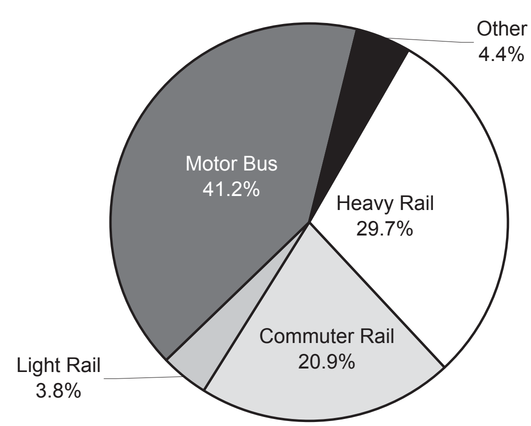


Note: "Other" includes Alaska railroad, automated guideway, cable car, demand response, ferryboat, inclined plane, monorail, Público, and trolleybus.

Source: National Transit Database.

Exhibit 2-31

Modal Distribution of 49.5 Billion Passenger Miles Traveled in 2006



Note: "Other" includes Alaska railroad, automated guideway, cable car, demand response, ferryboat, inclined plane, monorail, Público, and trolleybus.

Source: National Transit Database.

What factors affect transit ridership?

Transit ridership is composed of two segments, "transit-dependent riders" and "choice riders."

"Transit-dependent riders" are those riders without ready access to a personal vehicle. Many of these riders live in low-income households and cannot afford the expense of private vehicle ownership. Others chose to forego the costs of private vehicle ownership, as the local transit system provides sufficient mobility to workplaces, shopping centers, places of worship, and other activity centers. Transit-oriented development is a key factor in boosting transit-dependent ridership.

"Choice riders" are those who have access to a private vehicle, but choose to use transit based on the quality of transit service and the cost savings of using transit for the trip instead of a private vehicle. The quality of transit service depends upon numerous factors, including the frequency, reliability, and overall speed of service. Also important is whether the vehicles and transit stops are comfortable, clean, safe, and secure. Additionally, the ease of access to the route network and the clarity of the route network and schedule are important quality factors.

Transit ridership increases when transit, compared with a private vehicle, provides a savings in money, time, or both. Transit ridership will typically decrease after a fare increase, while transit ridership will often increase after an increase in gasoline prices or parking costs. Likewise, increasing congestion on roads and highways can boost transit ridership, particularly on modes with exclusive guideways, while adding stops in the middle of transit routes can cause ridership to decrease at outlying route points as the overall speed of service decreases.

A statistical analysis by FTA found a positive relationship between changes in employment in an area and transit use in the area. As approximately 50 percent of all transit trips are used to get to and from work, reduced unemployment in an area may boost transit ridership as more people in the area make daily trips to work. Additionally, total employment in an area typically rises concomitant with population growth, and increasing population in an area increases the overall market size available to transit. Research on the factors that affect transit ridership is ongoing; additional linkages are under examination, such as the connection between household income and transit ridership.

Exhibit 2-32 provides total PMT for selected years between 1997 and 2006. PMT increased at an average annual rate of 2.3 percent between 1997 and 2006, growing from 40.2 billion miles in 1997 to 49.5 billion

Exhibit 2-32

Transit Urban Passenger Miles, 1997 –2006

	(Millions)						Average Annual Rate of Change	
Mode	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2006/ 1997**	**2006/ 2004**
Rail	**21,138**	**22,875**	**24,603**	**24,616**	**25,668**	**26,972**	**2.7%**	**2.5%**
Heavy Rail	12,056	12,902	13,844	13,663	14,354	14,721	2.2%	1.3%
Commuter Rail	8,037	8,764	9,400	9,500	9,715	10,359	2.9%	3.3%
Light Rail	1,024	1,190	1,340	1,432	1,576	1,866	6.9%	8.8%
Other Rail[1]	21	19	20	22	22	25	2.2%	7.5%
Nonrail	**19,042**	**20,404**	**20,498**	**21,328**	**20,878**	**22,533**	**1.9%**	**3.9%**
Motor Bus	17,509	18,684	18,807	19,527	18,921	20,390	1.7%	3.8%
Demand Response	531	559	588	651	704	753	4.0%	3.4%
Vanpool	310	413	407	455	459	689	9.3%	22.5%
Ferryboat	254	295	298	301	357	360	3.9%	0.4%
Trolleybus	189	186	192	188	173	164	-1.6%	-2.7%
Other Nonrail[2]	249	267	205	206	265	176	-3.8%	-18.4%
Total	**40,180**	**43,279**	**45,101**	**45,944**	**46,546**	**49,504**	**2.3%**	**3.1%**
Percent Rail	52.6%	52.9%	54.6%	53.6%	55.1%	54.5%		

[1] *Alaska railroad, automated guideway, cable car, inclined plane, and monorail.*

[2] *Aerial tramway and Público.*

Source: National Transit Database.

miles in 2006. This rate of growth has increased in recent years, averaging 3.1 percent between 2004 and 2006. PMT on all rail modes combined has an average annual rate of change of 2.7 percent between 1997 and 2006, yet this continues to be significantly higher than the 1.9 percent average annual growth rate on all nonrail modes. As a result of this divergence, the share of PMT served by rail modes increased from 52.6 percent in 1997 to 54.5 percent in 2006.

The fastest growth in PMT has been on modes with low levels of ridership in 1997 and which have experienced rapid growth in capacity since then. PMT on vanpools grew the most rapidly between 1997 and 2006, at an average annual rate of 9.3 percent, and 22.5 percent between 2004 and 2006, as transit agencies expanded their offerings of this service to commuters. PMT on light rail also grew significantly, at an average annual rate of 6.9 percent between 1997 and 2006, and 8.8 percent between 2004 and 2006, as new light rail systems and extensions were opened. PMT on demand response systems has also grown rapidly, increasing at an average annual rate of 4.0 percent between 1997 and 2006, and 3.4 percent between 2004 and 2006.

Rural Transit Systems (Section 5311 Providers)

Rural operators are defined as those providing service outside urbanized areas or to areas with populations of less than 50,000. The information on rural systems presented here is taken from *Status of Rural Public Transportation 2000*, prepared for FTA and released in April 2001, which is the most recent data available on rural transit. This section has not been updated since the last edition of this report.

The *Status of Rural Public Transportation 2000* report was based on a 1997 comprehensive listing of U.S. rural transit operators, compiled by the Institute for Economic and Social Measurement from State Departments of Transportation, and on surveys conducted by the Community Transportation Association of America (CTAA) for FTA in 1999 and 2000. A total of 108 rural transit operators responded to the 1999 survey, and a total of 50 operators responded to the 2000 survey. Although survey respondents provided information covering different 12-month periods, with commencement dates ranging from June 1997 to June 1999, the data sets were combined for purposes of analysis.

Q&A

How are transit route miles and ridership in rural areas classified when they are associated with an agency that also operates in an urbanized area?

Transit agencies that operate in both urbanized and rural areas report data to the NTD for both areas combined. These combined data are included in NTD statistics for urbanized areas.

FTA instituted rural reporting to the NTD in 2006. In 2006, there were 1,327 rural transit operators, an increase of 112 since 2000. The average fleet size of active vehicles for 2006 was reported to be 15, compared with the 2000 sample (150 responses) of 17.5. Total rural fleet size was estimated to have increased from 12,223 vehicles in 1994 to 20,459 in 2006, of which 14,177 are ADA-accessible vehicles (almost 70 percent). For rural transit operators in 2006, operators incurred on average 345,931 vehicle miles.

Rural systems provide both traditional fixed-route and demand response services, with 1,146 demand response services, 180 motor bus services, and one vanpool service operator. Approximately 8.7 percent of rural systems also coordinate van or carpooling programs.

Transit System Characteristics for Americans With Disabilities and the Elderly

The ADA is intended to ensure that persons with disabilities have access to the same facilities and services as other Americans, including transit vehicles and facilities. This equality of access is brought about through the upgrading of transit vehicles and facilities on regular routes, through the provision of demand response transit service for those individuals who are still unable to use regular transit service, and through special service vehicles operated by private entities and some public organizations, often with the assistance of FTA funding.

Since the passage of the ADA in 1990, transit operators have been working to upgrade their regular vehicle fleets and improve their demand response services in order to meet the ADA's requirement to provide persons with disabilities a level of service comparable to the level provided to nondisabled persons using fixed-route systems. U.S. Department of Transportation (DOT) regulations provide minimum guidelines and accessibility standards for buses; vans; and heavy, light, and commuter rail vehicles. For example, commuter rail transportation systems are required to have at least one accessible car per train and all new cars must be accessible. The ADA deems it discriminatory for a public entity providing a fixed-route transit service to provide disabled individuals with services that are inferior to those provided to nondisabled individuals.

The percentage of transit vehicles that are ADA-compliant is increasing as old vehicles are retired and new vehicles are purchased with ADA compliance in mind. In 2006, 80.2 percent of all transit vehicles reported to the NTD were ADA-compliant. This percentage has slightly increased, from 78.9 percent in 2004, and is significantly greater than the 73.3 percent reported for 2000. The percentage of vehicles compliant with the ADA for each mode is shown in *Exhibit 2-33*.

Exhibit 2-33

Urban Transit Operators' ADA Vehicle Fleets by Mode, 2006

Mode	Active Vehicles	ADA-Compliant Vehicles	Percent of Active Vehicles ADA-Compliant
Rail			
Heavy Rail	11,083	10,511	94.8%
Commuter Rail	5,956	3,642	61.1%
Light Rail	1,830	1,486	81.2%
Alaska Railroad	43	18	41.9%
Automated Guideway	87	51	58.6%
Cable Car	40	0	0.0%
Inclined Plane	8	6	75.0%
Monorail	8	8	100.0%
Total Rail	**19,055**	**15,722**	**82.5%**
Nonrail			
Motor Bus	63,176	62,315	98.6%
Demand Response	27,954	19,820	70.9%
Vanpool	8,068	180	2.2%
Ferryboat	111	92	82.9%
Trolleybus	615	575	93.5%
Publico	4,118	0	0.0%
Total Nonrail	**104,042**	**82,982**	**79.8%**
Total All Modes	**123,097**	**98,704**	**80.2%**

Source: National Transit Database.

In addition to the services provided by urban transit operators, about 4,836 private and nonprofit agencies received FTA Section 5310 funding for the provision of "special" transit services (i.e., demand response) to persons with disabilities and the elderly. A recent survey by the University of Montana found that in 2002 there were 4,836 private and nonprofit agencies that received FTA Section 5310 funding, compared with 3,673 agencies reported by a CTAA survey in 1993. These providers include religious organizations, senior citizen centers, rehabilitation centers, the American Red Cross, nursing homes, community action centers, sheltered workshops, and coordinated human services transportation providers.

In 2002, the most recent year for which data are available, these providers were estimated to be using 37,720 special service vehicles. Approximately 62 percent of these special service providers were in rural areas, and 38 percent were in urbanized areas. Data collected by FTA show that approximately 76 percent of the vehicles purchased in FY 2002 were wheelchair accessible, about the same as in the previous few years.

In 2006, 71.9 percent of total transit stations were ADA-compliant. The NTD began collecting data on the ADA compliance of transit stations in 2002, and it has taken some time to ensure that this information is correctly reported. Therefore, data on total station compliance provided in previous reports may not be directly comparable to data provided in this report, due to improvements in reporting quality. The ADA requires that new transit facilities and alterations to existing facilities be accessible to the disabled [*Exhibit 2-34*].

Exhibit 2-34

Urban Transit Operators' ADA-Compliant Stations by Mode, 2006

Mode	Total Stations	ADA Compliant Stations	Percent of Stations ADA Compliant
Rail			
Heavy Rail	1,042	479	46.0%
Commuter Rail	1,169	712	60.9%
Light Rail	764	635	83.1%
Alaska Railroad	10	10	100.0%
Automated Guideway	48	47	97.9%
Inclined Plane	8	7	87.5%
Monorail	2	2	100.0%
Total Rail	**3,043**	**1,892**	**62.2%**
Nonrail			
Motor Bus	1,308	1,221	93.3%
Ferryboat	68	63	92.6%
Trolleybus	5	5	100.0%
Total Nonrail	**1,381**	**1,289**	**93.3%**
Total All Modes	**4,424**	**3,181**	**71.9%**

Source: National Transit Database.

Under the ADA, FTA was given responsibility for identifying "key rail stations" and facilitating the accessibility of these stations to disabled persons by July 26, 1993. Key rail stations are identified on the basis of the following criteria:

- The number of passengers boarding at the key station exceeds the average number of passengers boarding on the rail system as a whole by at least 15 percent.
- The station is a major point where passengers shift to other transit modes.
- The station is at the end of a rail line, unless it is close to another accessible station.
- The station serves a "major" center of activities, including employment or government centers, institutions of higher education, and major health facilities.

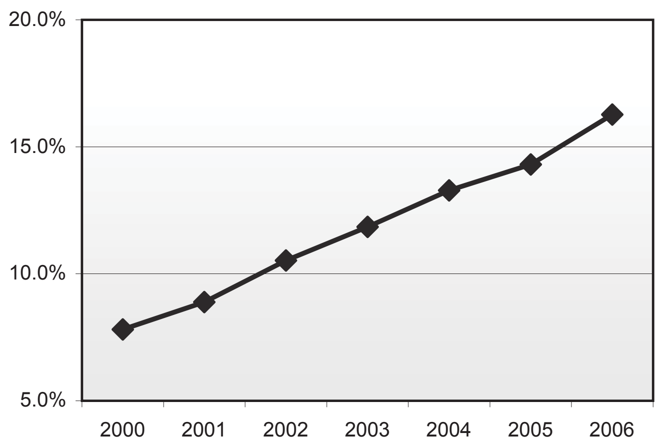
Although ADA legislation required all key stations to be accessible by July 26, 1993, the DOT ADA regulation in Title 49—*Code of Federal Regulations* (CFR), Part 37.47(c)(2), permitted the FTA Administrator to grant extensions up to July 26, 2020, for stations requiring extraordinarily expensive structural modifications to bring them into compliance. In 2006, there were 687 key rail stations, of which 27 stations (3.9 percent) were under FTA-approved time extensions. The total number of key rail stations has changed slightly over the years as certain stations have merged or closed and as other key rail stations have opened. Out of the 660 key rail stations that are not under an FTA-approved time extension, 632 stations (95.8 percent) have been determined to be ADA-accessible. A total of 321 stations (48.6 percent) are both ADA-accessible and have been found by FTA to be fully ADA-compliant. Another 311 stations (47.1 percent) are ADA-accessible, but are either not fully ADA-compliant or have not been reviewed by FTA for a determination that they are not fully compliant. Only 28 out of the 660 stations not under an FTA-approved time extension (4.2 percent) are not yet ADA-accessible. FTA continues to focus its attention on the 28 stations that are not under a waiver and not fully accessible, as well as on the 27 stations whose waivers will be expiring in the coming years.

Transit System Characteristics: Special Interests

Exhibit 2-35 presents an increase in the share of alternative fuel buses from 7.8 percent in 2000 to 16.3 percent in 2006. In 2006, 12.2 percent of buses used compressed natural gas, 2.0 percent used bio-diesel, 1.6 percent used liquefied natural gas, and 0.5 percent used other alternative fuels (e.g., electricity, ethanol, etc.). Conventional fuel buses, which comprise the majority of the U.S. bus fleet, utilized diesel fuel and gasoline.

Exhibit 2-35

Change in Percentage of Urban Bus Fleet Using Alternative Fuels, 2000 –2006



Source: National Transit Database.

Comparison

Exhibit 2-36 summarizes the key findings in this chapter, comparing system and use characteristics data in this report with the 2004 values shown in the 2006 C&P Report. Some of the 2004 values have subsequently been revised, which is reflected in the second column as appropriate. The third column contains comparable values based on 2006 data.

Exhibit 2-36

Comparison of System and Use Characteristics With Those in the 2006 C&P Report

	2004 Data		
Statistic	**2006 C&P Report**	**Revised**	**2006 Data**
Percentage of Total Highway Miles Owned by Local Governments	76.5%		76.5%
Percentage of Total Highway Miles Owned by State Governments	20.4%		20.3%
Percentage of Total Highway Miles Owned by the Federal Government	3.1%		3.2%
Local Transit Operators in Urbanized Areas	640		657
Rural and Specialized Transit Service Providers	6,051		6,163
Total Rural Highway Miles (Under 5,000 in Population)	3.00 million		2.99 million
Total Urban Highway Miles (5,000 or more in Population)	0.99 million		1.04 million
Total Highway Miles	3.99 million		4.033 million
Transit Route Miles (Rail)	9,782		10,865
Transit Route Miles (Nonrail)	216,620	216,619	223,489
Total Transit Route Miles	226,402	226,401	234,354
Total Rural Highway Lane Miles (Under 5,000 in Population)	6.15 million		6.12 million
Total Urban Highway Lane Miles (5,000 or more in Population)	2.23 million		2.34 million
Total Highway Lane Miles	8.37 million		8.45 million
Urban Transit Capacity-Equivalent Vehicle Miles (Rail)	2.41 billion		2.68 billion
Urban Transit Capacity-Equivalent Vehicle Miles (Nonrail)	2.06 billion		2.11 billion
Urban Transit Capacity-Equivalent Vehicle Miles (Total)	4.48 billion		4.80 billion
Vehicle Miles Traveled on Rural Highways (Under 5,000 in Population)	1.07 trillion		1.04 trillion
Vehicle Miles Traveled on Urban Highways (5,000 or more in Population)	1.91 trillion		1.99 trillion
Vehicle Miles Traveled on All Highways	2.98 trillion		3.03 trillion
Transit Urban Passenger Miles (Rail)	25.7 billion		27.0 billion
Transit Urban Passenger Miles (Nonrail)	20.9 billion		22.5 billion
Transit Urban Passenger Miles (Total)	46.5 billion		49.5 billion

Highway

There were 4.03 million miles of public roads in the United States in 2006, of which 2.99 million miles were in rural areas (rural areas are defined as locations with populations of less than 5,000 people and urban communities are defined as those areas with populations of 5,000 or more). Local governments controlled 76.5 percent of total highway miles in 2006; States controlled 20.3 percent; and the Federal government owned 3.2 percent. Consequently, the Nation's highway system is overwhelmingly *rural* and *local.*

Total highway lane mileage went from 8.37 million in 2004 to 8.45 million in 2006. Total lane miles have increased at an average annual rate of about 0.3 percent since 1997, mostly in urban areas. Urban lane mileage grew from 2.2 million in 2004 to more than 2.3 million in 2006. Rural lane mileage decreased slightly from 6.15 million in 2004 to 6.12 million in 2006. Some of this change can be attributed to the 2000 census and the resulting functional classification shifts from rural to urban areas.

The total number of vehicle miles traveled (VMT) between 1997 and 2006 has increased at a 2.1-percent average annual rate versus 2.5 percent for the period of 1995 to 2004 as presented in the previous C&P report. Rural highways remained at approximately 1 trillion VMT while urban roads increased to almost 2 trillion VMT. The most significant change occurred in the small urban areas, which experienced an average annual increase of 4.2 percent. The total VMT in rural areas decreased by 0.03 trillion VMT from 2004 to 2006. Total traffic increased in urban areas by nearly 0.08 trillion VMT between 2004 and 2006.

Bridge

In 2006, there were 597,562 bridges that were over 6.1 meters (20 feet) in total length on public roads in the United States, an increase from 594,101 bridges in 2004. While 75.5 percent of bridges are located in rural areas, 74.7 percent of the daily traffic on bridges is carried by the urban structures.

In comparison, 2006 figures show a decrease in the share of bridges located in rural areas from the 2004 level of 76.8 percent to the 2006 level of 74.7 percent. Daily traffic on bridges in urban areas increased from 72.6 percent in 2004 to 74.7 percent in 2006. This change can be explained in part by the 2000 census boundary changes, reclassifying some areas from rural to urban.

Responsibility for and ownership of bridges is split primarily between State agencies (47.6 percent) and local governments (50.5 percent). Federal agencies own 8,355 bridges nationwide (1.4 percent), and there are a small number of privately owned or railroad-owned bridges carrying public roadways. State agencies tend to own bridges located on roadways with higher functional classifications, such as principal arterials; the majority of local government bridges are located on local and collector roadways.

Transit

Transit system coverage, capacity, and use in the United States continued to increase between 2004 and 2006. In 2006, there were 657 transit operators serving urbanized areas compared with 640 operators in 2004. In 2002, the most recent year for which information is available, there were an estimated 4,836 providers of special transit services to the elderly and disabled in both urban and rural areas. In 2006, there were 1,327 transit operators serving rural areas. A transit provider may be an independent agency; a unit of a regional transportation agency; or a unit of a State, county, or city government.

In 2006, transit agencies in urban areas operated 128,133 vehicles, of which 96,697 were in areas of more than 1 million people. Also in 2006, rail systems had 11,796 miles of rail track and 3,053 rail stations, compared with 10,892 miles of track and 2,961 stations in 2004. The number of bus and rail maintenance facilities in urban areas increased from 793 in 2004 to 813 in 2006.

In 2006, the Federal Transit Administration (FTA) instituted rural reporting to the NTD. Rural operators, last surveyed about their vehicles in 2000, reported utilizing 20,459 transit vehicles in rural areas in 2006. Nearly 70 percent of these vehicles, or 14,177, are accessible as defined by the Americans with Disabilities

Act (ADA). Additionally, the FTA has estimated that in 2002 there were 37,720 special service vehicles operated for the elderly and disabled, of which 16,219 had been funded by the FTA.

In 2006, transit systems operated 234,354 urban directional route miles, of which 223,489 were nonrail and 10,865 were rail route miles. Total route miles increased by 3.5 percent between 2004 and 2006. Nonrail route miles increased by 3.2 percent and rail route miles increased by 11.1 percent.

Transit system capacity as measured by capacity-equivalent vehicle revenue miles (VRM) increased by 7.2 percent in total between 2004 and 2006. Capacity-equivalent VRM measure the distance traveled by a transit vehicle in revenue service, adjusted by the passenger-carrying capacity of each transit vehicle type, with the passenger-carrying capacity of a motorbus representing the baseline. The capacity of rail modes increased by 11.1 percent between 2004 and 2006, and the capacity of nonrail modes by 2.6 percent. In 2006, as in earlier years, slightly more than half of capacity-equivalent VRM were provided by rail modes, and slightly less than half were provided by nonrail modes. Capacity-equivalent VRM provided by light rail systems grew rapidly between 2004 and 2006, increasing in total by 10.1 percent. This largely reflects New Starts openings and extensions.

Transit passenger miles increased by 6.4 percent in total between 2004 and 2006, growing from 46.5 billion to 49.5 billion over that time period. Passenger miles traveled on nonrail modes increased from 20.9 billion in 2004 to 22.5 billion in 2006, or by a total of 7.9 percent. Passenger miles on rail transit modes increased in total by 5.1 percent from 2004 to 2006, increasing from 25.7 billion in 2004 to 27.0 billion in 2006.

Chapter 3

System Conditions

Road Conditions

The condition of the roadway pavement is an important factor in the cost to the public for the transportation of goods, the providing of services, and personal travel. Pavement condition affects costs associated with travel, including vehicle operation, delay, and crash expenses. Poor road surfaces cause additional wear and tear on, or even damage to, vehicle suspensions, wheels, and tires. When vehicles slow down in heavy traffic for potholes or very rough pavement, this can create significant queuing and subsequent delay. Inadequate road surfaces can reduce road friction, which affects the stopping ability and maneuverability of vehicles. Unexpected changes in surface conditions can also increase the probability that crashes may occur.

This section examines the physical conditions of the Nation's roadways, addressing both roadway surface conditions and other condition measures. This information is presented for the National Highway System (NHS) including its Interstate highway system component, and for the overall highway system. Chapter 4 addresses measuring operations performance trends from a broad perspective and Chapter 5 discusses safety performance measures.

Subsequent sections within this chapter explore the physical conditions of bridges and transit systems. This is followed by a section comparing key statistics from the highway, bridge, and transit sections with the information presented in the previous edition of this report.

Pavement Terminology and Measurements

The pavement condition ratings in this section are derived from one of two measures: the International Roughness Index (IRI) or the Present Serviceability Rating (PSR). The IRI measures the cumulative deviation from a smooth surface in inches per mile. The PSR is a subjective rating system based on a scale of 0 to 5. Prior to 1993, all pavement conditions were evaluated using PSR values. A conversion table is used to translate PSR values into equivalent IRI values to classify mileage for the tables in this section.

The FHWA adopted the IRI for the higher functional classifications because it is an objective measurement and is generally accepted worldwide as a pavement roughness measurement. The IRI system results in more consistent data for trend analyses and cross jurisdiction comparisons. *Exhibit 3-1* contains a description of qualitative pavement condition terms and corresponding quantitative PSR and IRI values. The translation between PSR and IRI is not exact; IRI values are based on objective measurements of pavement roughness, while PSR is a subjective evaluation of a broader range of pavement characteristics. For example, a given Interstate pavement section could have an IRI rating of 165, but might be rated a 2.4 on the PSR scale. Such a section would be rated as acceptable based on its IRI rating, but would not have been rated as acceptable had PSR been used. Thus, the mileage

Exhibit 3-1

Pavement Condition Criteria

	All Functional Classifications	
Ride Quality Terms*	**IRI Rating**	**PSR Rating**
Good	< 95	≥ 3.5
Acceptable	≤ 170	≥ 2.5

* The threshold for "Acceptable" ride quality used in this report is the 170 IRI value as set by the FHWA Performance Plan for the NHS. Some transportation agencies may use less stringent standards for lower functional classification highways to be classified as "Acceptable."

Source: Highway Performance Monitoring System (HPMS).

of any given pavement condition category may differ depending on the rating methodology. The historic pavement ride quality data in this report start in 1997, while IRI data only began to be collected in 1993. Caution should be used when making comparisons with older data from earlier editions of this report and when attempting to make comparisons between PSR and IRI data in general.

While this edition of the C&P report retains a summary exhibit based on pavement conditions in terms of mileage to maintain continuity with previous editions, most exhibits are based on the percentage of vehicle miles traveled (VMT) occurring on pavements with good and/or acceptable ride quality.

> **Q&A**
>
> **What are some measures of pavement condition other than IRI?**
>
> Other principal measures of pavement condition or distress such as rutting, cracking, and faulting exist, but are not currently reported in HPMS. However, FHWA has been working with states to determine a reasonable manner to report these items and is moving toward including them in future HPMS data requirements to be reported by the states. Adding these metrics to FHWA's database will enable the agency to account for national pavement needs more accurately.

The *Federal Highway Administration 1998 National Strategic Plan* introduced a new descriptive term for pavement condition: "acceptable ride quality," defined as pavements having an IRI value less than or equal to 170 inches per mile. While the initial target established in this plan was based on the percentage of miles of NHS pavements with acceptable ride quality, this metric was subsequently revised to be based on the percentage of NHS VMT on pavements with acceptable ride quality. In 2006, the FHWA adopted an even more rigorous performance measure, the percentage of NHS VMT pavements meeting the standard for "good ride quality," defined as having an IRI value less than 95 inches per mile. Note that "good" represents a subset of "acceptable" and this report does not apply any specific descriptive label to pavements with IRI values greater than or equal to 95 but less than or equal to 170 inches per mile, which fall within the "acceptable" range but outside the "good" range.

> **Q&A**
>
> **What effect does pavement ride quality have on the economic costs experienced by highway users?**
>
> Among the three major components of highway user costs measured in this report (travel time costs, vehicle operating costs, and crash costs), pavement condition has the most direct impact on vehicle operating costs in the form of increased wear and tear on vehicles and repair costs. Poor pavement can also impact travel time costs to the extent that road conditions force drivers to reduce speed and can have an impact on crash rates. Highway user costs are discussed in more detail in Chapter 7.
>
> As the terms "good ride quality" and "acceptable ride quality" are defined based on a range of IRI values, the impact that pavements classified in these categories would have on highway user costs tends to vary. In general, pavements falling below the acceptable ride quality threshold would tend to have greater impacts on user costs than those classified as having acceptable or good ride quality. However, the relative impacts on user costs of a pavement with an IRI of 169 (acceptable) compared to a pavement with an IRI of 171 (not acceptable) would not be significant. The same would be true for pavements just above or below the good ride quality standard (an IRI of less than or equal to 95). Other factors, such as vehicle speed, can significantly influence the impact that pavement ride quality has on highway user costs.

The Department of Transportation's *FY 2008 Performance and Accountability Report* presents an FY 2008 target of 57 percent for the share of travel on the NHS meeting pavement performance standards for good ride quality. This target was developed based on analyses using the Highway Economic Requirements System (HERS) model, which is discussed in more detail in Chapter 7 and Appendix A. It should be noted that the *FY 2008 Performance and Accountability Report* presents ride quality data on a Federal fiscal year basis, while the C&P report presents comparable data on a calendar year basis in order to retain consistency with the annual *Highway Statistics* publication.

The time required for the IRI on a roadway to transition from one pavement rating category to the next depends heavily on such factors as pavement design, the volume and types of traffic carried by the facility, environmental factors, and the type and frequency of maintenance actions performed on the facility. A new pavement will start at the top of the "Good" category and will, over time, transition to the lower range of that category; at some time in the future the pavement will likely transition to the "Acceptable" category and may move outside of this category, depending on the timing of future resurfacing or reconstruction actions.

Pavement Ride Quality on the National Highway System

As shown in *Exhibit 3-2,* the share of NHS VMT on pavements with good ride quality has risen sharply over time, from approximately 39 percent in 1997 to approximately 57 percent in 2006. The VMT on NHS pavements meeting the less stringent standard of acceptable ride quality grew more slowly, from approximately 89 percent in 1997 to approximately 93 percent in 2006.

Exhibit 3-2

Percent of NHS VMT on Pavements With Good and Acceptable Ride Quality, 1997–2006

	1997	1999	2000	2002	2004	2006
Good (IRI < 95)*	39%	46%	48%	50%	52%	57%
Acceptable (IRI ≤ 170)	89%	91%	91%	91%	91%	93%

**The data reflected in this exhibit are presented on a calendar year basis, consistent with the annual Highway Statistics publication. Some other Departmental documents, such as the FY 2008 Performance and Accountability Report, are based on a Federal fiscal year basis. For example the 57 percent figure identified as "good" for calendar year 2006 in this exhibit, is reported as a fiscal year 2007 value in the FY 2008 Performance and Accountability Report.*

Source: Highway Performance Monitoring System.

As shown in *Exhibit 3-3*, rural NHS routes tend to have better pavement conditions than urban NHS routes, as 73.6 percent of rural NHS VMT in 2006 was on pavements with good ride quality while 47.7 percent of the urban NHS VMT was on pavements with good ride quality. However, the total NHS traffic in urban areas was higher than in rural areas, approximately 0.9 trillion VMT on urban NHS routes versus approximately 0.5 trillion VMT on rural NHS routes.

The share of rural NHS VMT on pavements providing good ride quality increased from 68.0 percent in 2004 to 73.6 percent in 2006. The portion of VMT on rural pavements meeting the standard of acceptable ride quality also grew from 97.0 percent in 2004 to 97.8 percent in 2006. The share of NHS VMT on pavements with good ride quality in urban areas increased from 42.5 percent in 2004 to 47.7 percent in 2006. The urban NHS VMT on acceptable pavements rose from 86.9 percent in 2004 to 90.0 percent in 2006.

Exhibit 3-3

Percent of VMT on NHS Pavements With Good and Acceptable Ride Quality, by Population Area, 2004 vs. 2006

	2004	2006
Rural		
Good (IRI < 95)	68.0%	73.6%
Acceptable (IRI ≤ 170)	97.0%	97.8%
Urban		
Good (IRI < 95)	42.5%	47.7%
Acceptable (IRI ≤ 170)	86.9%	90.0%

Source: Highway Performance Monitoring System.

Interstate Pavement Ride Quality

As described in Chapter 2, the Interstate Highway System constitutes a key subset of the NHS. *Exhibit 3-4* shows the percentage of total Interstate VMT on pavements with good and/or acceptable ride quality broken down by population area subsets. Since 1997, the percentage of VMT on interstate pavements with good ride quality has increased in rural areas, small urban areas, and urbanized areas.

Exhibit 3-4

Percent of Interstate VMT on Pavements With Good and Acceptable Ride Quality, by Population Area, 1997–2006

Quality	1997	1999	2000	2002	2004	2006
Good (IRI < 95)						
Rural Areas	56.5%	66.8%	69.6%	72.2%	73.7%	78.6%
Small Urban Areas	51.4%	52.9%	59.8%	62.5%	65.6%	71.6%
Urbanized Areas	39.1%	35.4%	39.7%	42.5%	48.5%	52.9%
Acceptable (IRI ≤ 170)						
Rural Areas	95.7%	97.4%	97.4%	97.3%	97.8%	98.2%
Small Urban Areas	96.1%	95.9%	95.3%	94.6%	95.7%	96.9%
Urbanized Areas	88.1%	90.4%	91.0%	89.3%	89.9%	92.5%

Source: Highway Performance Monitoring System.

Among the three population area subsets shown, rural Interstates had the highest percentage of VMT on pavements with good ride quality in 2006, at 78.6 percent. A total of 98.2 percent of all VMT on the rural Interstate System occurred on pavements with acceptable ride quality.

The share of small urban Interstate VMT occurring on pavements with good ride quality was 71.6 percent in 2006. The portion of VMT on small urban Interstate pavements with acceptable ride quality was 96.9 percent. For urbanized Interstates, the share of VMT occurring on pavements with good ride quality was 52.9 percent in 2006, while the share of VMT on acceptable ride quality pavements was 92.5 percent.

STRAHNET Pavement Ride Quality

The Strategic Highway Network (STRAHNET) constitutes another key subset of the NHS. The STRAHNET is discussed in more detail in Chapter 2.

As shown in *Exhibit 3-5*, the share of VMT on STRAHNET on pavements providing good ride quality increased from 56.9 percent in 2004 to 61.2 percent in 2006. The portion of VMT on pavements meeting the acceptable standard increased from 93.0 percent in 2004 to 94.6 percent in 2006.

Exhibit 3-5

Percent of STRAHNET VMT on Pavements With Good and Acceptable Ride Quality, 2004 and 2006

	2004	2006
Rural		
Good (IRI < 95)	72.2%	77.3%
Acceptable (IRI ≤ 170)	97.6%	98.2%
Urban		
Good (IRI < 95)	47.6%	52.2%
Acceptable (IRI ≤ 170)	90.3%	92.7%
Rural and Urban		
Good (IRI < 95)	56.9%	61.2%
Acceptable (IRI ≤ 170)	93.0%	94.6%

Source: Highway Performance Monitoring System.

Pavement Ride Quality on Federal-Aid Highways

The Highway Performance Monitoring System collects ride quality data only for Federal-aid highways, which include all functional classes except for rural minor collectors, rural local, and urban local. As described in Chapter 2, these three functional classifications account for approximately three-fourths of the total mileage on the Nation's system, but carry less than one-sixth of the total daily VMT on the Nation's roadway system. Because the focus of this report is on VMT-based measures of ride quality rather than mileage-based measures, the omission of these functional classes from the statistics in this section is less significant.

The terms "good ride quality" and "acceptable ride quality" and the numeric thresholds that were used to describe NHS pavements for FHWA performance planning purposes are utilized in this section for all Federal-aid highways, although these thresholds may be less relevant to lower-ordered functional classes that carry less traffic than the typical route on the NHS. The ride quality for all Federal-aid highways (which include the NHS) tends to be worse on average than the ride quality for the average NHS route.

For those functional classes on which data are collected, the VMT on pavements with good ride quality increased from 39.4 percent in 1997 to 47.0 percent in 2006, as shown in *Exhibit 3-6.* The VMT on pavements meeting the standard of acceptable (which includes the category of good) declined slightly from 86.4 percent in 1997 to 86.0 percent in 2006.

Exhibit 3-6

Percent of VMT on Pavements With Good and Acceptable Ride Quality, 1997–2006

Quality	1997	1999	2000	2002	2004	2006
Good (IRI < 95)	39.4%	41.8%	42.8%	43.8%	44.2%	47.0%
Acceptable (IRI ≤ 170)	86.4%	86.0%	85.5%	85.3%	84.9%	86.0%

Note: Excludes roads functional classified as Rural Minor Collectors, Rural Local, and Urban Local, for which data are not available.

Source: Highway Performance Monitoring System.

Rural and Urban Pavement Ride Quality

When discussing ride quality, it is important to note the different travel characteristics between rural and urban areas. As noted in Chapter 2, rural areas contain about three-fourths of road miles, but support only about one-third of annual national VMT. In other words, although rural areas have a larger percentage of road miles, the majority of travel occurs in urban areas. According to 2006 data, the amount of VMT on pavements rated as having good ride quality in rural areas is higher than those in small urban and urbanized areas. *Exhibit 3-7* shows that 62.2 percent of total VMT in rural areas is on pavement with good ride quality, compared with 44.2 percent of VMT in small urban areas and 38.2 percent of the VMT in urbanized areas.

The share of VMT on pavements with good ride quality in the rural areas has steadily increased from 47.9 percent in 1997 to 62.2 percent in 2006. The percentages of VMT on similar pavements in small urban and urbanized areas have fluctuated during the same period. In small urban areas, the share of VMT on good pavements increased overall from 39.3 percent in 1997 to 44.2 percent in 2006. In urbanized areas, the share of VMT on good pavements increased from 33.5 percent in 1997 to 38.2 percent in 2006.

The portion of VMT on pavements with acceptable ride quality increased from 92.5 percent for 1997 to 94.9 percent for 2006 in rural areas; in small urban areas, the comparable share rose from 84.0 percent to 85.5 percent over the same period of time. In urbanized areas from 1997 through 2004, the portion of VMT on pavements rated in acceptable condition decreased from 82.6 percent to 79.2 percent, but increased in 2006 to 80.6 percent.

Exhibit 3-7

Percent of VMT on Pavements With Good and Acceptable Ride Quality, by Population Area, 1997–2006

	1997	1999	2000	2002	2004	2006
Rural						
Good (IRI < 95)	47.9%	53.0%	55.2%	58.0%	58.3%	62.2%
Acceptable (IRI ≤ 170)	92.5%	93.5%	93.8%	94.1%	94.5%	94.9%
Small Urban						
Good (IRI < 95)	39.3%	40.0%	41.2%	41.6%	41.2%	44.2%
Acceptable (IRI ≤ 170)	84.0%	83.9%	84.1%	84.4%	84.3%	85.5%
Urbanized						
Good (IRI < 95)	33.5%	34.1%	34.3%	34.1%	36.1%	38.2%
Acceptable (IRI ≤ 170)	82.6%	81.0%	79.9%	79.3%	79.2%	80.6%

Source: Highway Performance Monitoring System.

Q&A

Does the impact of poor pavement condition on highway user costs tend to vary by functional class?

Yes. The impact of pavement ride quality on user costs will tend to be higher on the higher functional classification roadways such as Interstate highways than on the roadways with lower functional classifications such as connectors.

The impact of poor ride quality on vehicle operating costs tends to vary with speed. For example, a vehicle encountering a pothole at 55 miles per hour on an Interstate highway would experience relatively more wear and tear than a vehicle encountering an identical pothole on a collector at 25 miles per hour.

Poor ride quality would also tend to have a greater impact on Interstate highways due to their higher traffic volumes. The Interstate System supports the movement of passenger vehicles and trucks at relatively high speeds across the Nation. Poor ride quality can cause drivers to travel at a lower speed than the facility is otherwise capable of supporting, thereby increasing the time of individual trips and adding to congestion. In the case of freight movement, this reduction in travel speed would add to the cost of the delivery of goods.

Poor ride quality on collectors would not have as great an impact on vehicle speeds because the average speed on such facilities is lower to begin with.

Pavement Ride Quality by Functional Classification

Roads classified as Interstate have the largest percentage of VMT per lane mile, followed (in order) by other principal arterials, minor arterials, collectors, and locals. Therefore, improving ride quality on a mile of an Interstate route affects more users than improving ride quality on a mile of road on a lower functional classification.

Exhibit 3-8 shows the percentage of VMT on good and acceptable pavements for each functional class from 1997 to 2006. Since 1997, the percentage of total rural road VMT on pavements with acceptable ride quality has increased for each of the four functional classes of rural roads for which data are available. The functional class of rural major collectors has shown a varied pattern between 1997 and 2006 and has ranged from a low of 86.1 percent in 1999 to a high of 88.5 percent in 2004, with 87.8 percent of VMT on this functional class occurring on roadways with acceptable ride quality in 2006.

Exhibit 3-8

Percent of VMT on Pavements With Good and Acceptable Ride Quality, by Functional System, 1997–2006

Functional System	1997	1999	2000	2002	2004	2006
Percent Good						
Rural Interstate	56.5%	66.8%	69.6%	72.2%	73.7%	78.6%
Rural Principal Arterial	47.0%	54.3%	56.8%	60.2%	61.0%	66.8%
Rural Minor Arterial	43.8%	47.2%	48.9%	51.0%	51.5%	56.3%
Rural Major Collector	41.9%	38.6%	39.9%	42.4%	40.3%	39.8%
Small Urban Interstate	52.9%	59.8%	62.5%	65.1%	65.6%	71.6%
Small Urban Other Freeway & Expressway	38.2%	39.8%	41.6%	48.1%	57.7%	61.4%
Small Urban Other Principal Arterial	32.9%	35.0%	38.0%	37.0%	37.6%	42.2%
Small Urban Minor Arterial	43.6%	39.2%	38.2%	38.5%	33.0%	32.5%
Small Urban Collector	36.6%	36.0%	34.1%	32.8%	30.7%	24.8%
Urbanized Interstate	35.4%	39.7%	42.5%	43.8%	48.5%	52.9%
Urbanized Other Freeway & Expressway	27.4%	31.3%	31.9%	32.8%	37.8%	44.5%
Urbanized Other Principal Arterial	26.1%	24.2%	25.0%	23.8%	24.8%	26.7%
Urbanized Minor Arterial	40.8%	37.8%	33.9%	33.4%	32.2%	33.7%
Urbanized Collector	39.8%	39.9%	38.5%	35.9%	36.4%	35.6%
Percent Acceptable						
Rural Interstate	95.7%	97.4%	97.4%	97.3%	97.8%	98.2%
Rural Principal Arterial	93.8%	95.5%	96.0%	96.2%	96.1%	97.0%
Rural Minor Arterial	92.1%	93.2%	93.1%	93.8%	94.3%	95.1%
Rural Major Collector	87.3%	86.1%	86.9%	87.6%	88.5%	87.8%
Small Urban Interstate	96.1%	95.9%	95.3%	94.6%	95.0%	96.9%
Small Urban Other Freeway & Expressway	92.6%	93.0%	94.4%	95.3%	93.9%	96.0%
Small Urban Other Principal Arterial	80.6%	82.2%	83.3%	83.8%	84.2%	86.7%
Small Urban Minor Arterial	84.0%	81.8%	81.7%	82.1%	77.6%	81.3%
Small Urban Collector	78.7%	76.6%	74.3%	74.9%	66.5%	71.0%
Urbanized Interstate	88.1%	90.4%	91.0%	89.3%	89.9%	92.5%
Urbanized Other Freeway & Expressway	86.9%	87.6%	86.8%	87.4%	87.4%	91.9%
Urbanized Other Principal Arterial	73.3%	68.3%	68.8%	68.8%	70.7%	71.8%
Urbanized Minor Arterial	83.3%	80.2%	75.7%	75.4%	73.1%	74.9%
Urbanized Collector	84.4%	80.1%	76.4%	74.5%	72.4%	72.9%

Source: Highway Performance Monitoring System.

Between 1997 and 2006, the share of VMT on roads with acceptable ride quality varied for the five functional classifications of roadways in small urban areas: the Interstate, other freeway and expressway, and other principal arterial functional classes each saw improvements, while the minor arterial and collector functional classes both experienced declines. In urbanized areas, the percentage of VMT on roads with acceptable ride quality rose for the Interstate and other freeway and expressway functional classes from 1997 to 2006, but declined over this period for the other principal arterial, minor arterial, and collector functional classes. Between 2004 and 2006, the percentage of VMT on pavements with acceptable ride quality for each small urban and urbanized functional class improved.

In rural areas, the percentages of VMT on pavements with good ride quality increased between 1997 and 2006 for the Interstate, other principal arterial, and minor arterial functional classes, but decreased for major collector routes. For both small urban areas and urbanized areas, the percentages of VMT on good ride quality pavements increased for the Interstate, other freeway and expressway, and other principal arterial functional classes, but declined for the minor arterial and collector functional classes. It is possible that the varied pattern shown is the result of the changes in the 2000 census adjustment of boundaries for population areas (rural, small, urban, and urbanized). These changes in the report of the distribution of mileage and VMT in the 2000 census for all population areas continues to have an impact on pavement ride quality. Another source of the change could be the deterioration in overall pavement conditions.

Pavement Ride Quality by Mileage

Exhibit 3-9 shows the pavement ride quality by functional classification from 1997 to 2006 based on mileage, rather than on VMT. Since 1997, the percentage of total rural road mileage of pavement with

Exhibit 3-9

Percent of Mileage With Acceptable and Good Ride Quality, by Functional System, 1997–2006

Functional System	1997	1999	2000	2002	2004	2006
Percent Acceptable						
Rural Interstate	95.9%	97.6%	97.8%	97.8%	98.1%	98.0%
Rural Other Principal Arterial	93.7%	95.4%	96.0%	96.6%	95.8%	96.7%
Rural Minor Arterial	91.5%	93.1%	93.0%	94.2%	93.5%	94.0%
Rural Major Collector	82.1%	81.5%	81.8%	83.2%	83.9%	84.5%
Subtotal Rural Areas	**86.5%**	**86.8%**	**87.1%**	**88.2%**	**88.4%**	**89.0%**
Small Urban Interstate	95.8%	95.4%	95.7%	95.3%	95.5%	96.5%
Small Urban Other Freeway & Expressway	91.2%	92.8%	93.7%	94.8%	93.8%	95.8%
Small Urban Other Principal Arterial	80.5%	81.7%	82.9%	83.0%	84.4%	85.9%
Small Urban Minor Arterial	81.9%	80.3%	80.1%	80.3%	76.9%	79.3%
Small Urban Collector	74.4%	73.1%	71.0%	71.8%	66.7%	66.9%
Subtotal Small Urban Areas	**79.4%**	**78.7%**	**78.1%**	**78.5%**	**75.6%**	**76.8%**
Urbanized Interstate	90.1%	92.2%	93.0%	91.7%	92.6%	94.2%
Urbanized Other Freeway & Expressway	87.7%	88.8%	88.3%	88.8%	89.7%	92.9%
Urbanized Other Principal Arterial	73.2%	67.6%	67.7%	67.5%	69.5%	71.1%
Urbanized Minor Arterial	82.5%	80.3%	75.8%	74.7%	72.2%	73.9%
Urbanized Collector	80.8%	76.2%	72.6%	71.3%	69.0%	68.2%
Subtotal Urbanized Areas	**80.7%**	**77.4%**	**74.6%**	**73.7%**	**72.4%**	**73.3%**
Total Acceptable	**84.8%**	**84.3%**	**83.9%**	**84.5%**	**83.7%**	**84.2%**
Percent Good						
Rural Interstate	56.9%	65.4%	68.5%	71.9%	73.2%	77.2%
Rural Other Principal Arterial	47.5%	54.0%	57.4%	60.9%	60.8%	65.3%
Rural Minor Arterial	42.6%	46.1%	46.8%	50.6%	50.0%	53.3%
Rural Major Collector	37.4%	34.1%	35.2%	37.1%	34.6%	35.1%
Subtotal Rural Areas	**41.0%**	**41.1%**	**42.6%**	**45.2%**	**43.7%**	**45.4%**
Small Urban Interstate	51.4%	58.2%	61.6%	64.9%	66.9%	71.1%
Small Urban Other Freeway & Expressway	35.8%	41.3%	43.8%	49.7%	54.6%	60.0%
Small Urban Other Principal Arterial	32.6%	33.7%	36.6%	35.4%	36.6%	40.3%
Small Urban Minor Arterial	40.4%	37.3%	35.8%	36.1%	31.1%	31.9%
Small Urban Collector	33.0%	31.9%	30.4%	29.4%	28.0%	23.6%
Subtotal Small Urban Areas	**36.1%**	**35.2%**	**35.0%**	**34.6%**	**32.9%**	**32.4%**
Urbanized Interstate	39.3%	45.0%	48.2%	48.7%	53.7%	57.5%
Urbanized Other Freeway & Expressway	31.4%	35.5%	37.9%	39.6%	43.6%	49.0%
Urbanized Other Principal Arterial	26.6%	23.5%	23.9%	22.8%	23.9%	26.6%
Urbanized Minor Arterial	39.7%	37.0%	33.8%	31.9%	30.6%	33.3%
Urbanized Collector	35.7%	34.7%	32.9%	31.0%	31.8%	31.9%
Subtotal Urbanized Areas	**35.3%**	**33.9%**	**32.5%**	**31.0%**	**31.6%**	**33.5%**
Total Good	**39.5%**	**39.2%**	**40.0%**	**41.5%**	**40.0%**	**41.5%**

Source: Highway Performance Monitoring System.

acceptable ride quality has increased for all four functional classes of rural roads for which data are available. For the five functional classifications of roadways in small urban areas, the total mileage meeting acceptable ride quality standards showed an increase for three functional classes—Interstate, other freeway and expressway, and other principal arterial—and a decrease for two other functional classes—minor arterial and collector. Urbanized functional classes showed increases in mileage meeting acceptable ride quality in two functional classes—Interstate, and other freeway and expressway—but a decrease for the remaining three classifications.

Between 1997 and 2006, the percentage of roadway miles with good ride quality increased in rural areas for three of the four functional class groups—Interstate, other principal arterial, and minor arterial. It declined for major collectors. In small urban areas, good ride quality miles increased for three of the five functional classes—Interstate, other freeway and expressway, and other principal arterial. Decreases were reported for the minor arterial and collector classes.

For urbanized areas during the same time period, two of the five classes showed an increase in mileage with good ride quality—Interstate, and other freeway and expressway. The percentage of pavement with good ride quality in the other principal arterial functional classification in 2006 remained unchanged from the level in 1997, but did increase from 23.9 percent in 2004 to 26.6 percent in 2006. The remaining two classes, minor arterial and collector, both showed decreases in mileage meeting the criteria for pavements with good ride quality.

Lane Width

Lane width affects capacity and safety; narrow lanes have a lower capacity. As with roadway alignment, lane width is more crucial on those functional classifications with higher travel volumes.

Currently, higher functional systems such as Interstates are expected to have 12-foot lanes. Approximately 98.75 percent of all Interstate highways had lane widths of 12 feet or greater in 2006. As shown in *Exhibit 3-10* approximately 98.99 percent of rural Interstate miles and 98.29 percent of urban Interstate miles have minimum 12-foot lane widths.

Exhibit 3-10

Lane Width by Functional Class, 2006

	> 12 foot	11 foot	10 foot	9 foot	< 9 foot
Rural					
Interstate	98.99%	1.00%	0.00%	0.00%	0.02%
Other Principal Arterial	89.39%	8.63%	1.62%	0.30%	0.07%
Minor Arterial	70.40%	18.74%	9.82%	0.91%	0.14%
Major Collector	38.08%	26.45%	26.42%	7.05%	2.00%
Urban					
Interstate	98.29%	1.66%	0.02%	0.01%	0.02%
Other Freeway & Expressway	95.03%	4.43%	0.46%	0.02%	0.07%
Other Principal Arterial	80.82%	13.15%	5.42%	0.34%	0.26%
Minor Arterial	66.37%	18.69%	12.61%	1.71%	0.63%
Collector	51.70%	19.47%	20.91%	5.76%	2.16%

Source: Highway Performance Monitoring System.

A slight majority (51 percent) of urban collectors have lane widths of 12 feet or greater, but approximately one-fifth have 11-foot lanes, and about one-fifth have 10-foot lanes. Among rural major collectors, 38 percent have lane widths of 12 feet or greater, but approximately one-quarter have 11-foot lanes, about one-quarter have 10-foot lanes, and roughly one-tenth have lane widths of 9 feet or less.

Roadway Alignment

Alignment adequacy affects the level of service and safety of the highway system. There are two types of alignment: horizontal (curvature) and vertical (gradient). Inadequate alignment may result in speed reductions and impaired sight distance. In particular, trucks are affected by inadequate vertical alignment with regard to speed. Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst).

Adequate alignment is more important on roads with higher travel speeds and/or higher volumes (e.g., Interstates). Alignment is not an issue in more than a small number of urban areas; therefore, only rural alignment issues are presented in this section. The amount of change in roadway alignment is gradual and occurs only during major reconstruction of existing roadways. New roadways are constructed to meet current vertical and horizontal alignment criteria and therefore do not have alignment problems, except under very extreme conditions.

As shown in *Exhibit 3-11*, approximately 93.2 percent of rural Interstate miles are classified as Code 1 for horizontal alignment and 93.8 percent as Code 1 for vertical alignment.

For rural major collectors, 68.5 percent are rated as Code 1 for horizontal alignment while 58.4 percent are rated as Code 1 for vertical alignment.

Exhibit 3-11

Rural Alignment by Functional Class, 2006

	Code 1	Code 2	Code 3	Code 4
Horizontal				
Interstate	93.2%	0.8%	2.3%	3.7%
Other Principal Arterial	77.5%	8.3%	8.6%	5.5%
Minor Arterial	71.8%	6.0%	14.4%	7.7%
Major Collector	68.5%	10.8%	11.7%	9.0%
Vertical				
Interstate	93.8%	5.7%	0.3%	0.2%
Other Principal Arterial	65.8%	23.0%	6.3%	4.9%
Minor Arterial	52.5%	27.2%	12.3%	7.9%
Major Collector	58.4%	25.7%	9.8%	6.1%

Code 1 All curves and grades meet appropriate design standards.

Code 2 Some curves or grades are below design standards for new construction, but curves can be negotiated safely at prevailing speed limits. Truck speed is not substantially affected.

Code 3 Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits.

Code 4 Frequent grades occur that impair sight distance or severely affect truck speeds. Generally, curves are unsafe or uncomfortable at prevailing speed limit, or the speed limit is severely restricted due to the design speed limits of the curves.

Source: Highway Performance Monitoring System.

Bridge System Conditions

Information relevant to the condition of the Nation's bridges is collected by the State, local, and Federal owners and provided to the Federal Highway Administration (FHWA). The data are maintained by the FHWA in the National Bridge Inventory (NBI) database. This database represents the most comprehensive source of nationwide information on bridges throughout the United States. **All data presented in this chapter are from the NBI database as of December 2006.**

Q&A

There is the perception that bridge failures such as the I-35W bridge collapse are common and that the potential of future collapses of this type is high. Is this correct?

No. The perception that bridge collapses are a common occurrence is not accurate. When considering the great number of bridges in the Nation, nearly 470,000 bridges in the 2006, the number of failures, such as those referenced below, are extremely rare.

The probable primary cause of the collapse of the I-35W bridge in Minneapolis, MN, as determined by the National Transportation Safety Board (NTSB) was an error in the original design of the gusset plates supporting the bridge. As designed, the gusset plates did not have adequate capacity to carry expected loads for the structure.

The first bridge accident investigated by the NTSB was in 1967. Since that time, the NTSB has investigated six collapses of bridges related to design problems or failure of materials. These investigations were of the Silver Bridge in 1967, the I-95 bridge over the Mianus River in 1983, the U.S. Chickasabogue bridge in 1985, the Schoharie Creek bridge in 1987, the Hatchie River bridge in 1989, and the I-35W bridge in 2007. These six accidents occurred over a period of approximately 40 years.

It must be noted that the investigations of each of these bridge accidents by the NTSB has advanced the knowledge of construction and inspection, improved the quality of the Nation's bridges, and increased the safety of the traveling public.

*Source: Accident Report NTSB/HAR-08/03 PB2008-916203 "Collapse of I-35W Highway Bridge Minneapolis, Minnesota August 1, 2007" Published November 14, 2008

The National Bridge Inspection Standards (NBIS), in place since the early 1970s, requires safety inspections every 24 months for bridges with lengths of more than 6.1 meters, approximately 20 feet, located on public roads. The conditions and composition of the structures are documented. Baseline composition information collected includes functional characteristics, descriptions and location information, geometric data, ownership and maintenance responsibilities, and other information. This information enables characterization of the system of bridges on a national level and analysis on the composition of the bridges. Safety, the primary purpose of the National Bridge Inspection Program, is ensured through periodic inspections and rating of the primary components of bridges, such as the deck, superstructure, and substructure.

Q&A

How often are the bridges inspected?

Most bridges in the U.S. Highway Bridge inventory are inspected once every 24 months. These inspections are performed by qualified inspectors. Structures with advanced deterioration or other conditions warranting close monitoring can be inspected more frequently. Certain types of structures in very good condition may receive an exemption from the 24-month inspection cycle. These structures that meet minimum criteria may be inspected less frequently. With FHWA approval, these structures may be inspected at intervals that do not exceed 48 months. Qualification for this extended inspection cycle is reevaluated depending on the conditions of the bridge. Approximately 83 percent are inspected once every 24 months, 12 percent are inspected on a 12-month cycle, and 5 percent are inspected on a minimum 48-month cycle.

Explanation of Bridge Deficiencies

From the information collected through the inspection process, assessments are performed to determine the adequacy of a structure to service the current structural and functional demands; factors considered include load-carrying capacity, deck geometry, clearances, waterway adequacy, and approach roadway alignment. Structural assessments together with condition ratings determine whether a bridge should be classified as "**structurally deficient.**" Functional adequacy is assessed by comparing the existing geometric configurations and design load carrying capacities to current standards and demands. Disparities between the actual and preferred configurations are used to determine whether a bridge should be classified as "**functionally obsolete.**" Structural deficiencies take precedence in the classification of deficiencies, so that a bridge that has been determined to be both structurally deficient and functionally obsolete would be classified as structurally deficient.

Q&A

What makes a bridge structurally deficient, and are structurally deficient bridges unsafe?

Structurally deficient bridges are not inherently unsafe. Bridges are considered structurally deficient if significant load-carrying elements are found to be in poor or worse condition due to deterioration and/or damage, or the adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing intolerable traffic interruptions. That a bridge is deficient does not imply that it is likely to collapse or that it is unsafe. By conducting properly scheduled inspections, unsafe conditions may be identified; if the bridge is determined to be unsafe, the structure must be closed. A deficient bridge, when left open to traffic, typically requires significant maintenance and repair to remain in service and eventual rehabilitation or replacement to address deficiencies. To remain in service, structurally deficient bridges often have weight limits that restrict the gross weight of vehicles using the bridges to less than the maximum weight typically allowed by statute.

Q&A

How does a bridge become functionally obsolete?

Functional obsolescence is a function of the geometrics (i.e., lane width, number of lanes on the bridge, shoulder width, presence of guardrails on the approaches, etc.) of the bridge in relation to the geometrics required by current design standards. While structural deficiencies are generally the result of deterioration of the conditions of the bridge components, functional obsolescence generally results from changing traffic demands on the structure. Facilities, including bridges, are designed to conform to the design standards in place at the time they are designed. Over time, improvements are made to the design requirements. As an example, a bridge designed in the 1930s would have shoulder widths in conformance with the design standards of the 1930s, but current design standards are based on different criteria and require wider bridge shoulders to meet current safety standards. The difference between the required, current-day shoulder width and the 1930s' designed shoulder width represents a deficiency. The magnitude of these types of deficiencies determines whether a bridge is classified as functionally obsolete.

Condition Ratings

Every structure begins to deteriorate from the completion of construction. Condition ratings have been established to measure the deterioration levels of bridges in a consistent and uniform manner to allow comparison of the condition of bridges on a National level.

The primary considerations in classifying structural deficiencies are the bridge component condition ratings. The NBI database contains ratings on the three primary components of a bridge: the deck, superstructure, and substructure. A bridge deck, the surface on which vehicles travel, is supported by the superstructure. This transfers the load of the deck and the traffic carried to the substructure, which provides support for the bridge.

Condition ratings are used to describe the existing, in-place status of a component and not its as-built state—the existing condition is compared with an as-new condition. Bridge inspectors assign condition

What was the condition rating of the I-35W bridge prior to collapse and why wasn't it closed to traffic?

Q&A

The last inspection of the I-35W bridge was completed in 2007 prior to the collapse. At that time, it was classified as "Structurally Deficient". The classification of a bridge as structurally deficient does not mean that a bridge is unsafe.

The I-35W bridge was classified as "Structurally Deficient" due to a Superstructure condition rating of "4" on a "0 to 9" scale. Any structure receiving a condition rating of "4" or less for Deck condition, Superstructure condition, or Substructure condition is given the status of "Structurally Deficient". A structurally deficient bridge with any rating of "4" can often remain open but may require inspection on a more frequent basis.

The transition from any given condition rating value to the next lower value can take a long period of time. In the case of the I-35W structure the Superstructure condition rating was "4" from 1991 to 2007, a period of 16 years. The Substructure condition rating was "6" from 1983 to 2007 or a period of 24 years. The Deck condition was rated as "6" from 1991 to 1998 and "5" from 2000 to 2007.

A structure that has received a condition rating of "2" (Critical) will be closely monitored. It is possible the structure may be closed until corrective action is implemented. This is normally the initial condition rating where a structure may be closed in addition to being inspected more frequently.

When a condition rating of "1" (Imminent Failure) is given to a structure it is closed due to the severity of the amount of deterioration of one or more of the major systems of the bridge—deck, superstructure, or substructure.

ratings by evaluating the severity of the deterioration of individual bridge components and the extent to which it affects the component being rated. Condition ratings are also used to determine if a culvert is structurally deficient. These ratings provide an overall characterization of the general condition of the entire component being rated and not an indication of localized conditions. *Exhibit 3-12* describes the bridge condition ratings in more detail.

Exhibit 3-12

Bridge Condition Rating Categories

Rating	Condition Category	Description*
9	Excellent	
8	Very Good	No problems noted.
7	Good	Some minor problems.
6	Satisfactory	Structural elements show some minor deterioration.
5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	Poor	Advanced section loss, deterioration, spalling, or scour.
3	Serious	Loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
1	Imminent Failure	Major deterioration or section loss present in critical structural components, or obvious loss present in critical structural components, or obvious vertical or horizontal movement affecting structural stability. Bridge is closed to traffic, but corrective action may put bridge back in light service.
0	Failed	Out of service; beyond corrective action.

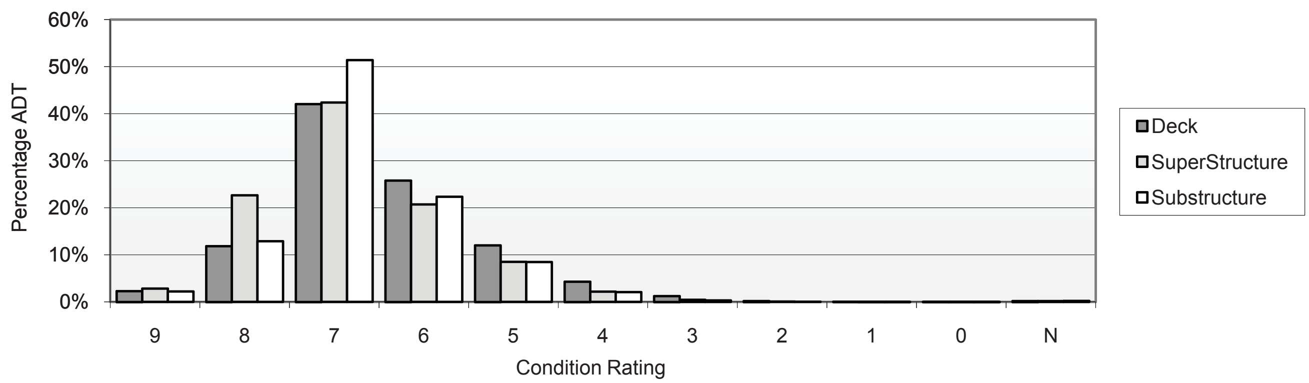
** The term "section loss" is defined in The Bridge Inspector's Reference Manual (BIRM) Publication No. FHWA NHI 03-001 as the loss of a refers to the loss of a bridge member's cross sectional area usually by corrosion or decay. A "spall" is a depression in a concrete slab, resulting from a fracture causing the separation and removal of a portion of the surface concrete. The term "scour" refers to the erosion of streambed or bank material due to flowing water around the piers and abutments of bridges.*

Source: Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, Report No. FHWA-PD-96-001.

Condition rating distributions are shown in *Exhibit 3-13* for decks, superstructures, and substructures for all bridges. Condition ratings of 4 and lower, as defined in *Exhibit 3-12*, indicate conditions of poor or worse and result in classification as structurally deficient; the majority of the condition ratings are 5 and greater. It should be noted that an individual structure may have more than one deficient component, so these classifications are not mutually exclusive.

Exhibit 3-13

Bridge Condition Ratings, Weighted by ADT, 2006



N – Data not recorded.
Source: National Bridge Inventory.

Appraisal Ratings

Appraisal ratings are based on an evaluation of bridge characteristics relative to the current standards used for highway and bridge design. *Exhibit 3-14* describes appraisal rating codes in more detail.

Exhibit 3-14

Bridge Appraisal Rating Categories

Rating	Description
N	Not applicable.
9	Superior to present desirable criteria.
8	Equal to present desirable criteria.
7	Better than present minimum criteria.
6	Equal to present minimum criteria.
5	Somewhat better than minimum adequacy to tolerate being left in place as-is.
4	Meets minimum tolerable limits to be left in place as-is.
3	Basically intolerable requiring a high priority of corrective action.
2	Basically intolerable requiring a high priority of replacement.
1	This value of rating code is not used.
0	Bridge closed.

Source: Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, Report No. FHWA-PD-96-001.

Functional and Geometric-Based

The primary considerations for functional obsolescence focus on functional and geometric-based appraisal ratings, including the deck geometry appraisal rating, the underclearance appraisal rating, and the approach roadway alignment appraisal rating.

Deck geometry ratings reflect the width of the bridge, the minimum vertical clearance of the bridge, the average daily traffic (ADT), the number of lanes carried by the structure, whether two-way or one-way traffic is serviced, and functional classifications. The basis for appraisal rating assignment is the difference between the minimum desired width for the roadways and the actual widths. For example, a bridge having a deck with 11 foot wide lanes would be considered deficient if the current design standards require 12 foot wide lanes.

Underclearance appraisals consider both the vertical and horizontal underclearances as measured from the roadway or railway to the nearest bridge component. For example, a bridge originally built with a vertical clearance of 15 feet would be considered deficient if the current design standards require 16 feet.

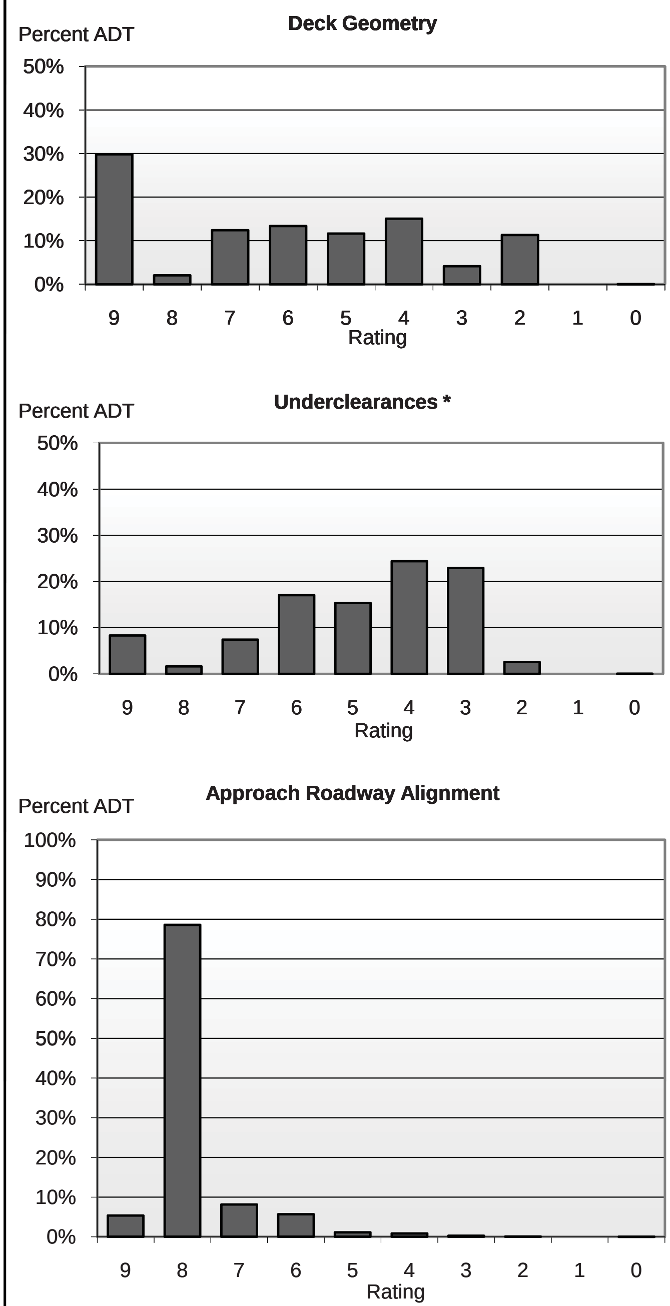
The functional classification, Federal-aid designation, and defense categorization are all considered for the underpassing route.

Approach alignment ratings differ from the deck geometry and underclearance appraisal ratings in that they are determined by evaluating the existing approach roadway alignment to the bridge as it relates to the general highway alignment for the section of highway the bridge is on rather than comparing approach roadway alignment with current standards. Deficiencies are identified where the bridge route does not function adequately because of alignment disparities.

Exhibit 3-15 identifies the distribution of the percentage of daily bridge traffic for each appraisal rating category based on deck geometry, underclearance, and approach roadway alignment. A rating of 2 or lower indicates a situation typically not correctable without replacement of the structure; the vast majority of travel occurs on structures have ratings of 3 or greater.

Exhibit 3-15

Ratings of Key Bridge Elements to Identify Level of Functional Obsolescence, Weighted by ADT, 2006



** Underclearance applies only to structures located over other structures or roadways. Approximately 80% of bridges are located over waterways.*

Source: National Bridge Inventory.

Structural Evaluation/Waterway Adequacy

While condition ratings are primarily associated with the designation of bridges as structurally deficient, and functional and geometric-based appraisal ratings are generally associated with the designation of bridges as functional obsolete, structural evaluation and waterway adequacy ratings can result in the classification of a bridge as either structural deficient or functional obsolete.

The structural evaluation appraisal rating is used as a factor for determining whether a bridge has sufficient load-carrying capacity. A rating of 3 indicates that the load-carrying capacity is too low but can be mitigated through corrective action; in this case, the bridge is classified as functionally obsolete. A rating of 2 or lower for the structural evaluation appraisal results in a bridge being classified as structurally deficient; these ratings typically are not correctable without replacement.

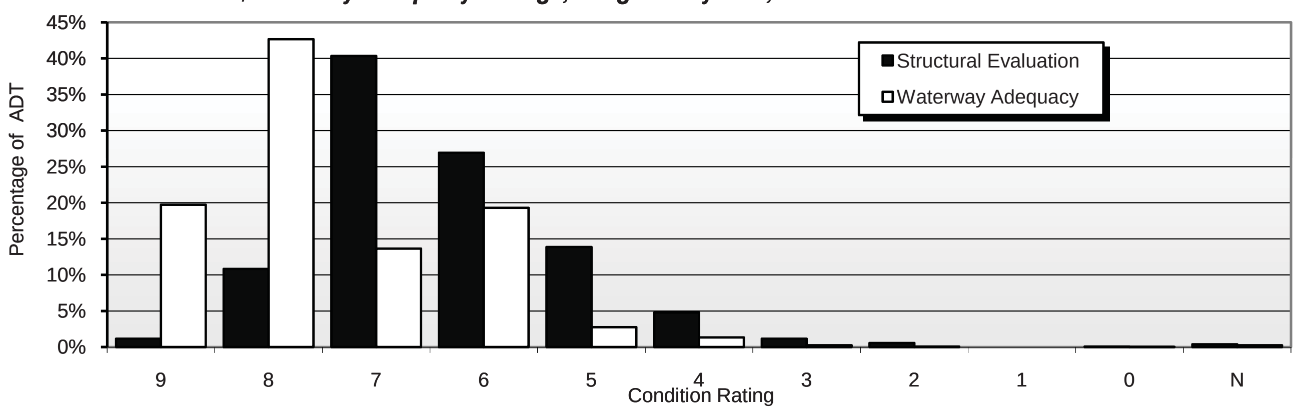
As an example, a steel truss bridge built in 1950 would have been designed using the standards of that period, which were based on lighter truck weights than are typical today. If the load-carrying capacity of the bridge was judged to be below the minimum tolerable limits, it would be given a load-carrying capacity of 3 or lower. If it is judged that the structure could be strengthened to meet the current load-carrying standards, it would be rated a 3 and considered functionally obsolete. If it is determined that the structure would need to be replaced in order to meet the current load-carrying standards, it would be rated a 2 and considered to be structurally deficient.

The waterway adequacy appraisal rating describes the opening of the structure with respect to the passage of water flow through the bridge. This rating, which considers the potential for a structure to be submerged during a flood event and the potential inconvenience to the traveling public, is based on criteria assigned by functional classification. Waterway adequacy appraisal ratings of 2 or lower result in bridges being classified as structurally deficient. Waterway adequacy appraisal ratings of 3 result in bridges being classified as functionally obsolete.

Exhibit 3-16 shows the distribution of structural evaluation appraisal and waterway adequacy ratings, weighted by ADT. As shown in the exhibit, the majority of the ratings are 3 and greater. Waterway adequacy impacts a much smaller percentage of structures than does load-carrying capacity, with less than 0.1 percent of the traffic carried by bridges in the network classified as structurally deficient resulting from waterway adequacy ratings of 2 or below.

Exhibit 3-16

Structural Evaluation/Waterway Adequacy Ratings, Weighted by ADT, 2006



N – Data not recorded.
Source: National Bridge Inventory.

Structural deficiency and functional obsolescence are not mutually exclusive, and a bridge may have both types of deficiencies. When deficiency percentages are presented, however, bridges are indicated as being in one of three categories—structurally deficient, functionally obsolete, or non-deficient. **If a bridge is classified both structurally deficient and functionally obsolete, it is identified only as structurally deficient.** Structural deficiencies are considered more critical because they have the potential to eventually lead to a loss of functionality or even closure unless the bridge is rehabilitated or replaced. Approximately 50 percent of structurally deficient bridges will have functional issues in need of correction, but bridges indicated as functionally obsolete do not have significant structural deficiencies. In other words, functional obsolescence alone does not indicate a bridge that requires rehabilitation or replacement but rather a bridge that, likely due to its build date, does not meet current design standards.

NHS Bridge Condition

Deficiencies by Bridge Deck Area

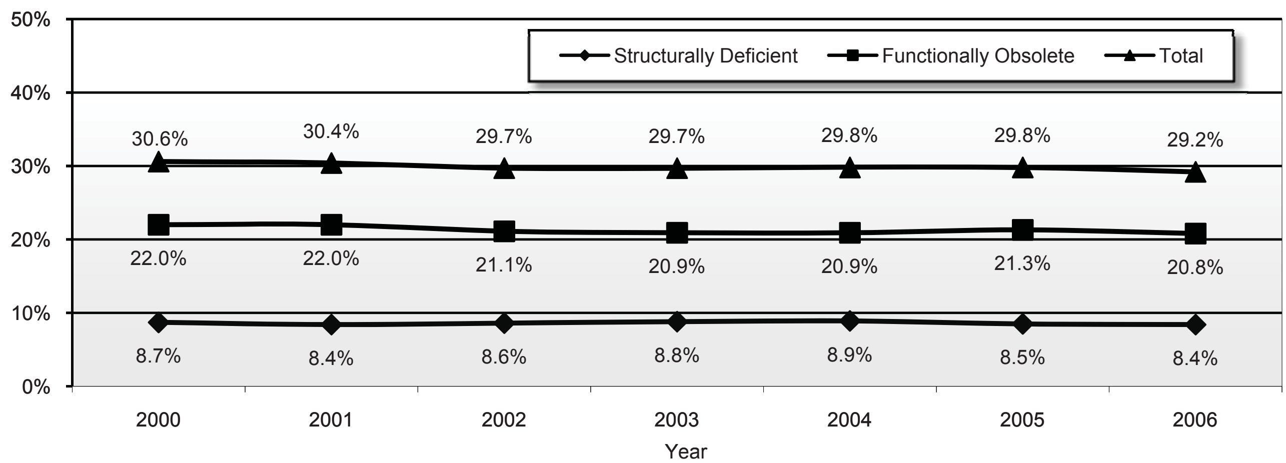
The FHWA has adopted as primary performance measures for bridge condition the percent of deck area on deficient bridges on the National Highway System (NHS) and the percent of deck area on deficient non-NHS bridges.

In 2006, the total deck area of bridges on the NHS was over 163 million square meters. The deck area on bridges classified as structurally deficient was slightly greater than 13.7 million square meters, or 8.4 percent of the total deck area for NHS bridges. Bridges classified as functionally obsolete had a total deck area of more than 33.9 million square meters, or 20.8 percent of the total NHS bridge deck area.

The total deck area of bridges considered either structurally deficient or functionally obsolete has decreased since 2000. The percent of deck area on structurally deficient bridges decreased from 8.7 percent in 2000 to 8.4 percent in 2006. During the same period, the deck area on bridges classified as functionally obsolete decreased from 22.0 percent in 2000 to 20.8 percent in 2006. Total deck area on either structurally deficient or functionally obsolete bridges on the NHS dropped from 30.6 percent in 2000 to 29.2 percent in 2006. These data are shown in *Exhibit 3-17.*

Exhibit 3-17

NHS Bridge Deficiencies—Deck Area



Source: National Bridge Inventory.

Deficiencies by ADT Carried

Approximately 7.5 percent of the traffic on NHS bridges in 2000 was on structurally deficient bridges. This decreased to 6.6 percent in 2006. Traffic on functionally obsolete bridges on the NHS decreased from 21.4 percent in 2000 to 20.1 percent on 2006. These data are shown in *Exhibit 3-18.*

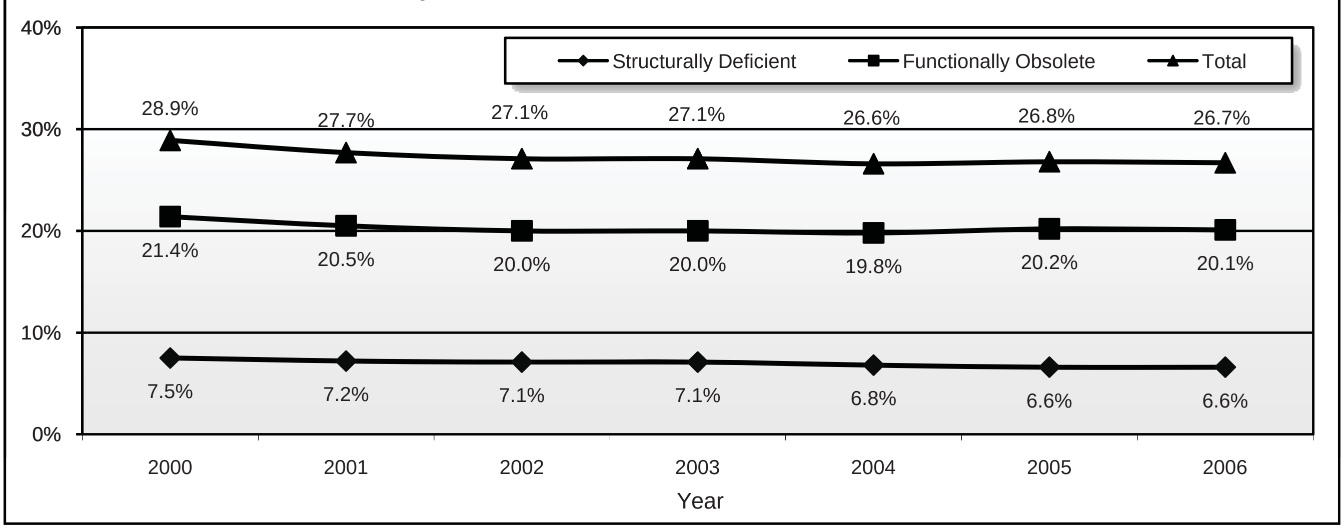
Deficiencies by Number of Bridges

There were 115,203 bridges on the NHS in 2006 compared with approximately 114,556 bridges in 2000. As shown in *Exhibit 3-19*, 5.5 percent of the NHS bridges in 2006 were classified as structurally deficient. This is a decrease from the 6.0 percent of the NHS bridges classified as structurally deficient in 2000.

Bridges classified as functionally obsolete in 2006 numbered 19,369, or 16.8 percent. This is a decrease from 20,223 bridges, 17.7 percent, in 2000. The total number of either structurally deficient or functionally obsolete bridges decreased from 27,143 bridges, 23.7 percent of NHS bridges, in 2000 to 25,708, 22.3 percent of the NHS bridges, in 2006.

Exhibit 3-18

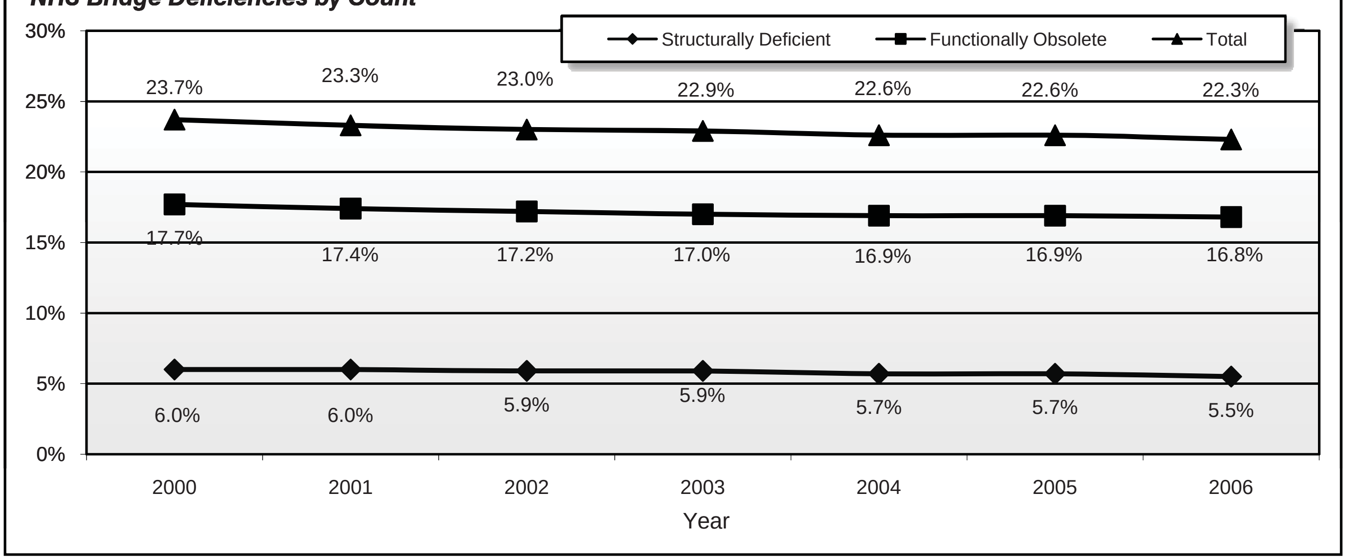
Percent ADT on Deficient NHS Bridges



Source: National Bridge Inventory.

Exhibit 3-19

NHS Bridge Deficiencies by Count



Source: National Bridge Inventory.

Interstate System

As stated in Chapter 2 and earlier in this chapter, the Interstate System constitutes a major subset of the NHS. Interstate bridge deficiencies by period built are shown in *Exhibit 3-20.* Approximately 80 percent—44,192 bridges of the total 55, 270 bridges on the Interstate System—were built between 1951 and 1980. Of the bridges built during this period, 2,684, approximately 6.1 percent, were classified as structurally deficient in 2006. A total of 8,221, approximately 18.6 percent, were classified as functionally obsolete.

The 2,684 structurally deficient bridges in this period constitute approximately 93.3 percent of the total number of structurally deficient bridges on the Interstate System. The 8,221 functionally obsolete bridges for the period between 1951 and 1980 account for approximately 82.6 percent of the total number of bridges on the Interstate System classified as functionally obsolete.

Exhibit 3-20

Interstate Bridge Deficiencies by Period Built

Time Period	Number of Interstate Bridges Built	Percent of Total Interstate Bridges	Structurally Deficient Bridges	Percent Structurally Deficient	Functionally Obsolete Bridges	Percent Functionally Obsolete	Total Number Deficient Bridges	Total Percent Deficient
≤ 1900	5	0.0%	-	0.0%	1	20.0%	1	20.0%
1901–1910	32	0.1%	7	21.9%	5	15.6%	12	37.5%
1911–1920	9	0.0%	3	33.3%	2	22.2%	5	55.6%
1921–1930	101	0.2%	8	7.9%	20	19.8%	28	27.7%
1931–1940	540	1.0%	34	6.3%	108	20.0%	142	26.3%
1941–1950	730	1.3%	52	7.1%	181	24.8%	233	31.9%
1951–1960	9,193	16.6%	767	8.3%	2,451	26.7%	3,218	35.0%
1961–1970	23,964	43.4%	1,505	6.3%	4,660	19.4%	6,165	25.7%
1971–1980	11,035	20.0%	412	3.7%	1,110	10.1%	1,522	13.8%
1981–1990	5,033	9.1%	52	1.0%	588	11.7%	640	12.7%
1991–2000	3,076	5.6%	30	1.0%	541	17.6%	571	18.6%
2001–2006	1,528	2.8%	6	0.4%	267	17.5%	273	17.9%
Not Reported	24	0.0%	-	0.0%	9	37.5%	9	37.5%
Total	**55,270**	**100.0%**	**2,876**	**5.2%**	**9,943**	**18.0%**	**12,819**	**23.2%**

Source: National Bridge Inventory.

Of the 55,270 bridges on the Interstate System in 2006, approximately 5.2 percent, or 2,876 bridges, were classified as structurally deficient and 18 percent, or 9,943 bridges, were classified as functionally obsolete. The total number of bridges on the Interstate System classified as either structurally deficient or functionally obsolete in 2006 was 12,819 bridges, or 23.2 percent.

STRAHNET System

The STRAHNET system is a key subset of the NHS. The physical composition of this system has been described in Chapter 2 and the condition of the pavement portion has been presented earlier in this chapter. There has been no significant change in the percentage of structurally deficient and functionally obsolete bridges on the STRAHNET System since 2004. The share of structurally deficient bridges decreased from 5.1 percent in 2004 to 5.0 percent in 2006. The share of functionally obsolete bridges remained constant at 17.3 percent. The share of bridges either structurally deficient or functionally obsolete remained constant at 22.3 percent. These data are shown in *Exhibit 3-21.*

Exhibit 3-21

STRAHNET Bridge Deficiency Percentages, 2004 and 2006

	2004	2006
Deficient Bridges	22.3%	22.3%
Structurally Deficient Bridges	5.1%	5.0%
Functionally Obsolete Bridges	17.3%	17.3%

Source: National Bridge Inventory.

Overall Bridge Condition

One commonly cited indicator of bridge condition is the number of deficient bridges. Of the 597,377 bridges listed in the inventory in 2006, 164,971, or slightly less than 27.6 percent, were classified as either structurally deficient or functionally obsolete. Of these, 75,408 (12.6 percent of all bridges) were classified as structurally deficient and 89,563 (15.0 percent of all bridges) were classified as functionally obsolete. Thus, 45.7 percent of the deficiencies were structural and 54.3 percent were functional.

What is the "10-Year Rule," and how is it applied?

Q&A

The FHWA established the "10-Year Rule" for determining a bridge's eligibility for Federal funds after new construction, replacement, or major rehabilitation has taken place. Bridges that have been newly constructed, replaced, or had major rehabilitation within the past 10 years are not considered nor eligible for Federal funds and are not used to apportion Highway Bridge Program funds.

Current laws and regulations permit the building of bridges off the Federal-aid system to design standards (width, clearance, etc.) that may be less than the minimum current design standards for bridges on the Federal-aid system. Newly constructed, replaced, or major rehabilitated bridges built to lesser design standards are often classified functionally obsolete once they are open to traffic. The "10-Year Rule" prevents Federal-aid funds from being used on bridges that were intentionally built to lesser design standards, and it prevents newly constructed, replaced, or major rehabilitated bridges that are immediately in a deficient status from being considered in the apportionment process of the Highway Bridge Program funds for a period of 10 years.

The "10-Year Rule" encourages the States to address all the deficiencies of a bridge at one time rather than separately, which results in multiple traffic disruptions and additional costs. The rule also assists in preventing intentional manipulation of the apportionment process of Highway Bridge Program funds. Without it, States may minimize the amount of improvements on deficient bridges to remain in a safe condition but still in a deficient classification so that the deck areas contribute to a stable or increased apportionment of Highway Bridge Program funds.

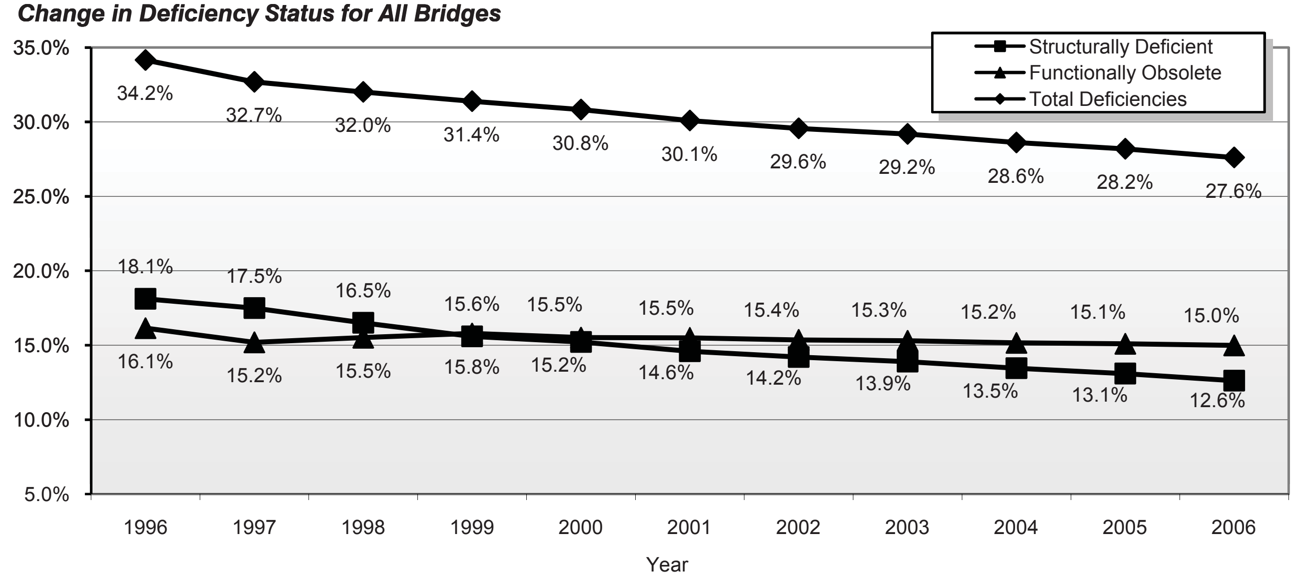
In prior C&P reports, the database used to develop the data on the condition of bridges on the Nation's highway system did not include those bridges that fell under the "10-Year Rule." This resulted in lower reported deficiency values. In order to provide a more accurate assessment of the condition of the Nation's bridges, all bridges are included in the data used in this version of the report. Trends in improvement are relatively the same, but the overall deficiency values are higher than in previous reports.

Exhibit 3-22 shows the overall trend of deficiency percentages from 1996 through 2006. Bridge deficiencies have been reduced primarily through reduction in the numbers of structurally deficient bridges. The percentage of functionally obsolete bridges has remained relatively static over this time period.

As indicated earlier, structural deficiencies and functional obsolescence are considered mutually exclusive, with structural deficiencies taking precedence where ratings classify a given bridge as both structurally deficient and functionally obsolete. Roughly half of the number of structurally deficient bridges have no functional obsolescence issues and are deficient solely because of deteriorated bridge components. The remaining structurally deficient bridges also have some type of functional obsolescence.

Exhibit 3-22

Change in Deficiency Status for All Bridges



Source: National Bridge Inventory.

Exhibit 3-23 shows a comparison between bridges on the NHS and bridges not on the NHS (non-NHS). There are 482,174 bridges that are off the NHS, compared to 115,203 bridges on the NHS. However, the total deck area of the bridges on the NHS is nearly equal to the total deck area of the bridges off the NHS, with the deck area of the bridges off the NHS being slightly higher.

The most significant characteristic difference between NHS bridges and non-NHS bridges is the total ADT carried. Slightly more than 3 billion ADT are carried on the bridges on the NHS, while approximately 1.2 billion are carried on non-NHS bridges. NHS bridges carry the over 70 percent of the national ADT compared to approximately 29 percent carried by non-NHS bridges.

Exhibit 3-23

Comparison of Conditions on NHS and non-NHS Bridges

	NHS	Non-NHS	Total
All Bridges			
Total Number of Bridges	115,203	482,174	597,377
Total Deck Area of Bridges (sq. meters)	163,090,974	170,633,496	333,724,470
Total ADT	3,019,188,106	1,256,100,752	4,275,288,858
Structurally Deficient Bridges			
Number of Structurally Deficient Bridges	6,339	69,069	75,408
Percent of Structurally Deficient Bridges	5.5%	14.3%	12.6%
Deck Area of Structurally Deficient Bridges (sq. meters)	13,702,644	18,435,417	32,138,060
Percent of Deck Area of Structurally Deficient Bridges	8.4%	10.8%	9.6%
ADT on Structurally Deficient Bridges	198,113,588	116,942,892	315,056,480
Percent of ADT on Structurally Deficient Bridges	6.6%	9.3%	7.4%
Functionally Obsolete Bridges			
Number of Functionally Obsolete Bridges	19,369	70,194	89,563
Percent of Functionally Obsolete Bridges	16.8%	14.6%	15.0%
Deck Area of Functionally Obsolete Bridges (sq. meters)	33,948,462	33,895,556	67,844,019
Percent of Deck Area of Functionally Obsolete Bridges	20.8%	19.9%	20.3%
ADT on Functionally Obsolete Bridges	606,839,658	330,056,558	936,896,216
Percent of ADT on Functionally Obsolete Bridges	20.1%	26.3%	21.9%
Structurally Deficient and Functionally Obsolete Bridges			
Total Number of Structurally Deficient/Functionally Obsolete Bridges	25,708	139,263	164,971
Percent of Structurally Deficient/Functionally Obsolete Bridges	22.3%	28.9%	27.6%
Total Deck Area on Structurally Deficient/Functionally Obsolete Bridges	47,651,106	52,330,973	99,982,079
Total Percent of Deck Area on Structurally Deficient/Functionally Obsolete Bridges	29.2%	30.7%	30.0%
Total ADT on Structurally Deficient/Functionally Obsolete Bridges	804,953,246	446,999,450	1,251,952,696
Total Percent of ADT on Structurally Deficient/Functionally Obsolete Bridges	26.7%	35.6%	29.3%

Note: Differences in total values result from coding omissions or submission obmissions.

Source: National Bridge Inventory.

Deficient Bridges by Owner

Bridge deficiencies by ownership are examined in *Exhibit 3-24.* For Federally owned bridges, the 1,599 bridges classified as functionally obsolete outweighs the 740 bridges classified as structurally deficient by a ratio of more than 2 to 1. Similar percentages are seen for State-owned bridges, with 48,219 classified as functionally obsolete and 24,222 classified as structurally deficient. These bridges constitute a much more significant proportion of the overall inventory of structures because State agencies own approximately 48 percent of all bridges. Locally owned bridges have an opposite trend, with the number of structurally deficient bridges, 49,869, outnumbering the number of functionally obsolete bridges, 39,149.

Exhibit 3-24

Bridge Deficiencies by Owner, 2006

	Federal	State	Local	Private/Other	Total
Numbers					
Total Bridges	8,355	284,668	301,912	2,627	597,562
Total Deficient	2,339	72,441	89,018	1,216	165,014
Structurally Deficient	740	24,222	49,869	591	75,422
Functionally Obsolete	1,599	48,219	39,149	625	89,592
Percentages					
Percent of Total Inventory for Owner	1%	48%	51%	0%	100.0%
Percent Deficient	28%	25%	29%	46%	27.6%
Percent Structurally Deficient	9%	9%	17%	22%	12.6%
Percent Functionally Obsolete	19%	17%	13%	24%	15.0%

Note: Differences in total values result from coding omissions or submission obmissions.

Source: National Bridge Inventory.

Examination of ownership percentages for structurally deficient and functionally obsolete bridges reveals that the majority of structurally deficient bridges are owned by local agencies, while the majority of functionally obsolete bridges are owned by State agencies. These percentages can be contrasted with the ownership percentages for all bridges. The percentages are dominated by State and local ownership, with only small percentages of the total population of all structures owned by Federal, private, and other owners. However, it should be noted that 46 percent of privately owned bridges are deficient: 22 percent are structurally deficient and 24 percent are functionally obsolete.

Rural and Urban Deficient Bridges by Functional Classification

As noted in Chapter 2 and shown in *Exhibit 3-25*, the majority of bridges are located in rural environments. With rural bridges, the number of structural deficiencies (62,515) outweighs the number of bridges

Exhibit 3-25

Bridge Deficiencies by Functional System, 2006

Functional System	Total Number of Structures	Structurally Deficient	Functionally Obsolete	Total Deficiencies
Rural				
Interstate	26,632	1,148	3,189	4,337
Other Principal Arterial	35,763	1,830	3,379	5,209
Minor Arterial	39,517	3,268	4,359	7,627
Major Collector	93,603	10,448	9,833	20,281
Minor Collector	48,635	6,181	5,777	11,958
Local	207,101	39,640	26,467	66,107
Subtotal Rural	**451,251**	**62,515**	**53,004**	**115,519**
Urban				
Interstate	28,635	1,728	6,754	8,482
Other Freeway and Expressway	17,985	1,047	4,152	5,199
Other Principal Arterial	26,051	2,275	6,387	8,662
Minor Arterial	26,238	2,620	7,717	10,337
Collector	17,616	1,940	5,060	7,000
Local	29,499	3,274	6,472	9,746
Subtotal Urban	**146,024**	**12,884**	**36,542**	**49,426**
Total Identified by Functional System	**597,275**	**75,399**	**89,546**	**164,945**
Unknown	102	9	17	26
Total, Including Unknown	**597,377**	**75,408**	**89,563**	**164,971**

Source: National Bridge Inventory.

classified as functionally obsolete (53,004). With urban bridges, the number of structurally deficient bridges (12,884) is significantly lower than the number of functionally obsolete bridges (36,542). Overall, a higher percentage of urban structures are classified as deficient; however, the majority of these deficiencies result from functional obsolescence. While the percentage of rural bridges classified as deficient is lower, the population and therefore the total number of deficiencies is larger.

Bridge conditions in rural and urban areas have steadily improved over the past decade. As seen in *Exhibit 3-26*, overall deficiencies and structural deficiencies have both decreased. Functional obsolescence

Exhibit 3-26

Percent Deficient Bridges by Functional System and Area, 1996–2006

Year		1996	1998	2000	2002	2004	2006
Interstates							
Rural	Deficient Bridges	21.3%	17.7%	17.2%	17.0%	17.1%	16.3%
	Structurally Deficient	4.6%	4.3%	4.0%	4.1%	4.3%	4.3%
	Functionally Obsolete	16.7%	13.5%	13.2%	12.9%	12.8%	12.0%
Urban	Deficient Bridges	35.7%	30.8%	30.6%	29.5%	29.6%	29.6%
	Structurally Deficient	8.1%	7.1%	6.7%	6.5%	6.3%	6.0%
	Functionally Obsolete	27.5%	23.6%	23.8%	23.0%	23.3%	23.6%
All Bridges on Interstates	Deficient Bridges	28.2%	24.2%	23.9%	23.3%	23.3%	23.2%
	Structurally Deficient	6.3%	5.7%	5.4%	5.3%	5.3%	5.2%
	Functionally Obsolete	21.9%	18.6%	18.5%	18.0%	18.0%	18.0%
Other Arterials							
Rural	Deficient Bridges	22.6%	20.4%	19.2%	18.4%	17.8%	17.1%
	Structurally Deficient	9.3%	8.5%	7.4%	7.2%	7.0%	6.8%
	Functionally Obsolete	13.3%	12.0%	11.8%	11.2%	10.8%	10.3%
Urban	Deficient Bridges	39.4%	37.7%	36.5%	35.6%	35.1%	34.4%
	Structurally Deficient	12.1%	11.0%	9.8%	9.3%	8.8%	8.5%
	Functionally Obsolete	27.4%	26.7%	26.7%	26.4%	26.3%	26.0%
All Bridges on Other Arterials	Deficient Bridges	30.1%	28.3%	27.1%	26.5%	25.8%	25.4%
	Structurally Deficient	10.5%	9.6%	8.5%	8.2%	7.8%	7.6%
	Functionally Obsolete	19.6%	18.6%	18.6%	18.3%	18.0%	17.9%
Collectors							
Rural	Deficient Bridges	27.1%	25.8%	25.3%	24.6%	23.7%	22.7%
	Structurally Deficient	15.2%	14.2%	13.5%	12.9%	12.3%	11.7%
	Functionally Obsolete	11.9%	11.6%	11.8%	11.7%	11.4%	11.0%
Urban	Deficient Bridges	44.2%	42.1%	41.0%	39.7%	39.7%	39.7%
	Structurally Deficient	16.1%	14.7%	12.9%	11.6%	11.1%	11.0%
	Functionally Obsolete	28.1%	27.4%	28.1%	28.1%	28.6%	28.7%
All Bridges on Collectors	Deficient Bridges	28.7%	27.4%	26.8%	26.0%	25.3%	25.4%
	Structurally Deficient	15.3%	14.2%	13.4%	12.8%	12.2%	11.6%
	Functionally Obsolete	13.4%	13.1%	13.4%	13.2%	13.1%	12.9%
Locals							
Rural	Deficient Bridges	42.0%	39.5%	37.5%	35.5%	33.9%	31.9%
	Structurally Deficient	28.3%	25.6%	23.9%	22.0%	20.7%	19.1%
	Functionally Obsolete	13.6%	13.8%	13.6%	13.5%	13.2%	12.8%
Urban	Deficient Bridges	37.7%	35.9%	34.7%	33.6%	33.5%	33.0%
	Structurally Deficient	16.0%	14.9%	13.4%	12.1%	11.5%	11.1%
	Functionally Obsolete	21.7%	21.1%	21.3%	21.4%	22.0%	21.9%
All Bridges on Locals	Deficient Bridges	41.6%	39.1%	37.2%	35.3%	33.8%	32.1%
	Structurally Deficient	27.1%	24.5%	22.7%	20.9%	19.6%	18.1%
	Functionally Obsolete	14.5%	14.6%	14.5%	14.4%	14.2%	13.9%

Source: National Bridge Inventory.

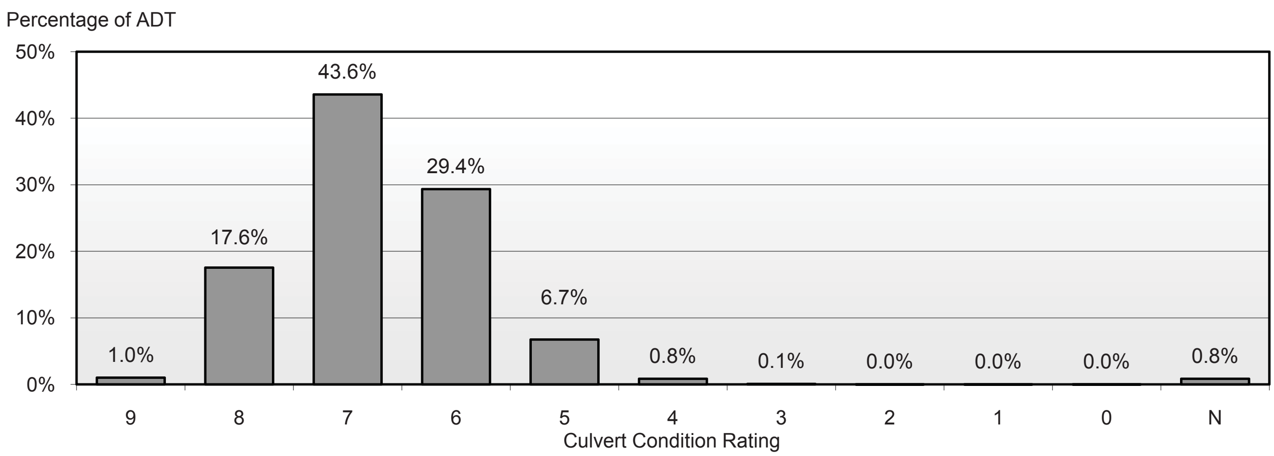
percentages, however, have not decreased and have remained relatively static in both rural and urban environments.

Culvert Conditions

There are 124,843 culverts in the bridge inventory. These structures do not have a deck, superstructure, or substructure, but rather are self-contained units located under roadway fill. Culverts are typically constructed of concrete or corrugated steel. Multiple pipes or boxes placed side-by-side are considered to be a structure and are included in the National Bridge Inventory given that together they span a total length in excess of 6.1 meters and carry a public roadway. As these structures lack decks, superstructures, and substructures, individual ratings are provided to indicate the condition of the culvert as a whole. The distribution of culvert condition ratings weighted by ADT is shown in *Exhibit 3-27.* Of all 124,843 culverts in the inventory, approximately 0.9 percent are classified as structurally deficient based on condition ratings less than or equal to 4 (poor conditions).

Exhibit 3-27

Culvert Condition Ratings, Weighted by ADT, 2006



Source: National Bridge Inventory.

Transit System Conditions

The condition of the U.S. transit infrastructure can be evaluated based on the quantity, the age, and the physical condition of the assets that comprise it. This infrastructure includes vehicles in service, maintenance facilities and the equipment they contain, and other supporting infrastructure such as guideways, power systems, rail yards, stations, and structures like bridges and tunnels.

The Federal Transit Administration (FTA) uses a numerical condition rating scale ranging from 1 to 5, detailed in *Exhibit 3-28*, to describe the relative deterioration of transit assets. It is important to note that the numerical scale used by FTA is continuous, meaning that condition ratings may take on any value within the 1 to 5 interval. This scale corresponds to the Present Serviceability Rating formerly used by the Federal Highway Administration to evaluate pavement conditions. A rating of 5, or "excellent," indicates that the asset is in nearly new condition or lacks visible defects. At the other end of the scale, a rating of 1 indicates that the asset needs immediate repair and may have one or more seriously damaged components.

Exhibit 3-28

Definitions of Transit Asset Conditions

Rating	Condition	Description
Excellent	5	No visible defects, near new condition.
Good	4	Some slightly defective or deteriorated components.
Adequate	3	Moderately defective or deteriorated components.
Marginal	2	Defective or deteriorated components in need of replacement.
Poor	1	Seriously damaged components in need of immediate repair.

Source: Transit Economic Requirements Model.

The FTA uses the Transit Economic Requirements Model (TERM) to estimate the conditions of transit assets. This model comprises a database of transit assets and deterioration schedules that express asset conditions principally as a function of an asset's age. Vehicle condition is based on an estimate of vehicle maintenance history and major rehabilitation expenditures in addition to vehicle age; the conditions of wayside control systems and track are based on an estimate of use (revenue miles per mile of track) in

Q&A

How do the criteria used in the C&P report compare to the Rail Modernization report criteria?

For the purposes of the Rail Modernization study, released by FTA in April 2009, a state of good repair was defined using TERM's numerically based condition rating system of 1 to 5 (poor to excellent) for evaluating transit asset conditions. Specifically, the Rail Modernization study considered an asset to be in a state of good repair when the physical condition of that asset is at or above a specific condition rating value of 2.5 (the mid-point between adequate and marginal). Similarly, an entire transit system would be in a state of good repair if all of its assets have an estimated condition value of 2.5 or higher. The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value.

The percent of transit vehicles below a condition of 2.5 is used in this report as a measure of the share of vehicles that have exceeded their useful life. This replaces the over-age criteria used in previous C&P reports that were based on FTA's minimum vehicle replacement ages. The analysis in this version of the C&P report, as in past versions, is focused on scenarios that depict the level of investment required to maintain or improve *average* asset conditions at specific target level. When assets with conditions below 2.5 are slated for replacement, a test is used to eliminate replacements where the benefits do not outweigh the costs. This additional cost-benefit criterion was not applied to similar analyses in the Rail Modernization study.

addition to age. For the purposes of this report, state of good repair was defined using TERM's numerically based system for evaluating transit asset conditions. Specifically, this report considers an asset to be in a state of good repair when the physical condition of that asset is at or above a specific condition rating value of 2.5 (the mid-point between adequate and marginal). Similarly, an entire transit system would be in a state of good repair if all of its assets have an estimated condition value of 2.5 or higher. The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value.

The deterioration schedules for vehicles; maintenance facilities; stations; and train control, electrification, and communication systems have been estimated by FTA with special on-site engineering surveys. Transit vehicle asset conditions also reflect the most recently available information on vehicle age, use, and level of maintenance from the National Transit Database (NTD) and data collected through special surveys. The information used in this report is for 2006. Age information is available on a vehicle-by-vehicle basis from the NTD and collected for all other assets through special surveys. Average maintenance expenditures and major rehabilitation expenditures by vehicle are also available on an agency and modal basis. Therefore, for the purpose of calculating conditions, average agency maintenance and rehabilitation expenditures for a particular mode are assumed to be the same for all vehicles operated by an agency in that mode. Because agency maintenance expenditures may fluctuate from year to year, TERM uses a 5-year average.

The deterioration schedules for guideway structures and track are based on much earlier studies. The methods used to calculate deterioration schedules and the sources of the data on which deterioration schedules are based are discussed in Appendix C.

Condition estimates in each new edition of the C&P report are based on updated asset inventory information and reflect updates in TERM's asset inventory. Since the 2006 C&P Report, asset data for approximately 71 percent of the Nation's transit assets have been updated. Data from the NTD were used to update asset records for the Nation's transit vehicle fleets. In addition, updated asset inventory data were collected from nine of the Nation's larger rail transit and bus agencies. Appendix C provides a more detailed discussion of TERM's data sources.

Bus Vehicles (Urban Areas)

Bus vehicle age and condition information is reported according to bus vehicle type for 1997 to 2006 in *Exhibit 3-29*. Based on a weighted average condition rating of all bus types, conditions gradually improved for buses from 1997 to 2004, on a revised basis for 2002 and 2004. Between 2004 and 2006, articulated, full-size, mid-size, and small buses experienced a slight decline in conditions; however, vans improved for that time period. In 2006, the estimated average condition rating of the urban bus fleet was 3.01 compared with 3.08 in 2004 and 2.94 in 1997; all condition estimates prior to 2002 are based on a different bus vehicle classification system, but the reclassification of vehicles had only a small impact on the condition estimates for the total bus fleet. The improvement in conditions between 1997 and 2004 reflects a decrease in the average age of the bus vehicle fleet from 6.6 to 6.1 years. For 2006, the average age of 6.1 years was maintained. Since 1997, larger vehicles (i.e., articulated, full-size, and mid-size buses) have tended to have, on average, slightly lower-rated conditions than smaller vehicles (i.e., small buses, vans). Vans, paratransit vehicles, and small buses, in general, decay more rapidly than full-size buses. Vans typically reach a condition rating of 2.50 in 7 years, compared with 14 years, on average, for a 40-foot bus. After the period of continual investment from 1997 to 2004 and gradual improvement in estimated average

Exhibit 3-29

Urban Transit Bus Fleet Count, Age, and Condition, 1997–2006

	1997	1999	2000	<-Revised Basis-> 2002	2004	2006
Articulated Buses						
Fleet Count	1,523	1,967	2,078	2,765	3,060	3,422
Average Age (Years)	11.8	8.7	6.9	7.1	4.9	5.4
Average Condition Rating	2.49	3.10	3.33	3.11	3.38	3.17
Below Condition 2.50 (Percent)	54.8%	35.1%	28.7%	30.6%	11.6%	9.0%
Full-Size Buses						
Fleet Count	47,149	49,195	49,721	46,685	46,090	45,260
Average Age (Years)	8.2	8.7	8.5	7.5	7.3	7.4
Average Condition Rating	2.86	2.90	2.93	3.02	3.00	2.95
Below Condition 2.50 (Percent)	35.6%	35.0%	33.8%	32.7%	31.0%	25.0%
Mid-Size Buses						
Fleet Count	5,328	6,807	7,643	7,304	7,114	6,893
Average Age (Years)	5.6	5.7	5.7	8.1	8.1	8.1
Average Condition Rating	3.30	3.30	3.30	2.93	2.93	2.86
Below Condition 2.50 (Percent)	15.7%	13.3%	14.4%	26.6%	23.3%	27.9%
Small Buses						
Fleet Count	7,081	8,461	9,039	14,857	15,981	17,441
Average Age (Years)	3.7	4.0	4.2	4.5	4.8	5.1
Average Condition Rating	3.56	3.51	3.47	3.39	3.37	3.26
Below Condition 2.50 (Percent)	3.9%	4.4%	4.1%	5.1%	8.6%	11.1%
Vans						
Fleet Count	13,796	14,539	16,234	17,300	19,164	21,982
Average Age (Years)	2.3	3.2	3.2	3.2	3.5	3.2
Average Condition Rating	3.75	3.71	3.71	3.62	3.61	3.74
Below Condition 2.50 (Percent)	1.3%	0.9%	1.2%	1.2%	1.5%	1.9%
Total Bus						
Total Fleet Count	**74,877**	**80,969**	**84,715**	**88,911**	**91,409**	**94,998**
Weighted Average Age (Years)	6.6	7.0	6.8	6.2	6.1	6.1
Weighted Average Condition Rating	2.94	3.01	3.05	3.07	3.08	3.01
Below Condition 2.50 (Percent)	26.7%	23.9%	23.1%	22.3%	19.3%	17.6%

Sources: Transit Economic Requirements Model and National Transit Database.

condition ratings, the overall decline in urban transit bus fleet average estimated conditions in 2006 is driven by lifecycle procurement fluctuations. Average bus fleet condition ratings vary considerably from agency to agency, ranging from 2.30 to 4.40 for the 31 agencies that participated in the most recent FTA bus vehicle conditions assessment in 2002.

Articulated buses experienced the largest fluctuations in condition ratings between 1997 and 2006, improving from 2.49 in 1997 to 3.17 in 2006. This fluctuation peaked in 2004 with an average estimated condition of 3.38, and is most likely the result of a 12-year industry replacement policy and the fact that many of these articulated buses were purchased between 1983 and 1984; because vehicle age frequently exceeds the recommended replacement age, the gradual replacement of articulated buses starting around 1997 would be consistent with the 12-year replacement policy. Mid-size buses maintained an average condition rating above 3.00 in all years based on the old bus classification systems. However, based on the new classification system, their average condition rating fell from 3.30 in 2000 to 2.86 in 2006 as a

How were bus vehicles reclassified in 2002?

The 2002 NTD collected information on buses according to length and seating capacity. Previously, bus information had been collected according to the number of seats only, except for articulated buses, which were reported separately. Two condition estimates are reported for 2002 in *Exhibit 3-28*, showing average conditions based on both the old classification system and on the new classification system. The 2002 NTD data on length revealed that a larger percentage of buses were 45 feet or longer than was previously estimated. Because all buses 45 feet or longer must be articulated for structural reasons, 458 vehicles were moved from the full-size bus category to the articulated bus category. A considerable number of buses that were previously categorized as full-size and mid-size (4,761) were reclassified as small. The number of articulated buses increased by 20 percent as a result of the reclassification, the number of full-size buses decreased by 7 percent, the number of mid-size buses decreased by 18 percent, and the number of small buses increased by 47 percent. Vans were not affected by the reclassification.

considerable number of these vehicles in better-than-average condition for this category were reclassified as small buses. Vans consistently maintained an average condition rating of between 3.61 and 3.75 while the rating of small buses declined from 3.56 in 1997 to 3.26 in 2006. This is partially the result of vehicles being reclassified from the full- and mid-size bus categories to the small bus category. Full-size buses, which were on average consistently just below "adequate" condition between 1997 and 2000, reached an adequate average condition rating of 3.00 in 2004, but declined to 2.95 in 2006.

Bus Maintenance Facilities (Urban Areas)

The number of urban maintenance facilities for bus, vanpool, and demand response systems for directly operated and purchased transit services increased significantly from 1,207 in 2004 to 1,280 in 2006. *Exhibit 3-30* provides the estimated age distribution of these maintenance facilities in 2006. This distribution is based on age information collected by the 1999 and 2002 National Bus Condition Assessments and applied to the total national bus maintenance facilities in 2006 as reported in the NTD. In 2006, 26.4 percent of bus maintenance facilities were estimated to be younger than 10 years old (compared with 10.4 percent in 2004), 24.6 percent were estimated to be 11 to 20 years old (compared with 41.8 percent in 2004), 40.8 percent were estimated to be 21 to 30 years of age (compared with 23.6 percent in 2004), and 8.2 percent were estimated to be 31 years or older (compared with 24.1 percent in 2004). It is important to note that individual facility ages may not relate well to condition, since substantive renovations are made to facilities at varying intervals.

Exhibit 3-30

Age of Urban Bus Maintenance Facilities, 2006

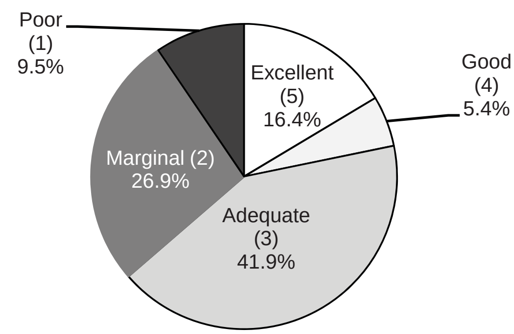
Age (Years)	Count	Percent
0–10	337	26.4%
11–20	315	24.6%
21–30	523	40.8%
31+	105	8.2%
Total	**1,280**	**100.0%**

Sources: Transit Economic Requirements Model and National Transit Database.

The estimated average condition rating of bus maintenance facilities, including those used for vans and demand response vehicles, declined from 3.41 in 2004 to 3.26 in 2006. In 2006, 16.4 percent of all urban bus maintenance facilities were estimated to be in excellent condition (compared with 17.3 percent in 2004), 5.4 percent were estimated to be in "good" condition (compared with 5.2 percent in 2004), and 41.9 percent were estimated to be in adequate condition (compared with 45.7 percent in 2004). Combined, 63.6 percent of all urban bus maintenance facilities were estimated to be in adequate or better condition in 2006 and 36.4 percent were estimated to be in marginal or worse condition in 2006, compared with 68.1 percent estimated to be in adequate or better condition and 31.9 percent estimated to be in marginal or worse condition in 2004. These data are presented in *Exhibit 3-31.*

Exhibit 3-31

Distribution of Urban Bus Maintenance Facilities Across Five Rating Categories, 2006



Condition of Urban Bus Maintenance Facilities, 2006

Condition Rating	Count	Percent
Excellent (5)	210	16.4%
Good (4)	69	5.4%
Adequate (3)	536	41.9%
Marginal (2)	344	26.9%
Poor (1)	121	9.5%
Total	**1,280**	**100.0%**

Source: Transit Economic Requirements Model.

Rail Vehicles

As shown in *Exhibit 3-32*, the average rail vehicle condition increased from 3.50 in 2004 to 3.51 in 2006. This corresponded with an increase in the average vehicle age from 19.7 to 19.8 years. By comparison, in 1997 the average rail vehicle condition rating was 3.42 with an average age of 20.4 years. Average rail vehicle age and condition are heavily influenced by the average age and condition of heavy rail vehicles, which in 2006 accounted for 55.8 percent of the total U.S. rail fleet. Further, 21.9 percent of the heavy rail fleet is considered below a condition of 2.5, or below a state of good repair. The total urban transit rail fleet estimated to be below an average condition of 2.5 is 13.2 percent. All rail vehicles combined have been, on average, in slightly better condition than all bus and bus-type vehicles during the 1997 to 2006 period.

Changes in ages and conditions of all rail vehicles appear to fall within the range of normal depreciation, rehabilitation, and replacement cycles. Although condition is often correlated with age, it is also correlated with preventive maintenance expenditures and vehicle rehabilitations. For this reason, a slight increase in average age may be accompanied by a slight decrease in condition or vice versa.

Exhibit 3-32

Urban Transit Rail Fleet Count, Age, and Condition, 1997–2006

	1997	1999	2000	2002	2004	2006
Commuter Rail Locomotives						
Fleet Count	586	644	591	709	772	797
Average Age (Years)	16.5	16.1	15.8	16.9	18.0	16.9
Average Condition Rating	3.70	3.82	3.77	3.72	3.72	3.72
Below Condition 2.50 (Percent)	0.0%	0.0%	0.0%	1.7%	2.0%	1.8%
Commuter Rail Passenger Coaches						
Fleet Count	2,470	2,886	2,793	2,985	3,549	3,520
Average Age (Years)	19.8	18.5	17.7	19.0	17.8	18.8
Average Condition Rating	3.68	3.74	3.76	3.68	3.78	3.69
Below Condition 2.50 (Percent)	0.0%	0.0%	0.0%	2.4%	1.7%	1.8%
Commuter Rail Self-Propelled Passenger Coaches						
Fleet Count	2,681	2,455	2,472	2,389	2,447	2,582
Average Age (Years)	22.0	24.3	25.2	27.1	23.6	16.0
Average Condition Rating	3.62	3.57	3.55	3.50	3.69	4.03
Below Condition 2.50 (Percent)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Heavy Rail						
Fleet Count	10,173	10,366	10,375	11,093	11,046	11,126
Average Age (Years)	21.0	22.5	23.0	20.0	19.8	21.6
Average Condition Rating	3.31	3.26	3.25	3.41	3.35	3.30
Below Condition 2.50 (Percent)	11.6%	22.1%	22.8%	18.5%	16.8%	21.9%
Light Rail						
Fleet Count	1,132	1,400	1,524	1,637	1,884	1,920
Average Age (Years)	14.6	18.9	18.4	16.1	16.5	15.8
Average Condition Rating	3.63	3.62	3.63	3.61	3.60	3.63
Below Condition 2.50 (Percent)	9.7%	8.4%	8.4%	11.8%	11.0%	6.2%
Total Rail						
Fleet Count	17,042	17,751	17,755	18,813	19,698	19,945
Weighted Average Age (Years)	20.4	21.6	21.8	20.4	19.7	19.8
Weighted Average Condition Rating	3.42	3.40	3.38	3.47	3.50	3.51
Below Condition 2.50 (Percent)	7.8%	13.6%	14.2%	12.6%	11.2%	13.2%

Sources: Transit Economic Requirements Model and National Transit Database.

Rail Maintenance Facilities

As shown in *Exhibit 3-33*, in 2006, 54.2 percent of all rail facilities were estimated to be 10 years old or younger (compared with 50.7 percent in 2004), 13.9 percent were estimated to be 11 to 20 years old (compared with 24.3 percent in 2004), 7.0 percent were estimated to be 21 to 30 years old (compared with 12.5 percent in 2004), and 24.9 percent were estimated to be 31 years old or older (compared with 12.5 percent in 2004.). These revisions reflect updated inventory information collected since the 2004 report.

Exhibit 3-33

Age of Urban Rail Maintenance Facilities, 2006

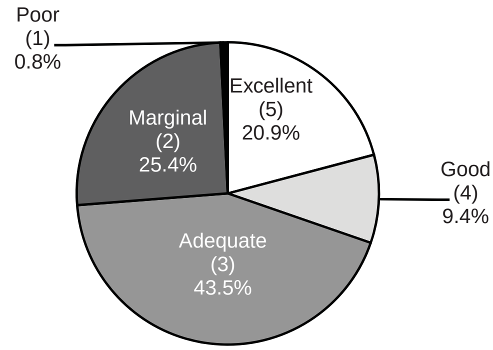
Age (Years)	Count	Percent
0–10	109	54.2%
11–20	28	13.9%
21–30	14	7.0%
31+	50	24.9%
Total	**201**	**100.0%**

Sources: Transit Economic Requirements Model and National Transit Database.

Including the updated inventory information, the estimated condition rating of these facilities decreased from 3.82 in 2004 to 3.68 in 2006. As shown in *Exhibit 3-34,* in 2006, 20.9 percent of facilities were estimated to be in excellent condition, 9.4 percent were estimated to be in good condition, 43.5 percent were estimated to be in adequate condition, 25.4 percent were estimated to be in marginal condition, and only 0.8 percent were estimated to be in poor condition.

Exhibit 3-34

Distribution of Urban Rail Maintenance Facilities Across Five Rating Categories, 2006



Condition of Urban Rail Maintenance Facilities, 2006

Condition Rating	Count	Percent
Excellent (5)	42	20.9%
Good (4)	19	9.4%
Adequate (3)	87	43.5%
Marginal (2)	51	25.4%
Poor (1)	2	0.8%
Total	**201**	**100.0%**

Source: Transit Economic Requirements Model.

Rail Stations

The estimated condition rating of rail stations increased from 3.37 in 2004 to 3.53 in 2006. As shown in *Exhibit 3-35*, 65.7 percent were estimated to be in adequate or better condition (compared with 48.9 percent in 2004) and 34.3 percent were estimated to be in marginal or worse condition (compared with 51.1 percent in 2004).

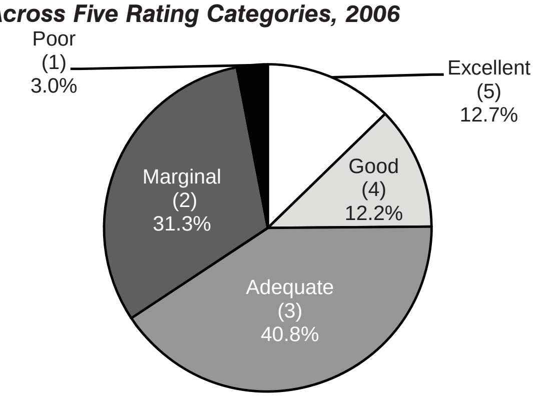
Q&A

How does the condition of nonrail stations compare with the condition of rail stations?

Nonrail stations are generally in better condition than rail stations. The estimated condition rating of nonrail stations decreased from 4.23 in 2004 to 4.00 in 2006. Surveys of nonrail stations have not been conducted. Nonrail stations are assumed to have the same deterioration schedules as light rail. The estimated condition rating of stations for all modes combined increased from 3.43 in 2004 to 3.55 in 2006. Rail stations dominate this average.

Exhibit 3-35

Distribution of Urban Rail Passenger Stations Across Five Rating Categories, 2006



Condition of Urban Rail Passenger Stations, 2006

Condition Rating	Count	Percent
Excellent (5)	387	12.7%
Good (4)	370	12.2%
Adequate (3)	1243	40.8%
Marginal (2)	951	31.3%
Poor (1)	93	3.0%
Total	**3,043**	**100.0%**

Source: Transit Economic Requirements Model.

Rail Systems

Exhibit 3-36 presents the physical condition of U.S. transit rail infrastructure and provides estimated average conditions for different types of rail systems, including train control, traction power, communications, and revenue collection. Historically, FTA has estimated the relative condition of rail systems using dollar amounts spent on different asset classes. This is still true, as shown by the percentages displayed across asset condition levels; however, this report also provides estimates of average condition by asset type, a new development since the release of the 2006 C&P Report.

Exhibit 3-36

Physical Condition of U.S. Transit Rail Infrastructure, 2000–2006

	Condition Estimates				Condition Rating (Percent)							
					Poor (1)				Marginal (2)			
	'00	'02	'04	'06	'00	'02	'04	'06	'00	'02	'04	'06
Track												
Track	4.06	4.17	4.27	4.06	7.0%	5.9%	3.8%	14.7%	10.0%	9.1%	4.4%	5.3%
Systems												
Train Control	3.89	4.00	3.39	3.50	9.5%	7.8%	12.0%	5.5%	10.3%	9.7%	14.1%	14.4%
Traction Power	4.15	4.37	3.95	3.61	7.3%	4.2%	0.0%	4.2%	6.9%	2.9%	1.4%	7.2%
Communications	3.73	4.10	4.05	3.96	11.9%	8.3%	0.0%	0.0%	14.0%	6.0%	0.0%	0.6%
Revenue Collection	4.08	4.29	4.27	3.66	3.8%	0.8%	3.0%	21.5%	18.1%	6.9%	8.0%	8.8%
Structures												
Elevated Structure	4.02	4.27	4.31	4.11	2.0%	2.3%	1.7%	7.3%	22.0%	7.3%	13.9%	7.9%
Underground Tunnels	3.75	4.09	4.23	3.70	12.0%	7.5%	7.4%	14.8%	11.0%	8.6%	5.6%	15.4%
Maintenance												
Vehicle Storage Yards	4.00	3.64	3.80	3.84	0.0%	0.0%	0.0%	0.0%	0.0%	19.6%	0.1%	7.5%

	Condition Rating (Percent)											
	Adequate (3)				Good (4)				Excellent (5)			
	'00	'02	'04	'06	'00	'02	'04	'06	'00	'02	'04	'06
Track												
Track	12.0%	11.6%	17.7%	6.7%	45.0%	33.9%	38.8%	33.4%	26.0%	39.5%	35.2%	39.8%
Systems												
Train Control	16.9%	11.1%	29.0%	41.0%	56.0%	65.9%	44.6%	37.0%	7.2%	5.5%	0.3%	2.2%
Traction Power	10.6%	10.8%	44.5%	46.5%	54.5%	45.0%	46.5%	35.0%	20.7%	37.0%	7.6%	7.0%
Communications	12.1%	9.7%	25.2%	54.8%	62.0%	68.6%	62.7%	30.5%	0.0%	7.4%	12.1%	14.0%
Revenue Collection	17.6%	2.4%	9.5%	10.7%	31.0%	56.4%	53.7%	30.0%	29.5%	33.5%	25.8%	28.9%
Structures												
Elevated Structure	16.0%	2.5%	4.1%	11.7%	59.0%	82.8%	77.2%	68.5%	2.0%	5.1%	3.1%	4.6%
Underground Tunnels	19.0%	13.0%	12.4%	10.5%	46.0%	36.7%	48.2%	41.1%	12.0%	34.2%	26.4%	18.2%
Maintenance												
Vehicle Storage Yards	50.0%	47.8%	51.7%	43.1%	50.0%	31.3%	48.2%	48.9%	0.0%	1.3%	0.0%	0.5%

Source: Transit Economic Requirements Model.

The estimated average condition rating for train control systems improved in 2006 to 3.50, compared with 3.39 in 2004. Conversely, the estimated average condition rating for all other rail systems assets declined from 2004 to 2006. The estimated average condition rating for rail communications systems was 3.96 in 2006, compared with 4.05 in 2004 showing a slight decline. The estimated average condition rating for traction power systems in 2006 was 3.61, a small decrease from the rating of 3.95 in 2004. These small decreases in condition mainly reflect improvements to the systems' asset decay algorithms housed in TERM, which are used to forecast how systems conditions deteriorate over time. The change in the estimated average condition rating of revenue collection systems—from 4.27 in 2004 to 3.66 in 2006—was a function of new and improved asset information contained in TERM.

Other Rail Infrastructure

Exhibit 3-36 also provides conditions for other rail infrastructure. Data for other rail infrastructure are based on the dollar amounts spent on different asset types (in constant dollars) rather than a numeric count of the assets. Earlier versions of this report provided condition results for these assets displayed as percentages across condition levels because this information is more accurate than average condition estimates. In addition to these data, this report also provides estimates of average condition by asset type.

The estimated average condition rating of elevated structures decreased from 4.31 in 2004 to 4.11 in 2006. During the time period from 2004 to 2006, the percentage of elevated structures estimated to be in adequate or better condition increased from 84.4 percent to 84.8 percent, and the percentage estimated to be in marginal or worse condition decreased from 15.6 percent to 15.2 percent. The estimated average condition rating of underground tunnels decreased from 4.23 to 3.70 during the same time period, as did the percentage of underground tunnels estimated to be in adequate or better condition, which went from 87.0 percent to 69.8 percent. The percentage of underground tunnels estimated to be in marginal and "poor" condition increased from 13.0 percent in 2004 to 30.2 percent in 2006.

Q&A

Why did the average condition of track increase while the percentage in adequate or better condition decreased?

The average condition of an asset may increase even when the percentage of assets in a higher condition category decreases. This occurs because of changes in the distribution of conditions of individual agency/mode assets within each condition category.

For example, assume that the percentage of assets in the adequate or better condition categories decreases by 5 percent. The average condition of all assets may still rise if the conditions of all other assets increase while remaining in their respective condition categories.

Track conditions worsened, going from an estimated average condition rating of 4.27 in 2004 to 4.06 in 2006, principally on the basis of updated asset information. The percentage of track estimated to be in adequate or better condition decreased from 91.7 percent in 2004 to 79.9 percent in 2006. The percentage estimated to be in marginal or poor condition increased from 8.2 to 20.0 percent.

The estimated condition rating of vehicle storage yards increased from 3.80 in 2004 to 3.84 in 2006. In 2006, 92.5 percent of all yards were estimated to be in adequate or better condition.

Across the board, the change in condition of rail infrastructure from 2004 to 2006 is primarily the result of updates to the asset inventory in TERM.

Q&A

What is a storage yard?

Rail vehicles are held in storage yards when they are not in service. Storage yard records in TERM consist entirely of track. The next edition of this report will combine storage track with regular track because it is not clear that all agencies consistently report their storage track separately to the NTD. Storage yard information has been reported separately because it was a separate line item in the 1987 Rail Modernization Study, which set the groundwork for this report.

The Replacement Value of U.S. Transit Assets

The total replacement value of the transit infrastructure in the United States was estimated at $607.2 billion in 2006. These estimates, presented in *Exhibit 3-37,* are based on the information contained in TERM and on data collected through the NTD and additional data collection efforts recently conducted for the nine largest rail operators. The data collected for these efforts represent a significant improvement in data availability, in terms of asset inventories and unit costs, and are significantly more comprehensive in comparison to previous C&P reports. The estimates are reported in current dollars. They exclude the value of

Exhibit 3-37

Estimated Replacement Value of the Nation's Transit Assets, 2006

	(Billions of Current Dollars)			
	Nonrail	**Rail**	**Joint Assets**	**Total**
Maintenance Facilities	$52.0	$30.4	$3.5	$85.9
Guideway Elements	$10.2	$221.9	$0.7	$232.9
Stations	$2.9	$80.3	$0.8	$84.0
Systems	$2.8	$110.0	$1.3	$114.1
Vehicles	$31.5	$58.2	$0.5	$90.2
Total	**$99.5**	**$500.8**	**$6.9**	**$607.2**

Source: Transit Economic Requirements Model.

assets that belong to special service operators that do not report to the NTD. Rail assets totaled $500.8 billion and nonrail assets were estimated at $99.5 billion in 2006. Joint assets—defined as assets that are used by one or more modes within a given transit agency—totaled $6.9 billion in 2006. Station assets formerly classified as joint have been reassigned to a specific rail or nonrail mode. Joint assets comprise assets that serve more than one mode within a single agency, and include administrative facilities, intermodal transfer centers, agency communications systems (e.g., PBX, radios, and computer networks), and vehicles used by agency management (e.g., vans and automobiles).

Q&A

What revisions were made to the generated assets component of TERM?

A comprehensive review assessed TERM's capacity to generate assets for nonvehicle data. TERM has consistently generated assets for new agencies, but did not have a standardized method for checking the consistency of the asset base for older systems. An algorithm was developed to generate assets by comparing TERM's current asset inventory with listings of station counts, facility counts, and track miles by grade as reported to the NTD.

Rural Transit Vehicles and Facilities

As rail transit does not serve rural areas, all rural transit vehicles are buses or vans. Historically, data on the condition of rural vehicles and maintenance facilities were not collected by FTA. To obtain this information, FTA relied on special studies completed on an as-needed basis. Starting in 2005, however, FTA required rural operators to submit this type of data to the NTD, allowing FTA to report more accurately on the conditions of rural transit vehicles and facilities. These data, summarized in *Exhibit 3-38*, are discussed below.

Exhibit 3-38

Average Vehicle Age and Percentage of Over-Age Vehicles in Rural Transit

Vehicle Type	Fleet Total	Average Age	Percent Over-Age
Motor Bus	1,610	5.5	31.3%
Vans	18,762	3.5	28.0%
Total	**20,372**	**3.7**	**28.2%**

Source: National Transit Database.

For 2006, data reported to the NTD indicated that 28.2 percent of the rural transit fleet—31.3 percent of buses and 28.0 percent of vans—was over-age. The rural transit fleet had an average age of 3.7 years in 2006; buses, with an average age of 5.5 years, were older than vans in 2006, which had an average age of 3.5 years.

Data on the conditions of rural maintenance facilities have not been updated since the 2002 edition of the report. The most recent data available were collected from surveys funded by the FTA and conducted by the Community Transportation Association of America. The information was collected between June 1997 and June 1999. The responses of the 158 rural operators that responded to these surveys have been combined. Note that, for the purpose of these surveys, rural operators are defined as those operators outside urbanized areas, a different definition than used by the U.S. Census. These surveys also found that approximately 30 percent of bus rural maintenance facilities were in excellent condition, 50 percent in good condition, 19 percent in poor condition, and 1 percent in very poor condition.

Special Service Vehicles

No information is available on the age and condition of special service vehicles. The FTA estimated that, in 2002, nearly 60 percent of special service vehicles were more than 5 years old.

Comparison

Exhibit 3-39 compares key highway and transit statistics discussed in this chapter with the values shown in the last C&P report. The first data column contains the values reported in the 2006 C&P Report, which were based on 2004 data. Some of the 2004 values have subsequently been revised, which is reflected in the second column as appropriate. The third column contains comparable values, based on 2006 data.

Exhibit 3-39

Comparison of System Conditions Statistics With Those in the 2006 C&P Report

		2004 Data		
Statistic	**Condition**	**2006 C&P Report**	**Revised**	**2006 Data**
Total VMT on Pavements With Ride Quality of:	Good	44.2%		47.0%
	Acceptable	84.9%		86.0%
Rural VMT on Pavements With Ride Quality of:	Good	58.3%		62.2%
	Acceptable	94.5%		94.9%
Small Urban VMT on Pavements With Ride Quality of:	Good	41.2%		44.2%
	Acceptable	84.3%		85.5%
Urbanized VMT on Pavements With Ride Quality of:	Good	36.1%		38.2%
	Acceptable	79.2%		80.6%
Deficient Bridges as a Percent of Total Bridges		26.7%	28.6%	27.6%
Structurally Deficient Bridges as a Percent of Total		13.1%	13.5%	12.6%
Functionally Obsolete Bridges as a Percent of Total		13.6%	15.2%	15.0%
Average Urban Bus Vehicle Condition Rating*		3.08		3.01
Average Rail Vehicle Condition Rating*		3.50		3.51
Urban Bus Maintenance Facilities With Condition of:	Excellent/Good	22%	22.4%	21.8%
	Adequate	46%	45.7%	41.9%
Rail Maintenance Facilities With Condition of:	Excellent/Good	43%	43.6%	30.3%
	Adequate	48%	48.5%	43.5%
Rail Stations With Condition of:	Excellent/Good	35%	34.7%	24.9%
	Adequate	14%	13.7%	40.8%
Rail Track With Condition of:	Excellent/Good	74%	74.0%	73.2%
	Adequate	18%	17.7%	6.7%

** Average Condition. Conditions are rated on ranking of 1 (poor) to 5 (excellent).*

Road Conditions

This chapter focused on pavement ride quality within rural, small urban, and urbanized population areas. The functional classification used was the National Highway System (NHS), which includes the Interstate highway system and the Strategic Highway Network. Rural minor collectors and local roads were not included as data were not available.

Road condition ratings were derived from International Roughness Index (IRI) or Present Serviceability Rating (PSR) measures, IRI measuring the cumulative deviation from a smooth surface in inches per mile and PSR being an objective rating system based on a scale of 0 through 5. Road conditions information in this report was primarily based on the percentages of vehicle miles traveled (VMT) occurring on pavement with good and/or acceptable ride quality.

Between 2004 and 2006, the percentage of VMT on pavements with good ride quality steadily increased from 44.2 percent to 47.0 percent. For the same period, all three population areas have increased their percentage of VMT on pavements with both acceptable and good ride quality.

For rural population areas, the percentage of VMT on pavements with acceptable ride quality increased from 84.9 percent to 86.0 percent, the percentage of VMT on pavements with good ride quality increased from 58.3 percent to 62.2 percent, and the percentage of VMT on pavements with acceptable ride quality increased from 94.5 percent to 94.9 percent. Small urban areas also experienced an increase in VMT on pavements with good and acceptable ride qualities during the same period from 41.2 percent to 44.2 percent and from 84.3 percent to 85.5 percent, respectively. Urban areas' acceptable VMT percentages rose from 79.2 percent in 2004 to 80.6 percent in 2006 and the urban VMT on pavement with good ride quality rose from 36.1 percent to 38.2 percent.

Bridge Conditions

The Federal Highway Administration (FHWA) has adopted as the performance measure for bridge condition the percent of total deck area that is on deficient bridges on the NHS and the percent of total deck area that is on deficient bridges off the NHS. This statistic is calculated based on the total deck area of deficient bridges, whether structurally deficient or functionally obsolete, divided by the total deck area for all bridges. All ranges of average daily traffic (ADT) are included in the calculation; however, separate and specific performance goals have been set for NHS and non-NHS bridges for performance planning purposes. This chapter focused on the physical conditions of all bridges; Chapter 12 examines bridge conditions on the NHS in more detail.

In 2006, 12.6 percent of all bridges were structurally deficient. This 2006 percentage is a decrease from the 13.5 percent of structurally deficient bridges in 2004. Functionally obsolete bridges accounted for 15.0 percent of all bridges in 2006, a decrease from 15.2 percent in 2004. When combined, the total number of structurally deficient and functionally obsolete bridges has decreased from 28.6 percent in 2004 to 27.6 percent in 2006.

Exhibit 3-39 provides a second column that includes revised 2004 data for structurally deficient and functionally obsolete bridges. The revision shows the total percent of 2004 deficient bridges as 28.6 percent compared to 26.7 percent shown in the first column, which provides the 2004 data as reported in the 2006 C&P Report. The 2004 revised data also show structurally deficient bridges as a percent of total as 13.5 percent compared to 13.1 percent and the functionally obsolete bridges as a percent of total as 15.2 percent compared to 13.6 percent.

These revisions are the result of the decision to change the 2004 data set to count structurally deficient and functionally obsolete bridges that are less than 10 years old. Previously, these "10-Year Rule" bridges were not included in the data set; however, they are part of the total picture of the condition of bridges in the country and, for the purposes of this report, have been added into the data set. The 2006 data set also uses the full data set. Although the data set has been revised for C&P report purposes, the "10-Year Rule" still applies; and any bridges newly constructed or reconstructed, less than 10 years in age, are not counted as structurally deficient or functionally obsolete and are not eligible for consideration in the apportionment process for Highway Bridge Program funds.

Transit Conditions

The Federal Transit Administration estimates conditions for transit vehicles, maintenance facilities, yards, stations, track, structures, and power systems using the Transit Economic Requirements Model, data collected through the National Transit Database, and special engineering surveys of transit assets. The data collected for the 2008 C&P Report represent a significant improvement in data availability and do not necessarily imply significant changes to estimated conditions of assets. The data for the 2008 C&P Report are significantly more comprehensive in comparison to previous C&P reports. Since the 2006 C&P Report, asset data for approximately 71 percent of the Nation's transit assets have been updated.

The average estimated condition and age of transit vehicles remained relatively stable between 2004 and 2006. On a scale of 1 (poor) to 5 (excellent), bus vehicles had an average condition of 3.01 in 2006 compared with 3.08 in 2004**.** The average age of the bus vehicle fleet remained unchanged, at 6.1 years. The average condition of the rail fleet increased slightly from 3.50 in 2004 to 3.51 in 2006. The average age of rail vehicles increased from 19.7 years in 2004 to 19.8 years in 2006. Average rail vehicle age and condition are heavily influenced by the average age and condition of heavy rail vehicles, which account for approximately 55.8 percent of the U.S. rail fleet.

The average condition of urban bus maintenance facilities (including facilities for vans and demand response vehicles) slightly declined, decreasing from 3.41 in 2004 to 3.26 in 2006. In 2006, 41.9 percent of urban bus maintenance facilities were in adequate condition, 5.4 percent were in good condition, and 16.4 percent were in excellent condition, for a combined total of 63.6 percent in adequate or better condition. The condition rating of rail maintenance facilities decreased from 3.82 in 2004 to 3.68 in 2006. Seventy-three and eight-tenths percent of all rail maintenance facilities are estimated to be in adequate or better condition, and 26.2 percent are in marginal or poor condition.

The condition rating of rail stations increased from 3.37 in 2002 to 3.53 in 2006, with 65.7 percent in adequate to excellent condition. The majority of structures, track, and yards are estimated to be in adequate to good condition for 2006, with 79.9 percent of track in adequate to excellent condition.

Chapter 4

Operational Performance

Highway Operational Performance

Americans continue to grapple with congestion in the form of travel delays, wasted fuel, and billions of dollars in congestion costs. Traffic congestion has increased during the past 20 years as the Nation's population, the number of drivers and vehicles, and travel volume have continued to increase at a much faster rate than system capacity.

This chapter focuses primarily on broadly measuring operational performance trends related to congestion. Subsequent sections within this chapter cover the operational performance of transit and summarize key highway and transit statistics. Chapter 13 addresses operational issues that relate specifically to freight transportation, while Chapter 14 discusses broad strategies that can reduce congestion. Issues relating to improving the measurement of operational performance are discussed in Part IV, "Afterword."

Congestion

In general terms, highway congestion results when traffic demand approaches or exceeds the available capacity of the highway system. *Exhibit 4-1* describes the typical sources of congestion. Congestion can occur when there are peaks in demand; of the total congestion experienced by Americans, it is estimated that roughly half is "recurring congestion" caused by an imbalance of routine daily demand with typical available capacity. Congestion can also occur when there are limitations on capacity, or temporary capacity reductions.

There is no universally accepted definition or measurement of exactly what constitutes a congestion "problem." The public's perception seems to be that congestion is getting worse, and it is by many measures. However, the perception of what constitutes a congestion problem varies from place to place. Traffic conditions that may be considered a congestion problem in a city of 300,000 may be perceived differently in a city of 3 million, based on differing congestion histories and driver expectations. These differences of opinion make it difficult to arrive at a consensus of what congestion means, the effect it has on the public, its costs, how to measure it, and how best to correct or reduce it. Because of this uncertainty, transportation professionals examine congestion from several perspectives.

Exhibit 4-1

Sources of Congestion

Peaks in Demand	Recurring weekday commuting in urban areas Recurring weekend shopping in urban areas Seasonal vacation travel on rural and intercity highways Major generators of freight traffic (ports, factories, distribution centers) Large events (sporting venues, concerts, disasters)
Capacity Limitations	Network extent and coverage Bottlenecks (interchanges and intersections, converging lanes, steep slopes, sharp turns) Impediments (toll booths, border crossings, truck inspection stations) Poor traffic control (traffic signal coordination) Traffic calming
Temporary Capacity Reductions	Crashes and breakdowns Work zones Weather Street closures for events (parades, street fairs, marathons, disasters) Rail-highway grade crossings Temporary curb-side obstructions (especially curb-side parking and construction adjacent to rights-of-way) Law enforcement actions

Source: Federal Highway Administration, Office of Operations.

Three key aspects of congestion are severity, extent, and duration. The **severity** of congestion refers to the magnitude of the problem at its worst. The **extent** of congestion is defined by the geographic area or number of people affected. The **duration** of congestion is the length of time that the traffic is congested, often referred to as the "peak period" of traffic flow.

Texas Transportation Institute Performance Measures

The Texas Transportation Institute (TTI) has studied congestion trends since 1982. Its study results are published annually in the Urban Mobility Report, which is cited nationwide for its list of congestion delays and potential solutions in the Nation's busiest cities. The Federal Highway Administration (FHWA) and TTI work in conjunction to establish and refine the performance metrics of congestion that provide a better indication of congestion's level of impact on the Nation's communities. Since 1982, the data source for the calculations in the Urban Mobility Report has been the FHWA Highway Performance Monitoring System (HPMS).

The 2006 C&P report relied on data computed by TTI for the FHWA using a methodology consistent with 2005 Urban Mobility Report, but which included all urbanized areas rather than the set of 85 areas covered in TTI's report. The FHWA also utilized TTI's 2005 methodology for performance measures in other documents such as the FY 2009 U.S. DOT Budget in Brief. In developing its 2007 Urban Mobility Report, TTI expanded the document's coverage to include all urbanized areas, developed new performance measures, and refined its methodology for computing several existing performance measures. This revised methodology was adopted for the FY 2008 U.S. DOT Performance and Accountability Report.

While this chapter focuses on statistics computed using the 2007 TTI methodology, in some cases comparable statistics are presented based on the 2005 TTI methodology as well. This information is included to allow for continuity and facilitate comparisons with previous editions of the C&P report. It is anticipated that future editions of the C&P report will not include statistics based on the 2005 TTI methodology. This chapter draws upon the following performance measures from the 2007 TTI Urban Mobility Report: percentage of daily travel in congested conditions, travel delay (recurring and non-recurring), annual hours of delay per capita, time travel index, wasted fuel, and congestion cost.

Q&A

What are the differences between the 2005 and 2007 TTI Urban Mobility Report methodologies?

TTI spent several years developing new procedures for the 2007 Urban Mobility Report. Significant changes to the 2005 methodology included:

1. Increasing the slowest speed for the peak direction speed function to 35 miles per hour from the 2005 report's 20-mile-per-hour peak direction speed function
2. Improving population estimates by local and State level planners, in some regions
3. Improving truck percentage estimates in State and local data sets
4. Including better estimates of fuel prices and providing an average of daily fuel prices in each State studied
5. Using all 437 U.S. urbanized areas to estimate congestion, rather than only the 85 areas used previously. (This difference does not represent a significant change for this report; the statistics shown were computed by TTI for FHWA based on data for all urbanized areas rather than on the limited number of areas covered in the Urban Mobility Report).

The 437 urban communities for which data is analyzed by TTI represent various population sizes and locations across the Nation. TTI divides these communities into four groups, based on population size; for 2005, the 338 urbanized areas with populations of less than 500,000 are classified as "Small," the 36 areas with populations between 500,000 and 999,999 are classified as "Medium," the 26 areas with populations between 1 million and 3 million are classified as "Large," and the 14 with populations greater than 3 million are classified as "Very Large." These shorthand terms have been adopted in this section for clarity. However, it should be noted that they are not consistent with the population break of 200,000 frequently used in other FHWA applications to distinguish "Small Urbanized Areas" from "Large Urbanized Areas."

It must be noted that the results of the 2000 census have impacted the studies conducted by TTI. As urban areas increase in size, they will migrate between the four categories used by TTI to define population groups. This adjustment due to population change can have a significant impact on the results for a particular group. TTI recalculates the measures for each group for each year of data.

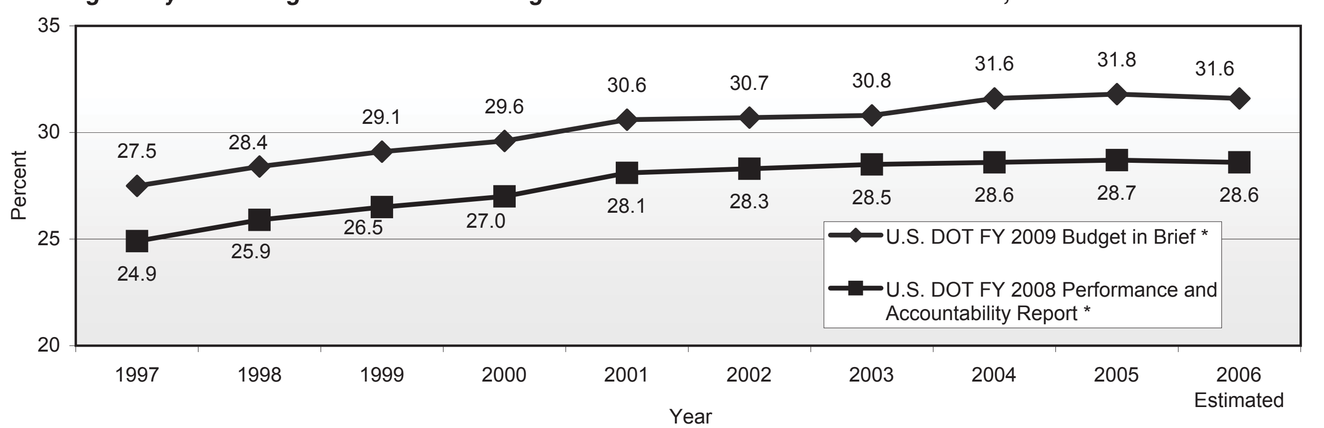
Average Daily Percentage of Vehicle Miles Traveled Under Congested Conditions

The average daily percent of vehicles miles traveled (VMT) under congested conditions is defined as the percentage of daily traffic on freeways and principal arterials in urbanized areas moving at less than free-flow speeds. Based on the 2007 TTI methodology, *Exhibit 4-2* shows that this measure of extent and duration of congestion has increased from 24.9 percent in 1997 to 28.6 percent in 2006 for all urbanized areas combined, a total increase of 3.7 percentage points. As the value for 2006 matched the 28.6 percent value for 2004, this suggests that the growth in congestion may be stabilizing.

Based on the 2005 TTI methodology, the percent of congested travel increased for all communities from 27.5 percent in 1997 to 31.6 percent in 2006, an increase of 4.1 percent, as shown in *Exhibit 4-2*. However, the increase between 2004 and 2005 was only 0.1 percent and the rate of increase declined to 28.6 percent in 2006. Again, this suggests that the rate of growth in congestion is slowing.

Exhibit 4-2

Average Daily Percentage of VMT Under Congested Conditions for All Urbanized Areas, 1997–2006



** The performance measures reported in the U.S. DOT's FY 2009 Budget in Brief and the 2006 C&P Report were computed by TTI based on the methodology consistent with TTI's 2005 Urban Mobility Report. Recently, the U.S. DOT FY 2008 Performance and Accountability Report adopted the revised methodology for calculating congestion metrics reflected in TTI's 2007 Urban Mobility Report.*

Source: U.S. DOT FY 2009 Budget in Brief; U.S. DOT FY 2008 Performance and Accountability Report.

As shown in *Exhibit 4-3*, using the 2007 TTI methodology, the greatest increase between 1997 and 2005 was experienced by communities in the Medium (population 500,000 to 999,999) category, with an increase of 4.7 percentage points, and communities in the Small (population less than 500,000) category, with an increase of 4.3 percentage points.

Exhibit 4-3

Average Daily Percentage of VMT Under Congested Conditions, by Urbanized Area Size, 1997–2005

Urbanized Area Population	1997	1999	2000	2002	2004	2005
Small (less than 500,000)						
2005 TTI Methodology	12.6%	13.7%	14.2%	15.4%	16.0%	16.1%
2007 TTI Methodology*	11.8%	13.0%	13.5%	14.5%	15.9%	16.1%
Medium (500,000 to 999,999)						
2005 TTI Methodology	20.6%	22.4%	22.6%	23.8%	25.3%	25.6%
2007 TTI Methodology*	19.3%	20.8%	21.1%	22.6%	23.3%	24.0%
Large (1 million to 3 million)						
2005 TTI Methodology	27.5%	29.8%	30.5%	31.2%	32.9%	33.2%
2007 TTI Methodology*	25.0%	27.0%	27.9%	28.7%	29.2%	29.6%
Extra Large (more than 3 million)						
2005 TTI Methodology	36.7%	38.2%	38.5%	39.6%	40.6%	40.7%
2007 TTI Methodology*	33.9%	35.7%	35.9%	37.2%	38.0%	38.2%
All Urbanized Areas						
2005 TTI Methodology	**27.5%**	**29.1%**	**29.6%**	**30.7%**	**31.6%**	**31.8%**
2007 TTI Methodology*	**24.9%**	**26.5%**	**27.0%**	**28.3%**	**28.6%**	**28.7%**

** The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calculating congestion metrics in its 2007 Urban Mobility Report.*

Source: Texas Transportation Institute; U.S. DOT Budget in Brief.

The 2005 TTI methodology, meanwhile, shows that communities in the Large (population 1 million to 3 million) category experienced the largest increase (5.7 percentage points from 1997 to 2005). The smallest increase was in communities in the Small (population less than 500,000) category for this same period of time, with an increase of 3.5 percentage points.

Travel Time Index

The Travel Time Index measures the additional time required to make a trip during the congested peak travel period rather than during the off-peak period in non-congested conditions, and indicates the severity and duration of congestion. The additional time required is a result of increased traffic volumes on the roadway and the additional delay caused by crashes, poor weather, special events, or other nonrecurring incidents.

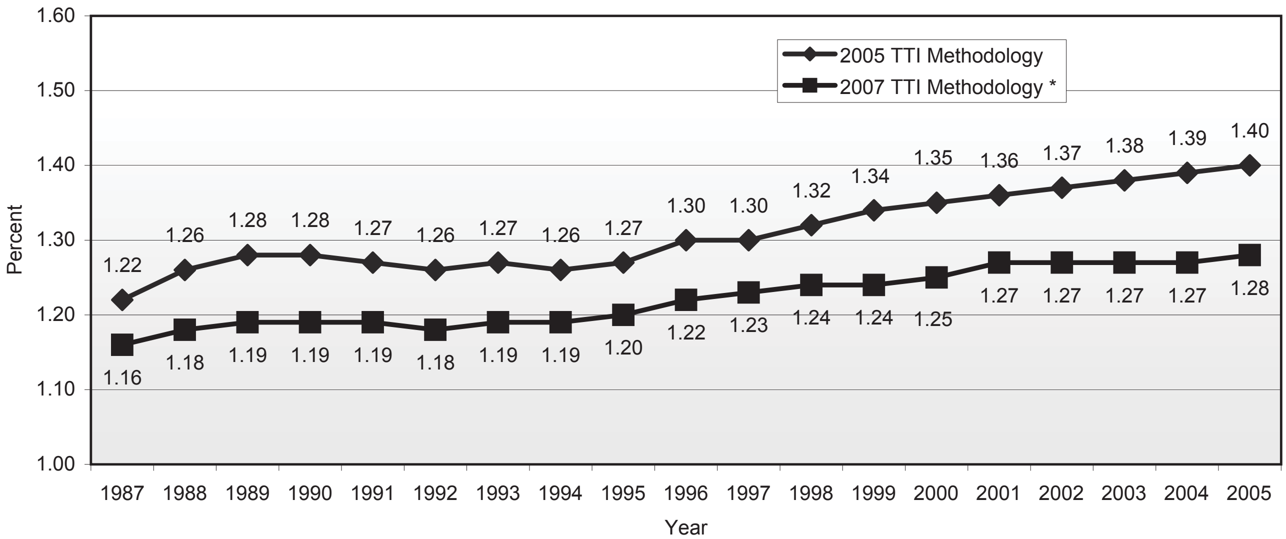
Exhibit 4-4 shows the growth of the national average of the Travel Time Index for all communities evaluated by TTI since 1987. Based on the 2007 TTI methodology, a trip in 1997 that would take 20 minutes during off-peak non-congested periods would take approximately 23 percent (4.6 minutes) longer on average during the peak period. The same trip in 2005 would take 28 percent (5.6 minutes) longer during the peak period, for a total trip length of 25.6 minutes.

The 2005 TTI methodology shows that in 1997, a trip that would take 20 minutes during off-peak non-congested periods would take 30.0 percent (6.0 minutes) longer on average during the peak period. The same trip in 2005 would require 40 percent (8.0 minutes) longer during the peak period than during the off-peak period. This difference of 2.0 minutes per trip between the peak period in 1997 and the peak period in 2005 becomes significant when multiplied by the total number of trips made on a daily basis.

The Travel Time Index for all urbanized areas increased from 1.16 in 1987 to 1.28 in 2005 based on the 2007 TTI methodology; this indicates an increase from an additional 3.2 minutes to an additional

Exhibit 4-4

Average Travel Time Index for All Urbanized Areas, 1987–2005



** The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calculating congestion metrics in its 2007 Urban Mobility Report.*

Source: Texas Transportation Institute.

5.6 minutes. Using the 2005 TTI methodology, the Travel Time Index for all urbanized areas increased from 1.22 in 1987 to 1.40 in 2005; this indicates an increase from an additional 4.4 minutes to an additional 8.0 minutes, an increased travel time over that indicated by the 2007 TTI methodology.

Exhibit 4-5 demonstrates that the additional travel time required because of congestion tends to be higher in larger urbanized areas than smaller ones. Using the 2007 TTI methodology, the largest change between 1997 and 2005, 0.07 or 1.4 additional minutes for a 20-minute off-peak trip, was experienced in

Exhibit 4-5

Travel Time Index by Urbanized Area Size, 1987–2005

Urbanized Area Population	1987 [2]	1997	1999	2000	2002	2004	2005
Small (less than 500,000)							
2005 TTI Methodology	1.05	1.10	1.12	1.12	1.13	1.13	1.14
2007 TTI Methodology[1]	1.04	1.09	1.10	1.11	1.11	1.11	1.13
Medium (500,000 to 999,999)							
2005 TTI Methodology	1.10	1.17	1.19	1.19	1.21	1.22	1.25
2007 TTI Methodology[1]	1.09	1.15	1.16	1.16	1.18	1.18	1.21
Large (1 million to 3 million)							
2005 TTI Methodology	1.12	1.26	1.30	1.31	1.31	1.35	1.36
2007 TTI Methodology[1]	1.15	1.21	1.23	1.24	1.25	1.26	1.27
Very Large (more than 3 million)							
2005 TTI Methodology	1.37	1.46	1.51	1.53	1.57	1.61	1.61
2007 TTI Methodology[1]	1.26	1.33	1.36	1.36	1.39	1.39	1.40
All Urbanized Areas							
2005 TTI Methodology	**1.22**	**1.30**	**1.34**	**1.35**	**1.37**	**1.39**	**1.40**
2007 TTI Methodology[1]	**1.16**	**1.23**	**1.24**	**1.25**	**1.27**	**1.27**	**1.28**

[1] The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calucating congestion metrics in its 2007 Urban Mobility Report.

[2] The base year for comparison purposes is 1987.

Source: Texas Transportation Institute.

communities in the Very Large category; the extra time required for a trip under congested conditions in these communities grew from 6.6 extra minutes in 1997 to 8.0 extra minutes in 2007. However, analysis using the 2005 TTI methodology shows there was no increase in the Travel Time Index in the communities in the Very Large category between 2004 and 2005.

Based on 2007 TTI methodology, the increase in the Travel Time Index for each population group from 2004 to 2005 was greatest for Medium communities at an additional 0.6 minutes. For communities in the Very Large and Large categories, the increase was 0.2 minutes. For communities in the Small category it was 0.4 minutes.

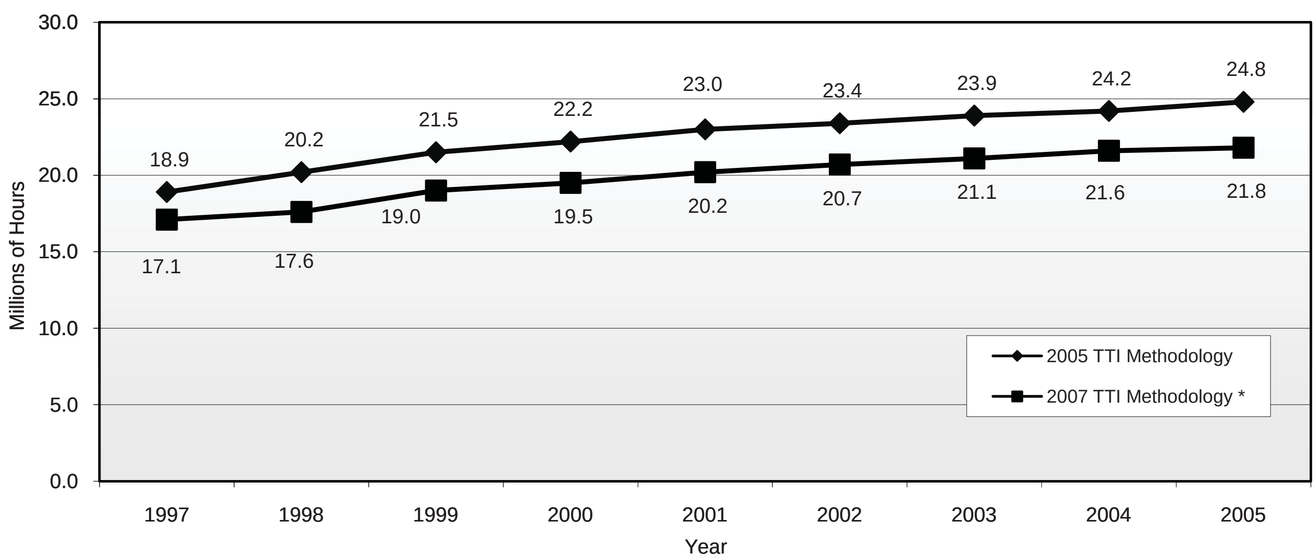
Annual Hours of Delay per Capita

Annual hours of delay per capita is another measure of the severity, duration, and extent of congestion. This metric represents the amount of lost time due to congested conditions in urbanized areas divided by the total number of urbanized area residents.

As shown in *Exhibit 4-6*, the annual hours of delay per capita for all urbanized areas combined has grown from 17.1 hours in 1997 to 21.8 hours in 2005. This translates into an annual rate of change of approximately 3.1 percent. Using the 2007 TTI methodology, the annual hours of delay per capita for all urbanized areas combined increased from 21.6 hours in 2004 to 21.8 hours in 2005, or approximately 0.9 percent.

Exhibit 4-6

Average Annual Hours of Delay per Capita for All Urbanized Areas, 1997–2005



** The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calculating congestion metrics in its 2007 Urban Mobility Report.*

Source: Texas Transportation Institute.

Using the 2005 TTI methodology, the annual hours of delay per capita for all urbanized areas combined increased from 18.9 hours in 1997 to 24.8 hours in 2005. This translates into an annual rate of change of approximately 3.5 percent. The metric increased from 24.2 hours in 2004 to 24.8 hours in 2005, or approximately 2.5 percent.

Exhibit 4-7 presents the values of this metric by population category. All four population categories experienced an increase in this metric in this period. Using the 2007 TTI methodology, communities in the Small (population less than 500,000) category experienced the largest increase in this metric between 1997 and 2005, from 7.6 hours in 2004 to 11.4 hours in 2005, or an annual rate of change of 5.2 percent; the rate of change based on the 2005 methodology was higher, at a 5.9 percent annual rate of change. Using the 2007 TTI methodology, the annual hours of delay per capita in 2005 was 16.6 hours for communities in the Medium category, 22.3 hours for communities in the Large category, and 29.4 hours for communities in the Very Large category.

Exhibit 4-7

Annual Hours of Delay per Capita by Urbanized Area Size, 1997–2005

Urbanized Area Population	1997	1999	2000	2002	2004	2005	Annual Rate of Change 2005/2004	Annual Rate of Change 2005/1997
Small (less than 500,000)								
2005 TTI Methodology	6.4	7.5	7.8	8.2	9.6	10.1	5.2%	5.9%
2007 TTI Methodology*	7.6	8.4	9.1	9.5	10.5	11.4	8.6%	5.2%
Medium (500,000 to 999,999)								
2005 TTI Methodology	11.8	13.5	13.4	13.9	15.2	15.5	2.0%	3.5%
2007 TTI Methodology*	12.5	14.3	14.5	15.4	16.5	16.6	0.6%	3.6%
Large (1 million to 3 million)								
2005 TTI Methodology	17.0	19.5	20.5	19.2	22.0	23.0	4.5%	3.9%
2007 TTI Methodology*	17.0	19.1	19.8	19.7	21.6	22.3	3.2%	3.5%
Very Large (more than 3 million)								
2005 TTI Methodology	28.8	32.5	33.5	36.6	36.7	37.8	3.0%	3.5%
2007 TTI Methodology*	23.5	25.6	26.2	28.6	29.1	29.4	1.0%	2.8%
All Urbanized Areas								
2005 TTI Methodology	**18.9**	**21.5**	**22.2**	**23.4**	**24.2**	**24.8**	**2.5%**	**3.5%**
2007 TTI Methodology*	**17.1**	**19.0**	**19.5**	**20.7**	**21.6**	**21.8**	**0.9%**	**3.1%**

** The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calculating congestion metrics in its 2007 Urban Mobility Report.*

Source: Texas Transportation Institute.

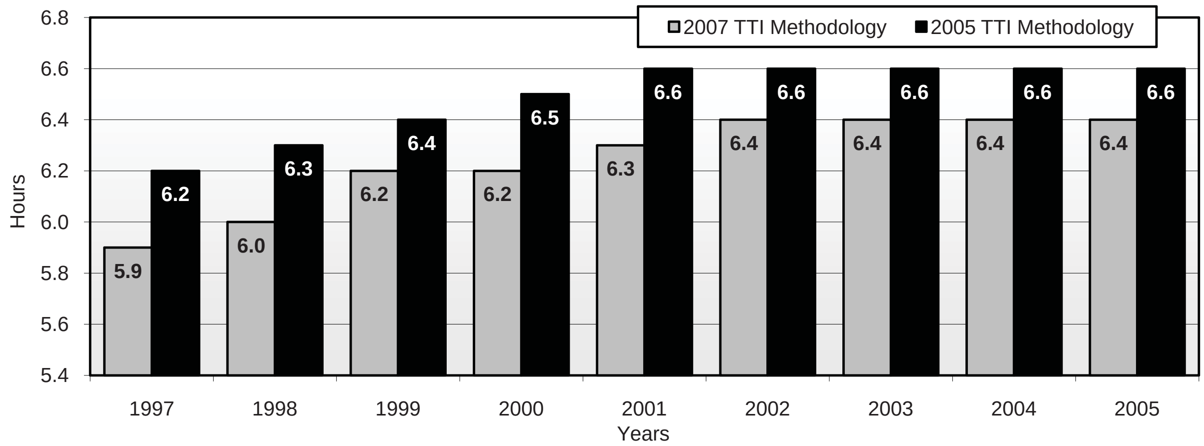
Average Length of Congested Conditions

The average length of congested conditions is a measure of the duration of congestion. This is the number of hours during a 24-hour period when traffic is operating under congested conditions, which can also be expressed as enduring from one time of day to another. For example, a community with a total of 8 hours of congested conditions may have experienced 4 hours between 6:00 am and 10:00 am and 4 hours between 3:00 pm and 7:00 pm, although congested time does not normally divide evenly between times of the day. The higher the amount of congested time experienced by a community, the greater the problem of congestion is in the community.

As shown in *Exhibit 4-8*, based on the 2007 TTI methodology, the average congested travel time period for all urbanized areas combined has increased from 5.9 hours in 1997 to 6.4 hours in 2005—an increase of 30 minutes, or almost 8.5 percent, over a period of 8 years. The measure has stabilized in recent years, as this metric has remained at 6.4 hours per 24-hour period since 2002. Based on the 2005 TTI methodology, the average length of congestion increased from 6.2 hours in 1997 to 6.6 hours in 2005.

Exhibit 4-8

Average Length of Congested Conditions, All Urbanized Areas, 1997–2005



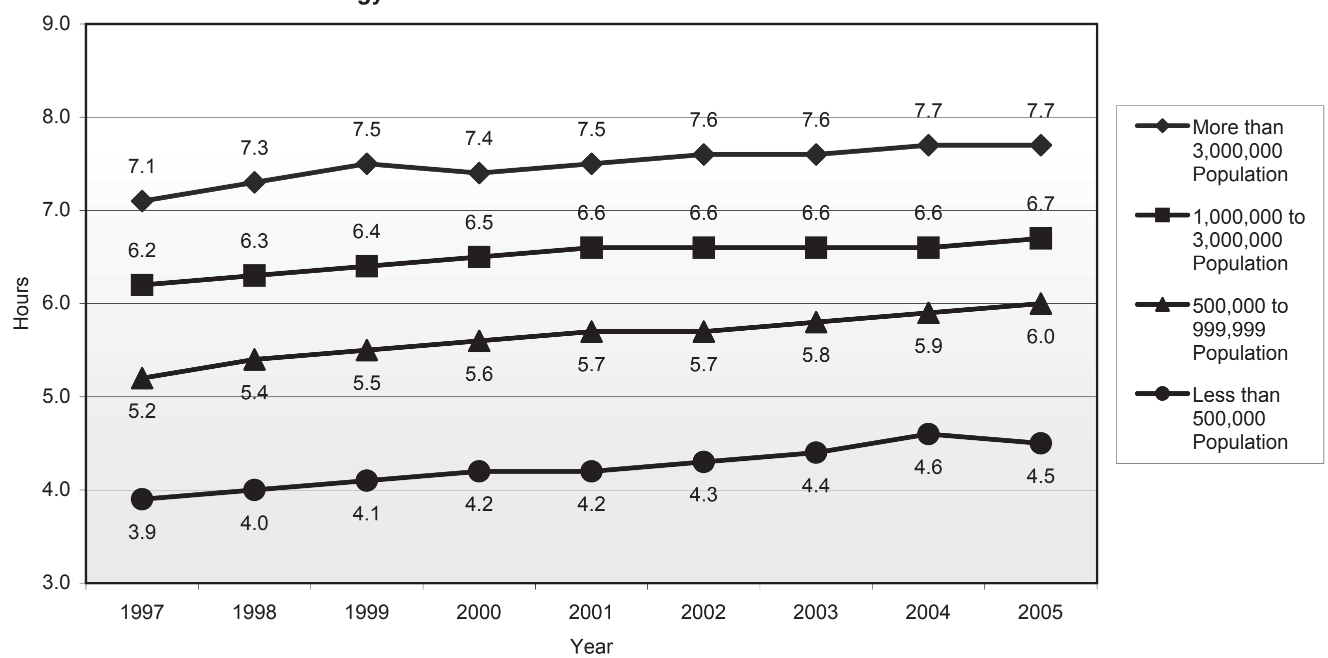
** The 2006 C&P Report used methodology consistent with TTI's 2005 Urban Mobility Report. TTI revised its methodology for calculating congestion metrics in its 2007 Urban Mobility Report.*

Source: Texas Transportation Institute.

Based on the 2007 TTI methodology, the patterns observed in the average length of congested conditions in each of the four urbanized area population categories are similar to the overall average pattern, as shown in *Exhibit 4-9.* The patterns shown for each of the community categories is similar to the overall average. This leveling in the growth in duration of congestion is a positive development; however, the length of congested conditions, particularly in the communities in the Large (population 1 million to 3 million) and Very Large (population 3 million or more) categories remains a major problem, where the length of the congested period extends through a major portion of a normal workday. Recurring congestion is now no longer restricted to the traditional peak commuting periods, resulting in ongoing travel delays for highway users.

Exhibit 4-9

Average Length of Congested Conditions by Urbanized Area, 1997 –2005
Based on 2007 TTI Methodology



Source: Texas Transportation Institute.

Recurring congestion also occurs on heavily traveled routes on Saturdays and Sundays so that even shopping and recreational travel is adversely impacted in urbanized areas.

As an example, the 7.7 average hours of congested conditions identified in *Exhibit 4-9* for communities in the Very Large (population 3 million or more) category could translate into congestion buildup during the morning period—from 6:00 am to 9:48 am, or 3.7 hours—and buildup during the afternoon period—for 4 hours beginning at 3:30 pm and extending to approximately 7:30 pm. The actual time of congested conditions varies by corridor and extends earlier or later than the times shown in this example. Not only are congestion periods lengthening, but more roads and lanes are affected at any one time. In the past, recurring congestion tended to occur only in one direction—toward downtown in the morning and away from it in the evening. Today, two-directional congestion is common, particularly on routes serving several major activity centers dispersed in suburban areas around the most congested metropolitan areas.

Cost of Congestion From TTI Urban Mobility Report

Congestion has an adverse impact on the American economy, which values speed, reliability, and efficiency. The problem is of particular concern to firms involved in logistics and distribution. As just-in-time delivery increases, firms need an integrated transportation network that allows for the reliable, predictable shipment of goods. If travel time increases or reliability decreases, businesses will need to increase average inventory levels to compensate, which will increase storage costs. Congestion, then, imposes a real economic cost for businesses and these costs will ultimately impact consumer prices. Chapter 14 discusses additional details on the impacts of congestion on freight transportation.

The TTI 2007 Urban Mobility Report estimates that drivers experienced more than 4.2 billion hours of delay and wasted approximately 2.9 billion gallons of fuel during delays in 2005. The total congestion cost for these areas, including wasted fuel and time was estimated to be approximately $78.2 billion, as shown in *Exhibit 4-10.* This is an increase of 220 million hours, 140 million gallons, and $5 billion from 2004. The Very Large category includes 14 urban areas that represent 55 percent of the population and 66 percent of the travel delays in 2005. The top 20 urban areas accounted for over 75 percent of the annual travel delays during that same period. In addition, the communities in the Very Large category accounted for about two-thirds of the wasted fuel and 60 percent of the total congestion costs, and 19 urban areas had total annual congestion costs of at least $1 billion each. It should be noted the total delay hours shown in *Exhibit 4-6* and *Exhibit 4-7* do not match the total delay hours shown in *Exhibit 4-10*, as the values for *Exhibit 4-10* reflect adjustments made by TTI to account for the effects of operational improvements.

Exhibit 4-10

National Congestion Measures, 1982 –2005

Year	Total Delay (Billions of Hours)	Total Fuel Wasted (Billions of Gallons)	Total Cost (Billions of 2005 Dollars)
1982	0.8	0.5	$16.2
1983	0.9	0.5	$16.2
1984	1.0	0.6	$17.7
1985	1.1	0.7	$20.5
1986	1.3	0.8	$23.1
1987	1.4	0.9	$25.8
1988	1.7	1.1	$29.7
1989	1.8	1.2	$32.9
1990	1.9	1.3	$35.5
1991	2.0	1.3	$35.8
1992	2.1	1.4	$38.0
1993	2.2	1.5	$40.1
1994	2.3	1.5	$41.9
1995	2.5	1.7	$45.4
1996	2.7	1.8	$48.5
1997	2.8	1.9	$51.3
1998	3.0	2.0	$53.2
1999	3.2	2.1	$57.2
2000	3.2	2.2	$57.6
2001	3.3	2.3	$60.4
2002	3.5	2.4	$63.9
2003	3.7	2.5	$67.2
2004	4.0	2.7	$73.1
2005	4.2	2.9	$78.2

Source: Texas Transportation Institute 2007 Urban Mobility Report.

Traditional Congestion Measures

As previously noted, it is difficult to measure congestion, largely because both travel demand and the availability of capacity are variable. Traffic demands vary significantly by time of day, day of the week, and season of the year, and for special events. While capacity is often thought of as a constant, the available capacity at any given time can vary because of weather, work zones, traffic incidents, or other nonrecurring events.

Two of the most traditional approaches to measuring congestion are daily vehicle miles traveled (DVMT) and the ratio of volume to service flow (V/SF). DVMT per lane mile is a basic measure of the relationship between highway travel and highway capacity. It is directly based on actual counts of traffic rather than estimated from other data. An increase in this measure over time indicates an increase in the density of traffic, but does not indicate how this affects speed, delay, or user cost. *Exhibit 4-11* shows that the volume of travel per lane mile increased between 1997 and 2006 on every functional highway system for which data were collected except Rural Major Collectors.

The largest increases between 1997 and 2006 occurred on the functional classes "Other Freeway and Expressway" and "Interstate" in urbanized areas. The DVMT per lane mile increased 1,263 on Other Freeway and Expressway and 1,213 on the Interstate in this population group. The largest percentage increase occurred on the Interstate in rural areas, where the DVMT per lane mile increased by 14.8 percent, from 4,952 to 5,684. The DVMT per lane mile on Interstates in Small Urban Areas increased 13.8 percent, from 6,842 to 7,784, in the same time period.

Note that the decreases in DVMT per lane mile between 2004 and 2006 for many functional classes are partially driven by boundary changes resulting from the 2000 decennial census, when many States adjusted their HPMS data to reflect the new boundaries. As the rural areas on the fringe of small urban or urbanized

Exhibit 4-11

Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile by Population Area and Functional Class, 1997 –2006

							Annual Rate of Change	
Functional System	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2006/2004**	**2006/1997**
Rural Areas (less than 5,000 in population)								
Interstate	4,952	5,322	5,455	5,711	5,707	5,684	-0.20%	1.54%
Other Principal Arterial	2,522	2,651	2,685	2,756	2,642	2,562	-1.53%	0.18%
Minor Arterial	1,557	1,622	1,640	1,683	1,632	1,580	-1.61%	0.17%
Major Collector	634	652	659	676	649	628	-1.65%	-0.11%
Small Urban Areas (5,000 to 49,999 in population)								
Interstate	6,842	7,457	7,545	7,955	7,925	7,784	-0.89%	1.44%
Other Freeway and Expressway	5,339	5,639	5,841	6,106	5,888	5,668	-1.89%	0.67%
Other Principal Arterial	4,032	4,173	4,204	4,258	4,092	4,035	-0.70%	0.01%
Minor Arterial	2,488	2,595	2,601	2,673	2,529	2,528	-0.02%	0.18%
Collector	1,224	1,254	1,253	1,306	1,214	1,260	1.88%	0.33%
Urbanized Areas (50,000 or more in population)								
Interstate	14,465	15,093	15,333	15,689	15,783	15,678	-0.33%	0.90%
Other Freeway and Expressway	11,304	12,021	12,286	12,730	12,630	12,567	-0.25%	1.18%
Other Principal Arterial	6,214	6,252	6,284	6,408	6,326	6,243	-0.66%	0.05%
Minor Arterial	3,893	4,160	4,210	4,345	4,307	4,148	-1.86%	0.71%
Collector	2,100	2,157	2,192	2,276	2,275	2,266	-0.20%	0.85%

Source: Highway Performance Monitoring System.

areas (which tend to have higher DVMT per lane-mile values within the rural category) were reclassified as small urban or urbanized, the average rural DVMT values decreased. The small urban averages were affected both by the addition of areas formerly classified as rural and the subtraction of areas reclassified as urbanized. The urbanized area averages were also affected by the reclassification of formerly small urban or rural areas as urbanized.

The other traditional congestion measure, V/SF, represents the number of vehicles traveling in a single lane in one hour in the peak travel hour divided by the maximum number of vehicles that could utilize the lane in an hour. *Exhibit 4-12* shows the percentage of peak-hour travel meeting or exceeding a V/SF of 0.80 as well as the percentage exceeding 0.95. A level of 0.80 is frequently used as a threshold for classifying highways as "congested," while a level of 0.95 indicates "severely congested" conditions. For urbanized Interstates, 61.0 percent had peak-hour travel with a V/SF ratio of 0.80 or higher, and 36.5 percent had peak-hour travel with a V/SF ratio of 0.95 or higher. Both of these values decreased between 2004 and 2006.

For most functional classes, the percent of peak-hour travel exceeding the 0.80 and 0.95 V/SF thresholds declined from 2004 to 2006. This is partially the result of the 2000 decennial census when many States adjusted their HPMS data during this time period to reflect new boundaries. However, this is also an indication that this measure of the severity of congestion at the peak hour excludes some critical components of the Nation's congestion problems that relate to the duration and extent of congestion.

This measure of congestion is limited, because as it only addresses the severity of the congestion, and not the duration and extent of congestion. Focusing on the V/SF measure alone can lead to erroneous conclusions about highway operational performance. For example, in some communities the major operational performance issue is not that peak congestion is getting worse; it is the length of the peak period of congestion and the time needed to make a single trip that are having detrimental impacts on communities and the public.

Exhibit 4-12

Percent of Peak-Hour Travel Exceeding Congestion Measure (V/SF) Thresholds, 1997 –2006

	1997		2000		2002		2004		2006	
Functional System	V/SF ≥ 0.80	V/SF > 0.95	V/SF ≥ 0.80	V/SF > 0.95	V/SF ≥ 0.80	V/SF > 0.95	V/SF ≥ 0.80	V/SF > 0.95	V/SF ≥ 0.80	V/SF > 0.95
Rural Areas (less than 5,000 in population)										
Interstate	11.0%	3.6%	10.4%	3.3%	15.9%	4.8%	15.1%	5.6%	15.1%	5.3%
Principal Arterial	7.0%	3.2%	7.4%	3.8%	6.9%	3.8%	6.3%	2.4%	5.6%	2.0%
Minor Arterial	4.2%	1.9%	4.6%	2.2%	4.8%	2.2%	4.0%	2.1%	3.6%	1.8%
Major Collector	2.4%	1.2%	2.3%	1.0%	2.3%	1.4%	1.8%	0.9%	1.7%	0.6%
Small Urban Areas (5,000 to 49,999 in population)										
Interstate	13.2%	4.7%	7.7%	3.2%	13.2%	5.5%	17.8%	3.2%	16.6%	5.0%
Other Freeway & Expressway	11.3%	6.6%	12.5%	6.3%	17.9%	8.9%	17.6%	8.7%	17.9%	8.1%
Other Principal Arterial	11.6%	6.4%	13.2%	6.0%	9.0%	3.8%	8.5%	4.1%	7.3%	3.3%
Minor Arterial	13.1%	6.6%	14.3%	8.0%	12.3%	6.3%	10.7%	4.8%	8.7%	4.0%
Collector	9.7%	5.6%	9.9%	5.7%	8.4%	4.9%	7.1%	3.8%	6.7%	3.3%
Urbanized Areas (50,000 or more in population)										
Interstate	55.0%	30.0%	50.0%	26.0%	64.3%	40.2%	63.5%	38.4%	61.0%	36.5%
Other Freeway & Expressway	47.5%	26.4%	46.4%	28.3%	56.7%	35.4%	55.3%	31.9%	51.9%	30.1%
Other Principal Arterial	29.6%	18.1%	29.3%	16.4%	22.3%	10.2%	21.5%	9.4%	20.7%	9.5%
Minor Arterial	25.2%	14.1%	26.4%	14.5%	18.6%	9.3%	17.1%	9.3%	17.3%	9.3%
Collector	21.0%	13.4%	20.3%	13.7%	18.2%	9.3%	15.5%	9.6%	15.8%	9.3%

Source: Highway Performance Monitoring System.

Exhibit 4-13 summarizes these two metrics—DVMT per lane mile and the V/SF ratio—for different sizes of urbanized areas by functional classification. For each type of urbanized area, not surprisingly, Interstate highways carried the highest share of DVMT per lane mile. Interstate highways were also the most congested elements of the road network when measured by the V/SF ratio. Only in the smallest-sized communities, at the V/SF level of 0.95 or higher, was another segment of the road network as congested as Interstate highways ("other freeways and expressways").

Exhibit 4-13

Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile and Percent of Peak-Hour Travel Exceeding Congestion Measure (V/SF) Thresholds, for Different Sizes of Urbanized Areas, by Functional Class, 2006

Functional System	DVMT per Lane-Mile	Percent of Peak-Hour Travel Exceeding V/SF Thresholds	
		V/SF ≥ 0.80	V/SF > 0.95
Small Urbanized Areas (50,000–499,999 in population)			
Interstate	11,257	40.4%	18.2%
Other Freeway and Expressway	8,869	35.2%	19.2%
Other Principal Arterial	5,422	16.1%	7.3%
Minor Arterial	3,497	12.5%	6.5%
Collector	1,842	12.3%	7.0%
Medium Urbanized Areas (500,000–999,999 in population)			
Interstate	14,869	62.2%	37.3%
Other Freeway and Expressway	10,928	42.1%	21.7%
Other Principal Arterial	6,257	21.0%	9.0%
Minor Arterial	4,277	18.5%	11.1%
Collector	2,333	15.0%	8.9%
Large Urbanized Areas (1 million–3 million in population)			
Interstate	17,337	65.9%	41.4%
Other Freeway and Expressway	12,786	49.4%	28.9%
Other Principal Arterial	6,474	20.6%	9.2%
Minor Arterial	4,329	22.4%	11.4%
Collector	2,445	19.5%	12.0%
Very Large Urbanized Areas (more than 3 million in population)			
Interstate	19,511	72.4%	46.1%
Other Freeway and Expressway	16,653	66.2%	39.6%
Other Principal Arterial	6,996	25.1%	12.0%
Minor Arterial	4,738	17.8%	9.6%
Collector	2,708	16.9%	9.8%

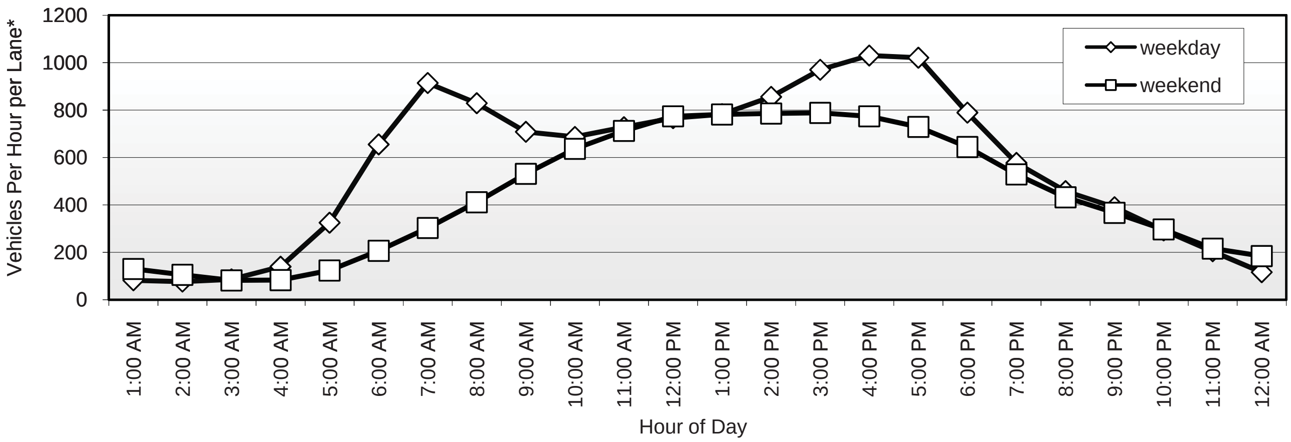
Source: Highway Performance Monitoring System.

Relationship of Congestion to Daily Travel

As previously noted, travel differs greatly by time of day. *Exhibit 4-14* describes the distribution of travel by hour as reported by a set of traffic monitoring stations located on various highway facilities throughout the country for a 4-month period extending from January 2006 through April 2006. The most congested conditions would tend to follow peak period travel hours. On weekdays, the peak period of morning travel is between 7 am and 8 am, and the peak period of evening travel is between 5 pm and 7 pm. On Saturdays and Sundays, peak travel is spread out over many hours between noon and 5 pm. Note that these are national averages and many individual traffic monitoring stations report hourly traffic distributions that are significantly different. The vehicle counts identified in *Exhibit 4-14* are raw counts of vehicles per hour per lane, and have not been weighted to reflect total VMT on different types of highway facilities.

Exhibit 4-14

Hourly Highway Travel, January 2006 to April 2006



** Vehicle counts shown represent averages of raw data from individual traffic monitoring stations located on all highway functional classifications. These values have not been weighted; thus while the relative hourly distribution is significant, the absolute total counts are not.*
Source: Travel Monitoring Analysis System.

Chapter 15 provides a more detailed look at recent changes in personal travel patterns.

Emerging Operational Performance Measures

Substantial research supports the use of delay as the definitive measure of congestion. Delay is certainly important; it exacts a substantial cost from the traveler and, consequently, from the consumer. However, it does not tell the complete story. Moreover, there currently is no direct measure of delay that can be collected both consistently and inexpensively.

Reliability is another important characteristic of any transportation system, one that industry in particular requires for efficient production. If a given trip requires 1 hour on one day and 1.5 hours on another day, an industry that is increasingly reliant on just-in-time delivery suffers. To compensate for variable trip times required to deliver products, an industry may be required to carry greater inventory than would otherwise be necessary, thereby incurring higher costs. Travel time reliability is a measure of congestion easily understood by a wide variety of audiences, and is one of the more direct measures of the effects of congestion on the highway user. However, additional research is needed to determine what measures should be used to describe congestion and what data will be required to supply these measures.

Q&A

How are the performance measures for congestion and greenhouse gas (GHG) emissions being linked?

Concern over GHG from vehicles and the potential impact on climate change has intensified in recent years. Currently, multiple transportation strategies are being used to reduce transportation-related GHG emissions including: improving system and operational efficiencies, reducing growth of VMT, reducing carbon content of fuels, and improving vehicle technologies.

In addition, work is being done to analyze the contribution of GHG emissions resulting from congestion and the potential to reduce those emissions through vehicle system and operational efficiencies such as Intelligent Transportation Systems (ITS) strategies, route optimization, and reduced engine idling.

FHWA is working with EPA on the development of the MOVES Model, which is a new emissions modeling system that will estimate emissions for both on-road and off-road mobile sources, including CO_2 emissions.

The Department is currently researching effective ways to promote a more performance-based transportation system in preparation for the next transportation reauthorization.

Additional information on U.S. DOT efforts in climate change in transportation is available at: http://www.fhwa.dot.gov/hep/climate/index.htm and http://www.climate.dot.gov/index.html.

How did SAFETEA-LU attempt to improve operations?

Q&A

Several provisions SAFETEA-LU were designed to broaden the use of operations strategies:

High Occupancy Vehicle (HOV) Facilities and Tolling

Section 1121—HOV Facilities—Clarifies the operation of HOV facilities and provides more exceptions to vehicle occupancy requirements. States may also establish exceptions for public transportation vehicles, certified low-emission and energy-efficient vehicles, and high occupancy toll vehicles. Tolls under this section may be charged on both Interstate and non-Interstate facilities.

Section 1604—Tolling—Extends and authorizes a total of $59 million in funding for the Value Pricing Pilot Program; creates a new Express Lanes Demonstration Program to permit tolling on up to 15 demonstration projects; and creates a new Interstate System Construction Toll Pilot Program that authorizes tolling to finance construction of up to three new Interstate highway facilities.

Planning and Agreements

Section 6001—Transportation Planning—Operations—Contains a number of elements that spell out the importance of management and operations in the planning process.

Section 10204—Catastrophic Hurricane Evacuation Plans—Requires the U.S. Departments of Homeland Security and Transportation to assess evacuation plans for catastrophic events in the Gulf Coast Region. The Report to Congress on Catastrophic Hurricane Evacuation Plan Evaluation was released on June 1, 2006.

Section 5211—Multistate Corridor Operations—Encourages multistate cooperative agreements, coalitions, or other arrangements to promote regional cooperation and planning.

System Information and Technology

Section 1201—Real-Time System Management Information Program—Requires the establishment of a real-time system management information program to provide, in all States, the capability to monitor the traffic and travel conditions of the Nation's major highways and to share that information with State and local governments and the traveling public.

Section 5508—Transportation Technology Innovation and Demonstration Program—Presents a two-part intelligent transportation infrastructure program to advance the deployment of an operational intelligent transportation infrastructure system, aid in transportation planning and analysis, and provide a basic level of traveler information.

Worker Protection

Section 1402—Worker Injury Prevention and Free Flow of Vehicular Traffic—Directs issuance of regulations to decrease the likelihood of worker injury and maintain the free flow of vehicular traffic by requiring workers whose duties place them on or in close proximity to a Federal-aid highway to wear high-visibility garments. A Federal Register notice was issued in April 2006, with an effective date of November 24, 2008.

System Reliability

Travel time reliability measures are relatively new, but a few have proven effective at the local level. Such measures typically compare high-delay days with average-delay days. The simplest method identifies days that exceed the 90th or 95th percentile in terms of travel times and estimates how bad delay will be on specific routes during the worst one or two travel days each month.

The Buffer Index measures the percentage of extra time travelers must add to their average travel time to allow for congestion delays and arrive at a location on time about 95 percent of the time. The Planning Time Index represents the total travel time that is necessary to ensure on-time arrival, including both the average travel time and the additional travel time included in the Buffer Index. Generally, the Buffer Index goes up during peak periods, when congestion occurs, indicating a reliability problem.

The Planning Time Index is especially useful because it uses a numeric scale which can be directly compared to the numeric scale of the Travel Time Index presented earlier in this chapter. While data are not currently available to support these measures at the national level, data in the 2007 TTI Urban Mobility Report were collected on planning time indicators for 19 metropolitan regions. The comparison of the Travel Time Index (in average conditions) and the Planning Time Index (for an important trip) for these 19 metropolitan areas suggest that travelers should plan on twice as much extra travel time if they have an important trip than if they are traveling during average conditions. These indexes can be applied to additional cities as equipment is deployed and data are accumulated.

Can system reliability be measured directly?

Q&A

FHWA's Office of Freight Management and Operations is conducting a freight performance measurement (FPM) research program that focuses on measuring average operating speeds and travel time reliability on freight significant corridors and on crossing time and crossing time reliability at major U.S. international land border crossings. Measures are based primarily on vehicle location and time data from communication technology used by the freight industry. These direct measures of reliability show potential for identifying areas of significant freight congestion and bottlenecking.

Since 2004, FHWA has been collecting and analyzing data for freight significant Interstate corridors. FHWA plans to continue to collect travel time information on these five corridors at least through October 2009 and have equivalent data for 20 additional Interstate corridors from April 2006 to the present. [See *Exhibit 4-15*]

Exhibit 4-15

Average Operating Speeds on Five Freight Significant Interstate Corridors, 2005 –2007

Interstate Corridor	Year (Miles Per Hour) 2005	2006	2007
I-5	49.7	49.9	51.6
I-10	55.9	55.4	55.5
I-45	54.1	53.3	54.4
I-65	57.7	56.8	57.8
I-70	54.3	53.6	53.9

Source: FHWA Office of Freight Management and Operations.

Key objectives of the current FPM research program are to expand on the existing data sources, further develop and refine methods analyzing data, derive national measures of congestion and reliability, and develop data products and tools that will assist DOT, FHWA, and State and local transportation agencies in addressing surface transportation congestion. The goal is to evolve the research into a credible freight data source that can be used to continuously measure freight performance and inform the development of strategies and tactics for managing and relieving freight congestion.

The importance of reliability is underscored by a November 2004 study, *Temporary Losses of Highway Capacity and Impacts on Performance: Phase 2*, produced for the FHWA by the Oak Ridge National Laboratory. Temporary capacity losses due to work zones, crashes, breakdowns, adverse weather, suboptimal signal timing, toll facilities, and railroad crossings caused over 3.5 billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999. For journeys on regularly congested highways during peak commuting periods, temporary capacity losses added 6 hours of delay for every 1,000 miles of travel. Americans suffer 2.5 hours of delay per 1,000 miles of travel from temporary capacity loss for journeys on roads that do not experience recurring congestion.

Bottlenecks

In July 2007, the FHWA prepared a report, *Traffic Bottlenecks: a Primer Focus on Low-Cost Operational Improvements*, to show that, although costly major construction projects are often the first option for addressing congestion issues, there are also significant opportunities for operational and low-cost infrastructure solutions for congestion relief.

Bottlenecks have gained more notice in recent years because several national studies have identified them as a significant part of the congestion problem; bottlenecks occur when surge demands are higher than can be accommodated by base capacity. On much of our urban highway system, there are specific points that are notorious for causing congestion on a daily basis.

An October 2005 report prepared by Cambridge Systematics for the FHWA, *An Initial Assessment of Freight Bottlenecks on Highways*, examines bottlenecks from a freight perspective. In assessing impacts of bottlenecks on truck travel, the significant finding of this study is that bottlenecks are more than just commuter-related issues; they are also a major source of truck delay. See Chapter 13 for additional information on this report and other freight operational performance measures.

State DOTs and regions are also beginning to recognize the significance of bottlenecks and undertaking studies of their own.

Transit Operational Performance

Transit operational performance can be measured and evaluated on the basis of a number of different factors such as the speed at which a passenger travels on transit, vehicle occupancy rate, and vehicle utilization, as well as service frequency and seating availability. These measures, however, do not necessarily all lead toward a single standard of higher operational performance. For example, while higher average operating speeds are good for passengers, they may indicate that transit systems are not carrying sufficient passengers, and therefore have shorter dwell times. Conversely, while higher vehicle utilization indicates more intensive vehicle use, it may also indicate that passengers are experiencing crowded conditions. For this reason, speed, occupancy, and capacity utilization are analyzed only on the basis of the direction of their change; the optimal levels of these measures are unknown.

Average Operating (Passenger-Carrying) Speeds

Average vehicle operating speed is an approximate measure of the speed experienced by transit riders; it is not a measure of the pure operating speed of transit vehicles between stops. Rather, average operating speed is a measure of the speed passengers experience from the time they enter a transit vehicle to the time they exit it, including dwell times at stops. It does not include the time passengers spend waiting or transferring. Average vehicle operating speed is calculated for each mode by dividing annual vehicle revenue miles by annual vehicle revenue hours for each agency in each mode, weighted by the passenger miles traveled (PMT) for each agency within the mode, as reported to the National Transit Database. In cases where an agency provides both directly operated service and purchased transportation service within a mode, the speeds for each of these services are calculated and weighted separately. The results of these average speed calculations are presented in *Exhibit 4-16*.

Exhibit 4-16

Average Transit Passenger-Carrying Speed, 2006

Mode	Miles per Hour
Heavy Rail	20.0
Commuter Rail	31.3
Light Rail	14.7
Other Rail[1]	7.9
Motor Bus	12.6
Demand Response	14.6
Vanpool	38.3
Other Nonrail[2]	10.7

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail.
[2] Público and trolleybus.

Source: National Transit Database.

The average speed of a transit mode is strongly affected by the number of stops it makes. Motor bus service, which typically makes frequent stops, has a relatively low average speed of 12.6 miles per hour. In contrast, commuter rail has high sustained speeds between infrequent stops, and a high average speed of 31.3 miles per hour. Vanpools also travel at high speeds, usually with only a few stops at each end of the route, and an average speed of 38.3 mph. Also, in many cases, modes using exclusive guideways offer more rapid travel time than modes that do not. Heavy rail, which travels exclusively on fixed guideways, has an average speed of 20.0 mph, while light rail, which often shares guideways, has an average speed of 14.7 mph.

Exhibit 4-17 provides average speed for each year from 1997 to 2006 for all rail modes, all nonrail modes, and all modes combined, as well as the overall average speed for these groups from 1997 through 2006. As speed numbers fluctuate from year to year, the relation of a given year's average speed to the long-term average provides a better indication of overall trends than comparison to an individual year. These average speeds are based on the average speed of each agency-mode weighted by the number of PMT on that agency-mode. Average transit operating speed as experienced by all transit passengers from 1997 to 2006 was 20.0 miles per hour. The average speed on nonrail modes was 14.4 miles per hour in 2006, which is slightly higher than the long-term average of 13.9 miles per hour, and indicating an overall trend of increasing speed on nonrail modes. The average speed on rail modes, however, at 24.8 miles per hour in 2006, was below the long-term average of 25.2 miles per hour, indicating an overall trend of declining average speed on rail modes.

Exhibit 4-17

Passenger-Mile Weighted Average Operating Speed by Transit Mode, 1997–2006

(Miles per Hour)	Rail	Nonrail	All Modes
1997	26.1	13.8	20.3
1998	25.6	14.0	20.5
1999	25.5	14.0	20.1
2000	24.9	13.7	19.6
2001	25.2	13.7	19.6
2002	25.3	13.7	19.6
2003	25.4	13.9	20.1
2004	25.0	14.0	20.1
2005	24.6	14.2	19.9
2006	24.8	14.4	20.0

Source: National Transit Database.

Vehicle Use

Vehicle Occupancy

Exhibit 4-18 shows vehicle occupancy by mode for selected years from 1997 to 2006. Vehicle occupancy is calculated by dividing PMT by vehicle revenue miles (VRMs) and shows the average number of people carried in a transit vehicle. In 2006, heavy rail carried an average of 23.2 persons per vehicle and light rail an average of 25.5 persons per vehicle. Commuter rail had an average occupancy of 36.1 persons per vehicle, motor bus had an average of 10.8 persons per vehicle, vanpool had an average of 6.3 persons per vehicle, ferryboat had an average of 130.7 persons per vehicle, and demand response had an average of 1.3 persons per vehicle.

Exhibit 4-18

Unadjusted Vehicle Occupancy: Passengers per Transit Vehicle, 1997–2006

Mode	1997	1999	2000	2002	2004	2006
Rail						
Heavy Rail	22.3	23.0	23.9	22.6	23.0	23.2
Commuter Rail	35.0	36.0	37.9	36.7	36.1	36.1
Light Rail	25.7	25.2	26.1	23.9	23.7	25.5
Other Rail[1]	9.5	8.7	8.4	8.4	10.4	8.4
Nonrail						
Motor Bus	10.9	10.9	10.7	10.5	10.0	10.8
Demand Response	1.5	1.3	1.3	1.2	1.3	1.3
Ferryboat	126.2	119.0	120.1	112.1	119.5	130.7
Trolleybus	14.1	13.7	13.8	14.1	13.3	13.9
Vanpool	7.7	6.9	6.6	6.4	5.9	6.3
Other Nonrail[2]	8.1	6.1	7.3	7.9	5.8	7.8

[1] *Alaska railroad, automated guideway, cable car, inclined plane, and monorail.*

[2] *Aerial tramway and Público.*

Source: National Transit Database.

Exhibit 4-19 provides adjusted vehicle occupancy, or the average number of persons carried per capacity-equivalent vehicle, with the average carrying capacity of motor bus vehicles as a base. Adjusted vehicle occupancy is calculated by dividing PMT by capacity-equivalent VRMs. This measure takes into account differences in seating and standing capacities. Note that modes where standing is not possible or not allowed tend to have higher adjusted vehicle occupancies than modes where standing is possible and allowed. Commuter rail and vanpool, used primarily for commuting, have high levels of adjusted occupancy. Standing is generally not feasible in vanpool vehicles and is frequently not allowed on commuter rail vehicles.

As discussed in Chapter 2, capacity-equivalent VRMs have been revised to reflect the actual carrying capacities that existed in each year. Prior reports had used the same factor for each mode for all years. For this reason, except for motor bus, which is the base, adjusted vehicle occupancy in this report may differ slightly from the values from C&P reports prior to 2006.

Exhibit 4-19

Adjusted Vehicle Occupancy: Passengers per Transit Vehicle, 1997–2006

Mode	1997	1999	2000	2002	2004	2006
Rail						
Heavy Rail	10.2	10.3	10.5	9.3	9.3	8.9
Commuter Rail	15.4	15.3	15.8	14.6	14.2	12.4
Light Rail	11.2	10.4	10.5	9.6	8.8	9.5
Other Rail[1]	5.4	5.0	6.3	6.3	8.3	6.0
Nonrail						
Motor Bus	10.9	10.9	10.7	10.5	10.0	10.8
Demand Response	9.5	7.8	7.7	6.5	7.0	6.3
Ferryboat	10.5	10.0	9.9	9.4	11.1	9.8
Trolleybus	10.0	9.7	9.7	9.6	8.8	8.7
Vanpool	40.8	37.2	35.6	31.3	30.6	31.5
Other Nonrail[2]	31.8	23.5	28.1	30.3	22.6	23.0

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail.

[2] Aerial tramway and Público.

Source: National Transit Database.

Vehicle Utilization

Exhibit 4-20 shows vehicle utilization as measured by PMT per capacity-equivalent vehicle (CEV) operated in maximum scheduled service. PMT per CEV is a measure of service effectiveness, measuring vehicle utilization by taking account of differences in vehicle carrying capacities. PMT per CEV, or capacity utilization, is calculated by dividing the total number of PMT on each mode by the total number of vehicles operated in maximum service in each mode, adjusted by the average capacity of the Nation's motor bus fleet. A high number of PMT per CEV indicates high passenger use; a low number of PMT per CEV indicates low passenger use. For example, in 2006 there were 1,644.3 thousand PMT per heavy rail vehicle, as compared with the 402.9 thousand PMT per motor bus vehicle. However, because heavy rail vehicles have, on

> **Q&A**
>
> **What is service effectiveness and how can it be measured?**
>
> Service effectiveness measures the extent to which transit agencies are providing service that is demanded and used by consumers. This is primarily measured as "vehicle utilization"—the PMT per capacity-equivalent vehicle mile. Other measures of service effectiveness include unlinked passenger trips per VRM, unlinked passenger trips per vehicle revenue hour, annual passenger miles per actual annual VRM, and passenger miles traveled per scheduled vehicle mile.

Exhibit 4-20

Transit Vehicle Utilization: Annual Passenger Miles per Capacity-Equivalent Vehicle by Mode, 1997–2006

	(Thousands of Passenger Miles)										
Mode	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Average**
Rail											
Heavy Rail	667.1	665.4	694.3	720.3	702.7	654.6	634.0	652.4	642.9	632.4	666.6
Commuter Rail	788.1	806.2	801.2	838.2	842.6	769.2	747.7	754.8	709.5	658.3	771.6
Light Rail	553.8	578.9	541.1	556.5	561.5	533.3	494.0	467.7	522.4	543.4	535.2
Nonrail											
Motor Bus	400.6	393.4	397.0	393.2	397.3	389.3	382.7	373.5	390.5	402.9	392.0
Demand Response	241.6	206.7	203.7	206.7	185.3	167.8	172.0	180.7	162.0	162.6	188.9
Ferryboat	297.8	298.0	293.7	304.6	284.5	297.2	350.0	328.4	336.0	287.8	307.8
Trolleybus	266.5	251.6	257.2	264.1	287.9	245.7	235.7	236.7	239.3	246.2	253.1
Vanpool	608.7	621.1	618.3	591.8	501.1	498.2	535.4	501.7	511.8	490.1	547.8

Source: National Transit Database.

average, two and a half times the capacity of a motor bus, heavy rail provides 632.4 thousand PMT per CEV, considerably less than on an unadjusted basis. (Note again that, due to revisions to the capacity-equivalent factors, vehicle utilization in this report may differ from the values in the 2006 C&P Report, except for motor bus, which is the base.) Commuter rail has consistently had the highest level of utilization, reflecting longer average trip lengths with seating capacity only. As shown in *Exhibit 4-20*, between 1997 and 2006, most modes reached their highest level of utilization in 2000 or 2001. Light rail and motor bus modes were at a higher level of capacity utilization in 2006 than the long-term average utilization from 1997 to 2006.

Revenue Miles per Active Vehicle (Service Use)

Vehicle service use, the average distance traveled per vehicle in service, can be measured by VRMs per vehicle in active service. *Exhibit 4-21* provides vehicle service use by mode for selected years from 1997 to 2006. Heavy rail, generally offering long hours of frequent service, had the highest vehicle use over this period, increasing from 53.8 thousand miles per vehicle in 1997 to 57.0 thousand miles per vehicle in 2006.

Exhibit 4-21

Vehicle Service Utilization: Vehicle Revenue Miles per Vehicle by Mode, 1997–2006

	(Thousands of Vehicle Revenue Miles)						Average Annual Rate of Change	
Mode	**1997**	**1999**	**2000**	**2002**	**2004**	**2006**	**2006/1997**	**2006/2004**
Rail								
Heavy Rail	53.8	53.8	55.6	55.1	57.0	57.0	0.6%	0.0%
Commuter Rail	40.8	40.8	42.1	43.9	41.1	41.5	0.2%	0.6%
Light Rail	32.4	32.4	32.5	41.1	39.9	37.4	1.6%	-3.1%
Nonrail								
Motor Bus	28.6	28.6	28.0	29.9	30.2	28.6	0.0%	-2.6%
Demand Response	18.8	18.8	17.9	21.1	20.1	19.0	0.1%	-2.8%
Ferryboat	23.8	23.8	24.1	24.4	24.9	23.7	0.0%	-2.3%
Vanpool	13.3	13.3	12.9	13.6	14.1	13.0	-0.2%	-4.0%
Trolleybus	18.1	18.1	18.9	20.3	21.1	19.0	0.5%	-5.1%

Source: National Transit Database.

Vehicle service use for light rail increased from 32.4 thousand miles per vehicle in 1997 to 37.4 thousand miles per vehicle in 2006, after reaching a peak of 41.1 in 2002. Vehicle service use for trolley bus increased from 18.1 thousand miles per vehicle in 1997 to 19.0 thousand miles per vehicle in 2006. Vehicle service use by demand response, vanpool, motor bus, and ferryboat remained relatively steady from year to year. The number of service miles provided per commuter rail vehicle in active service reached a high of 43.9 thousand in 2002, compared with 40.8 thousand in 1997 and 41.5 thousand in 2006.

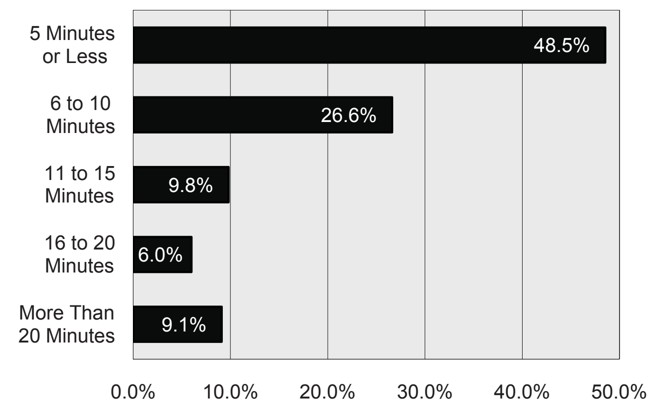
Frequency and Reliability of Services

The frequency of transit service varies considerably according to location and time of day. Transit service is more frequent in urban areas and during rush hours, in locations where and during times when the demand for transit is highest. Studies have found that transit passengers consider the time spent waiting for a transit vehicle to be less well spent than the time spent traveling in a transit vehicle. The higher the degree of uncertainty in waiting times, the less attractive transit becomes as a means of transportation, and the fewer users it will attract. Further, the less frequently scheduled service is offered, the more important reliability becomes to users.

Exhibit 4-22 shows findings on waiting times from the 2001 National Household Travel Survey (NHTS) by the Federal Highway Administration (FHWA), the most recent nationwide survey of this information. As indicated in the 2004 C&P Report, the NHTS found that 48.5 percent of all passengers who ride transit wait 5 minutes or less and 75.1 percent wait 10 minutes or less. The NHTS also found that 9.1 percent of all passengers wait more than 20 minutes. A number of factors influence passenger wait-times, including the frequency of service, the reliability of service, and passengers' awareness of timetables. These factors are also interrelated. For example, passengers may intentionally arrive earlier for service that is infrequent, compared with equally reliable services that are more frequent. Overall, waiting times of 5 minutes or less are clearly associated with good service that is either frequent, reliably provided according to a schedule, or both. Waiting times of 5 to 10 minutes are most likely consistent with adequate levels of service that are both reasonably frequent and generally reliable. Waiting times of 20 minutes or more indicate that service is likely both infrequent and unreliable.

Exhibit 4-22

Distribution of Passengers by Wait-Time

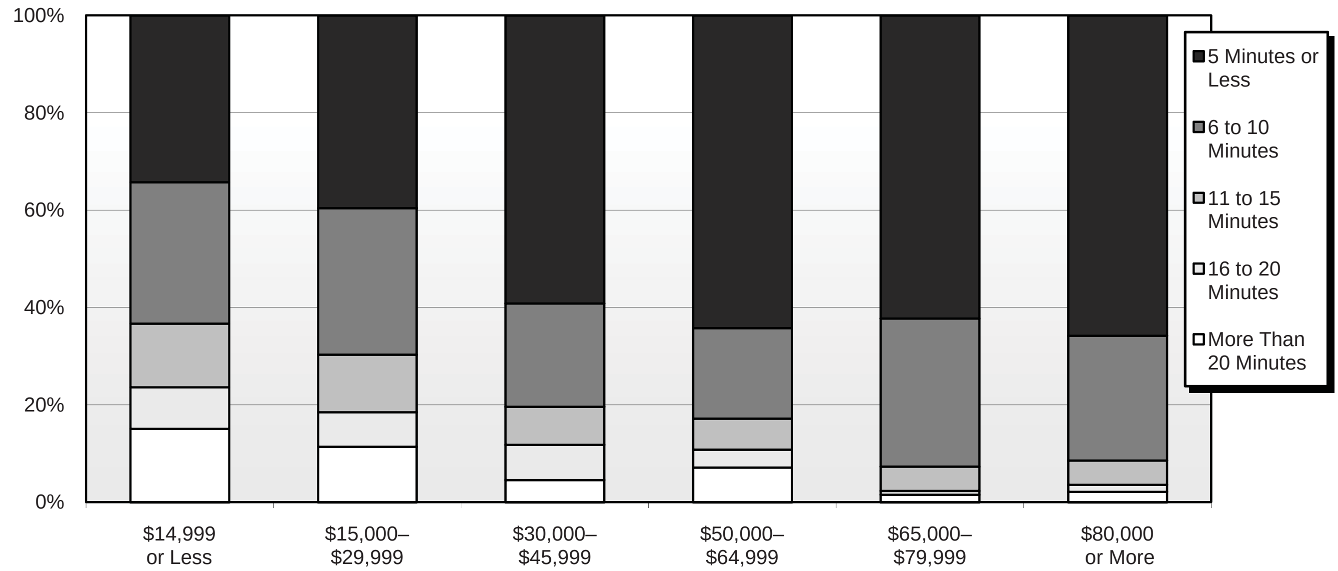


Source: National Household Travel Survey, FHWA, April 2001.

Waiting time is also correlated with income, as shown in *Exhibit 4-23*. Passengers from households with annual incomes of $30,000 or more are much more likely to report a waiting time of 5 minutes or less than passengers from households with incomes of less than $30,000. Additionally, passengers from households with more than $65,000 in annual income report almost never waiting more than 15 minutes for transit. This disparity is in large part due to the fact that high income riders tend to be "choice" riders who primarily ride transit on modes, routes, and at times of day when the service is frequent and reliable—and who generally substitute the use of personal automobiles for trips when these conditions aren't met. In contrast, passengers with lower incomes are more likely to use transit for basic mobility and have more limited alternative means of travel, therefore using transit even when the service is not as frequent or reliable as they may prefer.

Exhibit 4-23

Passenger Wait-Time According to Household Income



Source: National Household Travel Survey, FHWA, 2001.

Seating Conditions

Transit travel conditions are often crowded. Information on crowding was not collected by the 2001 NHTS. The 1995 Nationwide Personal Transportation Survey (NPTS), which was the FHWA nationwide personal travel survey preceding the NHTS and which is the most recent source of data available, found that 27.3 percent of the people sampled were unable to find a seat upon boarding a transit vehicle and that 31.3 percent were unable to find seats during rush hours.

Comparison

Exhibit 4-24 compares the key highway and transit statistics discussed in this chapter with the values shown in the last version of the C&P report. The first data column contains the values reported in the 2006 C&P Report, which were based on 2004 data. Where the 2004 data have been revised, updated values are shown in the second column. The third column contains comparable values based on 2006 or 2005 data.

Exhibit 4-24

Comparison of Highway and Transit Operational Performance Statistics With Those in the 2006 C&P Report

	2004 Data		2006
Statistic	**2006 C&P Report**	**Revised**	**(or 2005) Data**
Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions [1]	31.6%	28.6%	28.6%
Average Length of Congested Conditions (hours) [1]	6.6	6.4	(6.4)[2]
Travel Time Index [1]	1.39	1.27	(1.28)[2]
Annual Hours of Delay Per Capita [1]	24.4	21.6	(21.8)[2]
Passenger-Mile Weighted Average Operating Speed (miles per hour)			
Total	19.9		20.0
Rail	25.3		24.8
Nonrail	13.7		14.4
Annual Passenger Miles per Capacity-Equivalent Vehicle (thousands)			
Motor Bus	373		402.9
Heavy Rail	652		632.4
Commuter Rail	755		658.3
Light Rail	468		543.4
Demand Response	181		162.6

[1] *The 2004 data presented in the 2006 C&P Report were based on the 2005 TTI methodology. The revised 2004 data are based on 2007 TTI methodology, as are the 2005 and 2006 data shown.*

[2] *Based on 2005 data.*

Highways

This chapter used Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions, Average Length of Congested Conditions, Travel Time Index, and Average Annual Hours of Delay per Capita metrics in the development and calculation of highway operational performance measures. The metrics were developed at the Texas Transportation Institute (TTI) to measure congestion on the Nation's highways.

TTI reports congestion trends in its Urban Mobility Report. The statistics presented in the 2006 C&P Report reflected in *Exhibit 4-24* were consistent with the methodology utilized in TTI's 2005 Urban Mobility Report. The TTI 2007 Urban Mobility Report included some key methodology changes, which have been adopted by the FHWA for use in various performance planning documents. The revised 2004 data and the 2005 and 2006 data presented in *Exhibit 4-24* are consistent with the revised TTI 2007 methodology.

"Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions" is defined as the portion of the total vehicle miles traveled (VMT) in an urbanized area occurring during periods of less than free-flow conditions. Using the 2007 methodology, the metric remained unchanged between 2004 and 2006 at 28.6 percent.

"Travel Time Index," defined as the percentage of additional time needed to make a trip during a typical peak travel period in comparison to traveling at free-flow speeds, increased slightly from 1.27 in 2004 to 1.28 in 2005. In 2005, an average peak period trip required 28 percent longer than the same trip under nonpeak, non-congested conditions. For example, a trip that would have taken an average of 20 minutes during non-congested periods would have required 25.6 minutes during congested periods in 2005.

"Annual Hours of Delay per Capita" is defined as the amount of lost time due to congested conditions per urbanized area resident. In 2005, delay per capita experienced for all urbanized areas increased to 21.8 hours from 21.6 hours in 2004.

"Average Length of Congested Conditions" represents the number of hours during a 24-hour period during which travel at less than free-flow speeds occurs on a portion of the road system of an urbanized area. This metric remained constant at 6.4 hours between 2004 and 2005.

Transit

The operational performance of transit affects its attractiveness as a means of transportation. People will be more inclined to use transit that is frequent and reliable, travels more rapidly, has adequate seating capacity, and is not too crowded.

Vehicle utilization is one indicator of service effectiveness that measures how well a service output attracts passenger use. It is also a measure of vehicle crowding. Vehicle utilization is calculated as the ratio of the total number of passenger miles traveled annually on each mode to the total number of vehicles operated in maximum scheduled service in each mode, adjusted for the passenger-carrying capacity of the mode in relation to the average capacity of the Nation's motor bus fleet. Vehicle utilization rates have been revised using new capacity-equivalent factors as discussed in Chapter 2. These factors are based on seating and standing capacities as reported to the National Transit Database and are unique to each year. Utilization rates for light rail increased from 2004 to 2006 while utilization rates for heavy rail and commuter rail decreased over the same time period. With the exception of motor bus and trolleybus, utilization rates for nonrail modes decreased from 2004 to 2006.

Average transit operating speeds remained relatively constant between 1997 and 2006. Average operating speed measures the average speed that a passenger will travel on transit rather than the pure operational speed of transit vehicles. These speeds exclude waiting time and the time spent transferring, but are affected by changes in vehicle dwell times to let off and pick up passengers. In 2006, the average speed was 20.0 miles per hour, down from 20.1 miles per hour in 2004, and equal to the 10-year average of 20.0 miles per hour. The average operating speed as experienced by passengers on rail modes was 24.8 miles per hour in 2006, compared with 25.0 miles per hour in 2004 and the 10-year average of 25.2 miles per hour. The average operating speed of nonrail vehicles, which is affected by traffic, road, and safety conditions, was 14.4 miles per hour in 2006, up from 14.0 in 2004, and above the 10-year average of 13.9.

Most transit passengers do not experience unacceptably long waiting times. The 2001 National Household Travel Survey conducted by the FHWA, the most recent nationwide survey of passenger travel, found that 48.5 percent of all passengers who ride transit wait 5 minutes or less and 75.1 percent wait 10 minutes or less, and that wait times are inversely correlated with incomes. Higher-income passengers are more likely to be choice riders and ride only if transit is frequent and reliable. In contrast, passengers with lower incomes are more likely to use transit for basic mobility, have more limited alternative means of travel, and, therefore, use transit even when the service is not as frequent or reliable as they may prefer.

Chapter 5

Safety

Highway Safety

This section describes the safety of the Nation's highway system. It looks at fatalities and injuries on highway functional systems, across vehicle types, and among different segments of the population. It also examines the causes and costs of fatal crashes.

Three operating administrations within the DOT have responsibility for addressing highway safety. The Federal Highway Administration (FHWA) focuses on infrastructure safety design and operations. The National Highway Traffic Safety Administration (NHTSA) has responsibility for overseeing vehicle safety standards and administering driver behavior programs. The Federal Motor Carrier Safety Administration (FMCSA) has the mission to reduce crashes, injuries, and fatalities involving large trucks and buses.

Statistics in this section are primarily drawn from the Fatality Analysis Reporting System (FARS). The FARS is maintained by NHTSA, which has a cooperative agreement with an agency in each State to provide information on all qualifying crashes in that State. Police accident reports, death certificates, and other documents provide data that are tabulated daily and included in the FARS. The statistics represent a "snapshot in time" during the preparation of this report, which is why they may not precisely correspond to reports completed during the same year. Information was compiled during the summer of 2008.

NHTSA publishes an annual Traffic Safety Facts report that comprehensively describes safety characteristics on the highway transportation network.

Overall Fatalities and Injuries

Exhibit 5-1 describes the considerable improvement in highway safety since Federal legislation first addressed the issue in 1966. That year, the fatality rate was 5.50 per 100 million VMT. By 2006, the fatality rate had declined to 1.41 per 100 million VMT. This sharp decline in the fatality rate occurred even as the number of licensed drivers nearly doubled.

The overall number of traffic deaths also decreased between 1966 and 2006. In 1966, there were 50,894 traffic deaths. Fatalities reached their highest point in 1972 (54,589), then declined sharply following the implementation of a national speed limit, reaching their lowest point in 1992 (39,250). Since 1992, there has been more limited progress in reducing the number of fatalities. The number of fatalities generally increased year-to-year from 1992 to 2006, when 42,642 Americans lost their lives in crashes. *Exhibit 5-2* and *Exhibit 5-3* compare the number of fatalities with fatality rates between 1980 and 2006.

The overall number of traffic-related injuries also decreased between 1988 and 2006, from 3,416,000 to 2,575,000. Injuries increased between 1992 and 1996, but have steadily declined since then. In 1988, the injury rate was 169 per 100 million VMT; by 2006, the number had dropped to 85 per 100 million VMT.

Fatalities by Functional Class

Exhibit 5-4 and *Exhibit 5-5* show the number of fatalities and fatality rates by rural and urban functional system between 1997 and 2006. These exhibits show the distinction between fatalities and fatality rate; fatality rate expresses fatalities in terms of VMT, so an increase in the overall number of fatalities does not necessarily translate into an increase in the fatality rate.

Exhibit 5-1

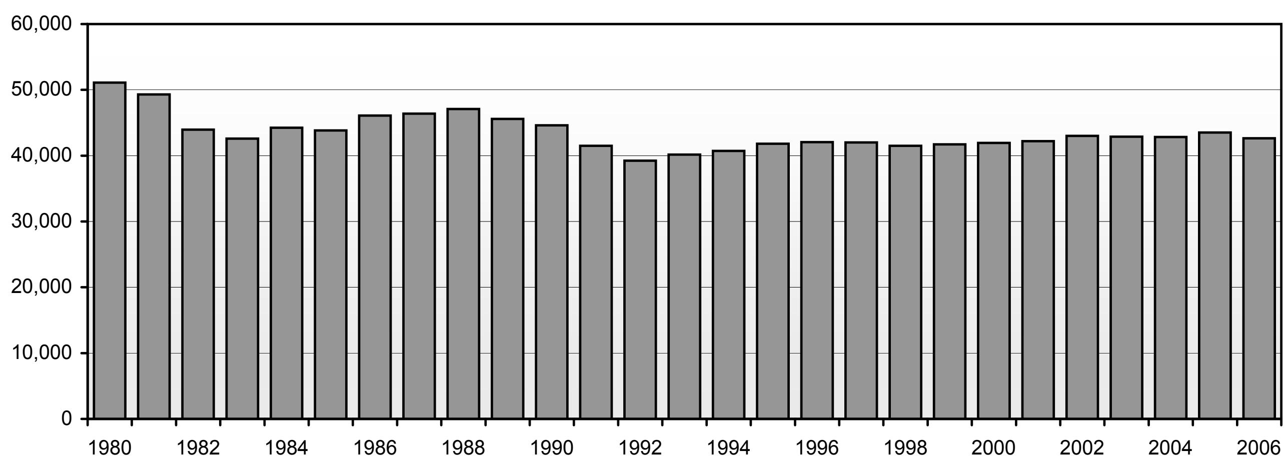
Summary of Fatality and Injury Rates, 1966–2006

Year	Fatalities	Resident Population (Thousands)	Fatality Rate per 100,000 Population	Licensed Drivers (Thousands)	Fatality Rate per 100 Million VMT	Injured	Injury Rate per 100,000 Population	Injury Rate per 100 Million VMT
1966	50,894	196,560	25.89	100,998	5.50			
1968	52,725	200,706	26.27	105,410	5.20			
1970	52,627	205,052	25.67	111,543	4.74			
1972	54,589	209,896	26.01	118,414	4.30			
1974	45,196	213,854	21.13	125,427	3.50			
1976	45,523	218,035	20.88	134,036	3.25			
1978	50,331	222,585	22.61	140,844	3.26			
1980	51,091	227,225	22.48	145,295	3.35			
1982	43,945	231,664	18.97	150,234	1.76			
1984	44,257	235,825	18.77	155,424	2.57			
1986	46,087	240,133	19.19	159,486	2.51			
1988	47,087	244,499	19.26	162,854	2.32	3,416,000	1,397	169
1990	44,599	249,439	17.88	167,015	2.08	3,231,000	1,295	151
1992	39,250	254,995	15.39	173,125	1.75	3,070,000	1,204	137
1994	40,716	260,327	15.64	175,403	1.73	3,266,000	1,255	139
1996	42,065	265,229	15.86	179,539	1.69	3,483,000	1,313	140
1998	41,501	270,248	15.36	184,980	1.58	3,192,000	1,181	121
2000	41,945	282,192	14.86	190,625	1.53	3,189,000	1,130	116
2002	43,005	288,126	14.93	194,602	1.51	2,926,000	1,015	102
2004	42,836	293,638	14.59	198,889	1.44	2,788,000	950	94
2006	42,642	299,398	14.24	202,810	1.41	2,575,000	860	85

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Exhibit 5-2

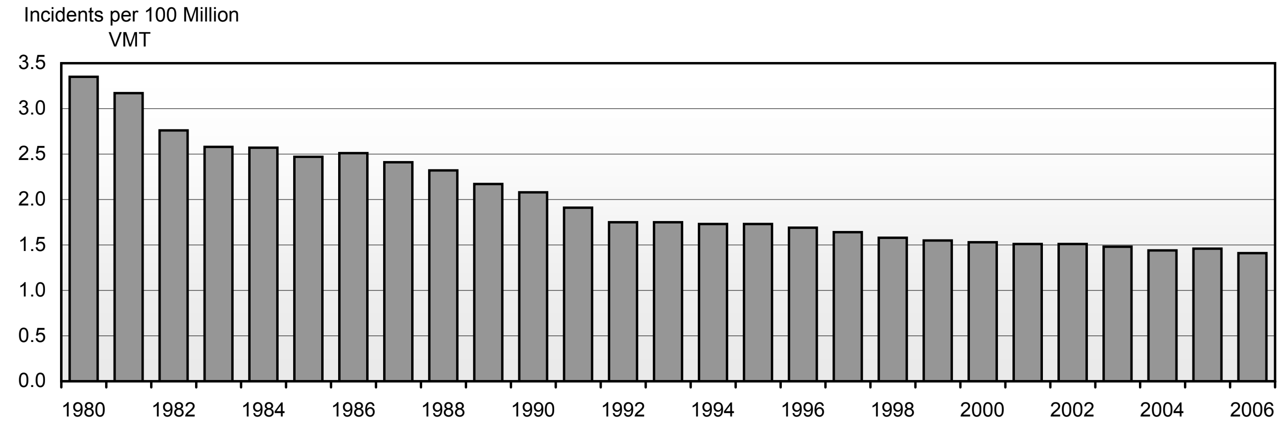
Fatalities, 1980–2006



Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Exhibit 5-3

Fatality Rate, 1980–2006



Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Exhibit 5-4

Fatalities by Functional System, 1997–2006

Functional System	1997	2000	2002	2004	2005	2006
Rural Areas (under 5,000 in population)						
Interstate	3,040	3,254	3,298	3,227	3,248	2,870
Other Principal Arterial	5,394	4,917	4,894	5,167	4,821	4,491
Minor Arterial	4,284	4,090	4,467	5,043	4,483	4,277
Major Collector	5,920	5,501	6,014	5,568	5,757	5,628
Minor Collector	1,723	1,808	2,003	1,787	1,635	1,614
Local	4,450	4,414	5,059	4,162	4,443	4,219
Unknown Rural	324	854	161	225	200	240
Subtotal Rural Areas	**25,135**	**24,838**	**25,896**	**25,179**	**24,587**	**23,339**
Urban Areas (5,000 or more in population)						
Interstate	2,292	2,419	2,482	2,602	2,734	2,619
Other Freeway and Expressway	1,296	1,364	1,506	1,673	1,735	1,653
Other Principal Arterial	5,420	4,948	5,124	4,847	5,364	5,299
Minor Arterial	3,523	3,211	3,218	3,573	3,836	3,720
Collector	1,163	1,001	1,151	1,385	1,426	1,478
Local	3,064	2,912	3,497	3,290	3,458	3,540
Unknown Urban	71	258	35	211	74	50
Subtotal Urban Areas	**16,829**	**16,113**	**17,013**	**17,581**	**18,627**	**18,359**
Unknown Rural or Urban	49	994	96	76	296	944
Total Highway Fatalities	**42,013**	**41,945**	**43,005**	**42,836**	**43,510**	**42,642**

Source: Fatality Analysis Reporting System / National Center for Statistics and Analysis, NHTSA.

As shown in *Exhibit 5-4*, the absolute number of fatalities grew slightly between 1997 and 2006, from 42,013 to 42,642 deaths. During this period, the number of fatalities on urban roads grew from 16,829 to 18,359 (about 43 percent of total fatalities). At the same time, the number of fatalities on rural roads decreased from 25,135 to 23,339 (about 57 percent of all fatalities). The fatality rate, however, decreased on both urban and rural roads, due to a significant increase in VMT, as well as to the other crash factors discussed later in this chapter.

Exhibit 5-5 shows the decrease in fatality rate on every urban and rural functional system between 1997 and 2006. Urban Interstate highways were the safest functional system, with a fatality rate of 0.55 per 100 million

VMT in 2006. Minor arterials, however, recorded the sharpest decline in fatality rates. The fatality rate for minor arterials in 2006 was 21.7 percent lower than in 1997.

Exhibit 5-5

Fatality Rates by Functional System, 1997–2006 (per 100 Million VMT)

Functional System	1997	2000	2002	2004	2005	2006
Rural Areas (under 5,000 in population)						
Interstate	1.27	1.21	1.18	1.21	1.27	1.11
Other Principal Arterial	2.36	1.98	1.90	2.15	2.07	1.94
Minor Arterial	2.62	2.38	2.53	2.99	2.74	2.63
Major Collector	2.93	2.62	2.82	2.78	2.99	2.91
Minor Collector	3.29	3.14	3.26	2.97	2.80	2.78
Local	3.94	3.47	3.67	3.15	3.45	3.17
Subtotal Rural	**2.52**	**2.29**	**2.30**	**2.36**	**2.38**	**2.25**
Urban Areas (5,000 or more in population)						
Interstate	0.63	0.61	0.61	0.57	0.58	0.55
Other Freeway and Expressway	0.81	0.77	0.79	0.80	0.81	0.76
Other Principal Arterial	0.91	0.81	0.79	0.79	0.83	0.80
Minor Arterial	1.80	1.53	1.51	1.33	1.44	1.41
Collector	0.89	0.74	0.81	0.85	0.84	0.85
Local	1.43	1.24	1.46	1.28	1.31	1.33
Subtotal Urban	**1.08**	**0.97**	**0.98**	**0.93**	**0.95**	**0.93**
Total Highway Fatality Rate	**1.64**	**1.53**	**1.51**	**1.44**	**1.46**	**1.41**

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Q&A

What steps are being taken to improve safety on the Nation's rural roads?

In February 2008, the U.S. Department of Transportation announced a Rural Safety Initiative that targets resources to reduce the number of crashes on the Nation's rural roads. The Rural Safety Initiative has five key areas.

First, the initiative focuses on **safe driving**. The National Highway Traffic Safety Administration (NHTSA) will fund four demonstration projects in rural communities to either improve safety belt use or increase the deployment of ignition interlocks to combat drunk driving by repeat offenders. NHTSA has published guidelines on sobriety checkpoints, and is developing performance standards to protect occupants during rollover crashes. The Federal Motor Carrier Safety Administration, meanwhile, is working with States to improve the safety of commercial vehicles on rural roadways and include a component on rural commercial vehicle safety in each State's annual Commercial Vehicle Safety Plan.

Second, the initiative aims to **create better roads**. Among other activities, this Department goal is encouraging States to tap the underutilized High Risk Rural Road program. The Department will also use $9.2 million in FY 2008 funding for the Delta Region Transportation Development Program for innovative safety measures in the Delta region.

Third, the initiative aims to **develop smarter roads**. The Department will continue to advance critical research that can help States and localities design smarter highways. As an example, the Research and Innovative Technology Administration will target $6 million in Intelligent Transportation Systems (ITS) funding toward rural road safety.

Fourth, the initiative aims to **better train emergency responders**. In 2008, for instance, NHTSA will initiate a grant program that better clarifies data sent from a cell phone and determines the location of a caller. NHTSA is also developing National Trauma Field Triage Protocols so that emergency personnel can better transport seriously injured patients to trauma centers.

Finally, the Department will **improve outreach and partnerships** to rural transportation stakeholders.

The fatality rate decreased by 10.7 percent on rural roads between 1997 and 2006. The fatality rate decreased sharply on urban minor arterials, although rural minor arterials was the one segment of the rural functional system in which the fatality rate rose between 1997 and 2006, from 2.62 to 2.63 deaths per 100 million VMT.

Despite the overall decrease in fatality rate on both urban and rural functional systems, rural roads are far more dangerous than their urban counterparts. The fatality rate for rural functional systems was 141.9 percent higher in 2006 than on urban functional systems, with lower-level local roads having the highest fatality rate of any functional system. There are a number of factors that collectively result in this rural road safety challenge. These may include limited right-of-way, which can result in greater curvature and obstacles close to the roadway, and higher levels of speeding on non-separated roadways.

There were a total of 5,973,000 crashes reported in 2006. Only a small percentage of these crashes, 0.6 percent, were severe enough to result in a fatality, while 70.1 percent of these crashes resulted in property damage only, as shown in *Exhibit 5-6*.

Exhibit 5-6

Crashes by Severity, 1997–2006

	Crash Severity							
	Fatal		Injury		Property Damage Only		Total Crashes	
Year	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1997	37,324	0.6	2,149,000	32.4	4,438,000	67.0	4,438,000	100.0
1998	37,107	0.6	2,029,000	32.0	4,269,000	67.4	6,335,000	100.0
1999	37,140	0.6	2,054,000	32.7	4,188,000	66.7	6,279,000	100.0
2000	37,526	0.6	2,070,000	32.4	4,286,000	67.0	6,394,000	100.0
2001	37,862	0.6	2,003,000	31.7	4,282,000	67.7	6,323,000	100.0
2002	38,491	0.6	1,929,000	30.5	4,348,000	68.8	4,349,000	100.0
2003	38,477	0.6	1,925,000	30.4	4,365,000	69.0	6,328,000	100.0
2004	38,444	0.6	1,862,000	30.1	4,281,000	69.3	6,181,000	100.0
2005	39,252	0.6	1,816,000	29.5	4,304,000	69.9	6,159,000	100.0
2006	38,588	0.6	1,746,000	29.2	4,189,000	70.1	5,973,000	100.0

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Highway Fatalities by Major Crash Type or Contributing Factors

When a crash occurs, it is generally the result of numerous contributing factors. Combinations of driver, roadway, and vehicle factors all have an impact on the safety of the Nation's highway system.

The FHWA is focused on reducing four types of roadway-related crashes: roadway departures, intersections, pedestrian-related crashes, and speeding. *Exhibit 5-7* shows data for these crash types between 1997 and 2006. These categories are not mutually exclusive; the fatalities shown in *Exhibit 5-7* can involve a combination of factors—intersection and pedestrian-related, for example—so that some fatalities will appear in more than one category.

Exhibit 5-7

Highway Fatalities* by Crash Type, 1997–2006

	1997	2000	2002	2004	2005	2006
Roadway Departures	22,741	23,046	25,412	25,805	25,477	24,806
Intersection-Related	9,093	8,689	9,273	9,273	9,238	8,797
Pedestrian-Related	5,321	4,763	4,851	4,675	4,892	4,784
Speeding-Related	13,188	12,552	13,799	13,291	13,583	13,543

** Some fatalities may overlap; for example, some intersection-related fatalities may involve pedestrians.*

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Roadway Departures

In 2006, there were 24,806 fatalities related to a vehicle leaving its lane and crashing. In some cases, the vehicle crossed the centerline and struck another vehicle, hitting it head-on or sideswiping it. In other cases, the vehicle left the roadway and struck one or more man-made or natural objects, such as utility poles, embankments, guardrails, trees, or parked vehicles.

Roadway departures occur because of human factors, roadway design factors, or environmental factors. Human factors include driving while intoxicated, driver fatigue, and drowsiness; and these factors can contribute to roadway departures. It is widely recognized that drunk drivers can create hazardous driving conditions. Surprisingly, a drowsy driver can be as dangerous as a drunk driver. In other cases, drivers are inattentive, careless, or distracted, drifting out of the lane and off the road. Visibility also is an issue. The majority of roadway departure crashes happen at night.

About two-thirds of roadway departure fatalities occur on rural roads. Rural highways are often not as well-lit as urban roadways or could include design factors such as narrow travel lanes, sharp roadway curvatures, or unimproved shoulders. Environmental factors including inclement weather such as fog, snow, smoke, or dust storms can also decrease the visibility of pavement markings or roadway curvature. In these conditions, or a combination of these conditions, run-off-road crashes can increase.

Of the 24,806 roadway departure fatalities that occurred in 2006, about 43.1 percent involved the rollover of a passenger vehicle. As shown in *Exhibit 5-8*, the total number of passenger vehicle occupant fatalities in rollovers has steadily increased, from 9,527 in 1997 to 10,698 in 2006 (a rise of about 12.3 percent). While the number of occupant fatalities in rollovers among passenger cars decreased slightly, from 4,765 in 1997 to 4,352 in 2006 (a 8.7 percent decrease),

Exhibit 5-8

Comparison of Number of Fatalities and Fatality Rates for Vehicles Involved in Rollover Crashes, 1997 and 2006

	Fatalities	Registered Passenger Vehicles	Fatality Rate per 100,000 Registered Vehicles
1997			
Passenger Cars	4,765	124,672,920	3.82
Light Pickup Trucks	2,479	34,314,455	7.22
Light Utility Trucks	1,489	14,531,850	10.25
Vans	768	16,159,473	4.75
Other Light Trucks	26	2,281,692	1.14
Total	**9,527**	**191,960,390**	**4.96**
2006			
Passenger Cars	4,352	136,866,137	3.18
Light Pickup Trucks	2,840	40,678,320	6.98
Light Utility Trucks	2,888	37,168,577	7.77
Vans	604	19,491,830	3.10
Other Light Trucks	14	890,532	1.57
Total	**10,698**	**235,095,396**	**4.55**
Percent Change	**12.3%**	**22.5%**	

Source: Fatality Analysis Reporting System/ National Center for Statistics and Analysis, NHTSA.

the number of occupant fatalities in rollovers among light (sport) utility trucks nearly doubled, growing from 1,489 in 1997 to 2,888 in 2006 (an increase of 93.9 percent). The number of occupant fatalities in rollovers among pickup trucks for the same period increased by 12.7 percent (from 2,479 in 1997 to 2,840 in 2006). Among vans, fatalities related to rollover crashes decreased by 21.3 percent (from 768 in 1997 to 604 in 2006).

Among the vehicles that rolled over, the occupant fatality rates for light (sport) utility trucks were the highest, followed by the rates for light pickup trucks, vans, and passenger cars. In 2006, in fatal crashes where a rollover occurred, the occupant fatality rate per 100,000 registered vehicles for light trucks was 7.77, 6.98 for light pickup trucks, 3.10 for vans, and 3.18 for passenger cars.

Intersections

Of the 42,642 fatalities that occurred in 2006, about 21 percent—8,797—were related to intersections. FARS contains information on the functional system where 8,580 of these fatalities occurred, of which 39.7 percent occurred at rural intersections and 60.3 percent at urban intersections, as shown in *Exhibit 5-9*.

Exhibit 5-9

Intersection-Related Fatalities by Functional System, 2006

	Fatalities	
	Count	**Percent of Total**
Rural Areas (under 5,000 in population)		
Principal Arterials	1,007	11.7%
Minor Arterials	739	8.6%
Collectors (Major and Minor)	1,047	12.2%
Locals	614	7.2%
Subtotal Rural Areas	**3,407**	**39.7%**
Urban Areas (5,000 or more in population)		
Principal Arterials	2,367	27.6%
Minor Arterials	1,336	15.6%
Collectors (Major and Minor)	447	5.2%
Locals	1,023	11.9%
Subtotal Urban Areas	**5,173**	**60.3%**
Total Highway Fatalities*	**8,580**	**100.0%**

** Total excludes 217 intersection-related fatalities not identified by functional class.*

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Intersection incidents account for more than 45 percent of all reported crashes and approximately 50 percent of all injuries. Older drivers and pedestrians are particularly at risk at intersections; half of the fatal crashes for drivers aged 80 or older and about one-third of the pedestrian deaths among people aged 70 or older occurred at intersections.

There are over three million intersections in the United States, including both signalized and non-signalized (e.g., those controlled by stop or yield signs) and many factors may contribute to unsafe conditions at these areas. Road designs may be inadequate for current traffic levels or traffic signals may not be optimally programmed. There may also be insufficient law enforcement, prompting some drivers to ignore red lights. Approximately one-third of signalized intersection fatalities involve red-light running.

Q&A

How are Federal, State, and local transportation agencies working to improve intersection safety?

Some engineering improvements can greatly improve intersection safety. Signal visibility is important, and many States and localities are increasing the size of signal displays to increase the line of sight for drivers. Rumble strips and "signal ahead" signs can also make drivers aware of an upcoming intersection. In many places, transportation officials are also modifying traditional intersections or eliminating the need to stop by installing flashing signals or converting intersections to roundabouts.

Education and law enforcement are also very important. Red light cameras are used in many cities, including Baltimore, Chicago, Denver, New York, Phoenix, San Diego, and San Francisco.

Pedestrians and Other Nonmotorists

Exhibit 5-10 displays nonmotorist fatalities that occurred between 1997 and 2006. For the purposes of this report, the term "nonmotorist" refers to fatalities and crashes that involve pedestrians, pedalcyclists, and other nonmotorists, such as skateboarders and roller skaters.

The number of nonmotorist fatalities decreased from 6,288 in 1997 to 5,740 in 2006, an 8.7 percent decrease. However, this may be because people are walking less than they used to—not because conditions are safer for pedestrians. The number of pedestrians and pedalcyclists killed has decreased over the past decade, while the number of other nonmotorists killed has increased. Still, in 2006, 83.3 percent of all nonmotorist fatalities were pedestrians. About 13.4 percent were pedalcyclists, and the remaining 3.2 percent were other nonoccupants.

Overall, the fatality rate for pedestrians was 1.6 per 100,000 population in 2006. Most pedestrian crashes occurred in 2006 in urban areas (about 74 percent). They also tend to occur at nonintersection locations (about 79 percent), during normal weather conditions (about 90 percent), and at night (roughly 79 percent).

Of the traffic crashes that resulted in pedestrian fatalities in 2006, 49 percent were alcohol-related; in other words, either the driver or the pedestrian had consumed alcohol. In 6 percent of the crashes that occurred, both driver and pedestrian had a blood alcohol concentration (BAC) of 0.08 or higher.

Exhibit 5-10

Pedestrian and Other Nonmotorist Traffic Fatalities, 1997–2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Pedestrians	5,321	5,228	4,939	4,763	4,901	4,851	4,774	4,675	4,892	4,784
Pedalcyclists	814	760	754	693	732	665	629	727	786	773
Other	153	131	149	141	123	114	140	130	186	183
Total	**6,288**	**6,119**	**5,842**	**5,597**	**5,756**	**5,630**	**5,543**	**5,532**	**5,864**	**5,740**

Source: Fatality Analysis Reporting System / National Center for Statistics and Analysis, NHTSA.

Speeding

Speeding is one of the most prevalent factors contributing to traffic crashes. In 2006, the National Highway Traffic Safety Administration estimates that 13,543 lives were lost in speeding-related crashes. The estimated annual economic costs of speeding-related crashes exceeded $40.4 billion in 2000. This included $10.3 billion in fatalities, $13.3 billion in injuries, and $3.8 billion in property damage.

Young males are the most likely drivers to be involved in fatal speeding-related crashes. The relative proportion of speeding-related crashes to all crashes decreases with increasing driver age. For example, in 2006, 39 percent of male drivers between the ages of 15 and 20 who were involved in fatal crashes were speeding at the time of the crash, while the comparable figure for male drivers between the ages of 35 and 44 was only 21 percent.

In 2006, 41 percent of the drivers with a BAC of 0.08 or higher involved in fatal crashes were speeding, compared with only 15 percent of drivers in fatal crashes who had not consumed alcohol. Speeding was a factor in 37 percent of fatal crashes in work zones and nearly 60 percent of roadway departure crashes on curves.

Many speeding-related crashes also occur during bad weather. Speeding was a factor in 33 percent of all crashes that occurred on wet roads in 2006. Speeding was a factor in 55 percent of the fatal crashes that occurred when there was snow or slush on the road and in 59 percent of those that occurred on icy roads.

Although much of the public concern about speed-related crashes focuses on high-speed roadways, speeding is a safety concern on all roads. In 2006, about 87 percent of speed-related fatalities occurred on roads that were not Interstate highways.

Alcohol

Alcohol-impaired driving is a serious public safety problem in the United States. In 2006, 17,602 Americans were killed in alcohol-related crashes on the Nation's highways. The National Highway Traffic Safety Administration estimates that alcohol was involved in 41 percent of fatal crashes and 9 percent of all crashes in 2006.

Exhibit 5-11 shows the number of fatalities attributable to alcohol between 1997 and 2006. There has been no consistent trend in the number of alcohol-related fatalities over the past decade. Alcohol-related fatalities declined between 1997 and 1999, increased between 1999 and 2002, declined between 2002 and 2004, and have increased since then.

In 2006, there were 13,582 fatalities in which either the driver or motorcycle operator was legally intoxicated—in other words, the operator had a BAC of 0.08 or higher. Of these fatalities, 5,319—about 39 percent—were among people between the ages of 21 and 34 years old; this was the largest of the six age groups surveyed by the NHTSA. Between 2005 and 2006, for this age demographic, the number of fatalities involved in crashes where the operator was legally intoxicated grew by about 1 percent. Using this standard, the group aged 16 to 20 was the only other age group to experience an increase in fatalities, where the number of fatalities grew by about 4 percent—from 1,586 to 1,648 deaths. Underage drinking and driving continues to be a major problem, despite years of education and law enforcement programs.

Exhibit 5-11

Alcohol-Related Fatalities, 1997–2006

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
16,711	16,673	16,572	17,380	17,400	17,524	17,105	16,919	17,590	17,602

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Unbelted Occupants

Safety belt use is one of the most significant factors in determining the severity of a motor vehicle crash. According to NHTSA's National Occupant Protection Use Survey, the national seat belt use rate was 81 percent in 2006. This means that about 55 million people do not use seat belts all of the time when driving or riding in motor vehicles. These results were obtained by observing traffic on roads at selected observation points.

In 2006, 30,521 occupants of passenger vehicles were killed in motor vehicle traffic crashes—72 percent of the 42,642 traffic fatalities reported for the year. Of the 28,141 passenger vehicle occupant fatalities for which restraint use was known, an estimated 15,523 (or 55 percent) were unrestrained.

In 1984, the U.S. Department of Transportation promulgated rules that phased in automatic occupant-protection systems for all automobiles. This rulemaking prompted many States to enact seat belt use laws of varying degrees. To date, 26 States and the District of Columbia have seat belt use laws that provide for primary enforcement, enabling police officers to stop vehicles and write citations whenever they observe violations of the seat belt law. Twenty-three States have laws that specify secondary enforcement (allowing officers to write a citation only after a vehicle is stopped for some other traffic infraction). One State, New Hampshire, has no adult seat belt use law.

Crashes by Vehicle Type

Exhibit 5-12 shows the breakdown of occupant fatalities by vehicle type from 1997 to 2006. The number of occupant fatalities that involved passenger cars decreased from 22,199 in 1997 to 17,800 in 2006, while occupant fatalities involving light and large trucks, motorcycles, and other vehicles all increased during this period.

The number of occupant fatalities in light trucks increased sharply between 1997 and 2006. Fatalities in these vehicles increased from 10,249 in 1997 to 12,722 in 2006, or an increase of 24.1 percent. There were 856,896 light truck occupants injured in 2006, up from 754,820 in 1997.

The number of occupant fatalities in large trucks increased 11.3 percent, from 723 in 1997 to 805 in 2006. There were 22,815 large truck occupants injured in 2006. However, the number of all other vehicle occupants killed in crashes involving a large truck decreased by 10.8 percent, from 4,223 in 1997 to 3,766 in 2006. Occupants of large trucks are less than 2 percent of all highway fatalities, but others killed in crashes involving large trucks are 10 percent of all highway fatalities.

The most significant increase in fatalities among vehicle types involved those who ride motorcycles. The number of motorcyclists who died in crashes increased 127.3 percent between 1997 and 2006, from 2,116 to 4,810.

Exhibit 5-12

Fatalities for Vehicle Occupants by Type of Vehicle, 1997–2006

Type of Vehicle	1997	2000	2002	2004	2005	2006
Motorists						
Passenger Cars	22,199	20,699	20,569	19,192	18,512	17,800
Light Trucks	10,249	11,528	12,273	12,674	13,040	12,722
Large Trucks	723	754	689	766	804	805
Motorcycles	2,116	2,897	3,270	4,028	4,576	4,810
Buses	18	22	45	42	58	27
Other and Unknown Vehicles	420	448	529	602	656	738
Nonmotorists						
Pedestrians	5,321	4,763	4,851	4,675	4,892	4,784
Pedalcyclists	814	693	665	727	786	773
Other and Unknown	153	141	114	130	186	183
Total	**42,013**	**41,945**	**43,005**	**42,836**	**43,510**	**42,642**

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Motorcycle crashes are frequently speed-related. Speed is two times more likely to be a factor in fatal motorcycle crashes than in passenger car or light truck crashes. Studies also have shown that alcohol is more likely to be a factor in motorcycle crashes than in passenger car or light truck crashes.

Exhibit 5-13 describes the breakdown of occupant injuries between 1997 and 2006. The number of injuries decreased for passenger cars, buses, light and large trucks during that period, but sharply increased among motorcycle riders. During this same period, the number of motorcyclists injured increased by 59.9 percent, from 52,574 to 87,652.

Exhibit 5-13

Injuries for Vehicle Occupants by Type of Vehicle, 1997–2006

Type of Vehicle	1997	2000	2002	2004	2005	2006
Motorists						
Passenger Cars	2,340,612	2,051,609	1,804,788	1,642,549	1,573,396	1,474,536
Light Trucks	754,820	886,566	879,338	900,171	872,137	856,896
Large Trucks	30,913	30,832	26,242	27,287	27,284	22,815
Motorcycles	52,574	57,723	64,713	76,379	87,335	87,652
Buses	16,887	17,769	18,819	16,410	11,133	9,839
Other and Unknown Vehicles	5,602	10,120	6,187	7,262	9,832	10,843
Nonmotorists						
Pedestrians	77,000	78,000	71,000	68,000	64,000	61,000
Pedalcyclists	58,000	51,000	48,000	41,000	45,000	44,000
Other and Unknown Vehicles	11,000	5,000	7,000	9,000	8,000	7,000
Total	**3,347,408**	**3,188,619**	**2,926,087**	**2,788,058**	**2,698,117**	**2,574,581**

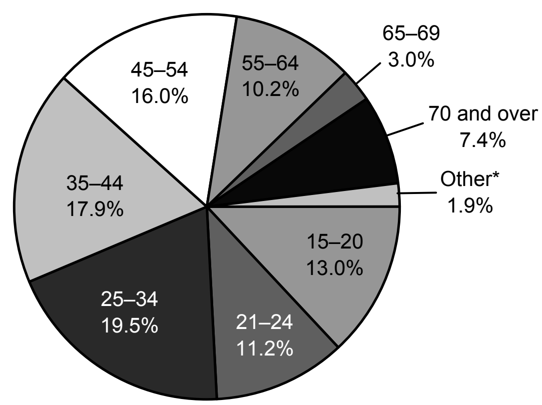
Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Crashes by Age Group

Another important way of examining highway crashes is by demographic segment. *Exhibit 5-14* shows the breakdown of drivers, by age, involved in fatal crashes in 2006. In recent years, much attention has been focused on the safety of drivers at either extreme of the age spectrum.

Exhibit 5-14

Age of Drivers Involved in Fatal Crashes, 2006



**Other includes drivers under age 15 and those whose age could not be determined from the accident data reported.*

Source: Fatality Analysis Reporting System/National Center for Statistics and Analysis, NHTSA.

Americans between the ages of 15 and 20 constituted 6.4 percent of the total population of licensed drivers in 2006, but about 13 percent of all those involved in fatal crashes. In 2006, 3,490 drivers 15 to 20 years old were killed in crashes, while an additional 272,000 were injured. Motor vehicle crashes are the leading cause of death for young Americans and, as previously discussed, underage drinking is a major factor.

Meanwhile, the number of older drivers continues to rise. Between 1996 and 2006, the total number of licensed drivers increased by 13 percent, but the number of drivers aged 65 and older grew by 18 percent. Older Americans, however, are among the safest drivers. About 10.4 percent of all fatal crashes involved drivers aged 65 and older. Older drivers tend to be more experienced, and they are also less likely to be intoxicated while driving.

Q&A

Why could older drivers be among the safest drivers, as measured by the age of drivers involved in fatal crashes?

There are many factors. Older drivers tend to have the most experience in operating a vehicle, and they avoid conditions that compromise a vehicle's safety. Older drivers tend to take shorter trips, and many avoid driving during bad weather and at night. In 2006, for example, about 81 percent of traffic fatalities involving older drivers occurred during the daytime. Older drivers involved in fatal crashes also have the lowest proportion of intoxication of all adult drivers. In 2006, only 6 percent of drivers aged 65 and older involved in fatal crashes had a blood alcohol content (BAC) of 0.08 or higher.

Transit Safety

Transit operators report safety information to the National Transit Database (NTD) for three major categories: incidents, injuries, and fatalities. Safety information presented in this chapter is for directly operated and purchased transportation services. As safety information for both types of services is now presented, the absolute number of reported incidents and injuries has increased

In 2002, the FTA Office of Safety revised the definitions of an "incident" and an "injury." Given that there is no "statistical bridge" across the change in definitions that occurred between 2001 and 2002, this chapter provides only injury and incident data from 2002 onward. Data on injuries and incidents prior to 2002, which are not comparable with the new data, are available in the 2004 C&P Report.

An incident is recorded by a transit agency for a variety of events occurring on transit property or vehicles, involving transit vehicles, or to persons using the transit system. Included among these is any event that results in significant property damage, one or more reported injuries, one or more reported fatalities, or some combination thereof. Since 2002, the definition of "significant property damage" has been total property damage in excess of $7,500; prior to 2002, the definition was property damage in excess of $1,000. This increase in the property damage threshold has greatly reduced the number of reported incidents.

Q&A

What sort of events result in a recorded transit incident?

A transit agency records an incident for any event occurring on transit property, onboard or involving transit vehicles, or to persons using the transit system that results in one of the following:

- One or more confirmed fatalities within 30 days of the incident
- One or more injuries requiring immediate transportation away from the scene for medical attention
- Total property damage to transit property or private property in excess of $7,500
- An evacuation for life safety reasons
- A mainline derailment (i.e., occurring on a revenue service line, regardless of whether the vehicle was in service or out-of-service)
- A fire

Additionally, an incident is recorded by a transit agency whenever one of the following security situations occurs on transit property, onboard or involving transit vehicles, or to persons using the transit system:

- A robbery, burglary, or theft
- A rape
- A suicide or attempted suicide
- An aggravated assault
- An arrest or citation, such as for trespassing, vandalism, fare evasion, or an assault
- A bomb threat
- A bombing
- A release of chemical, biological, nuclear, or radiological materials
- A cybersecurity incident
- A hijacking
- A nonviolent civil disturbance that results in the disruption of transit service
- A sabotage

In 2002, the definition of an injury was switched from a claims basis to a verifiable basis, leading to a reduction in reported injuries. Since 2002, an injury has been reported only when a person has been immediately transported away from the scene of a transit incident for medical care. Prior to 2002, all injuries for which claims were made were reported by transit agencies to the NTD. Since any event producing a reported injury is also reported as an incident, the definitional change for an injury also reduced the number of reported incidents.

The definition of a fatality was not revised in 2002. A fatality is reported for any death occurring within 30 days of a transit incident which is confirmed to be a result of that incident. Although suicides are reported as transit incidents, they are not included in the data on transit fatalities. Fatality data are provided from 1997 through 2006.

Injuries and fatalities include those suffered by riders, as well as those suffered by pedestrians, bicyclists, and people in other vehicles. Injuries and fatalities may occur while traveling on transit, as well as while boarding, alighting, or waiting for transit vehicles to arrive. An injury or fatality may also occur while not using transit, such as in the cases of being struck by a transit vehicle, or in the case of a collision in a transit station parking lot.

Exhibit 5-15 shows annual fatalities for transit services in both absolute numbers and adjusted according to the number of passenger miles traveled (PMT) in each year for 1997 to 2006. Between 1997 and 2006, total fatalities fluctuated between a high of 260 in 1998 and a low of 213 in 2006. There were 214 fatalities in 2005 and 213 in 2006. When adjusted for passenger use, the fatality rate per PMT has decreased over this time period, falling from 0.66 fatalities per 100 million PMT in 1997, to 0.51 per 100 million PMT in 2005, and to 0.49 fatalities per 100 million PMT in 2006.

Exhibit 5-15

Annual Transit Fatalities, 1997–2006

Year	Total	Per 100 Million PMT
1997	244	0.66
1998	260	0.67
1999	255	0.64
2000	245	0.59
2001	236	0.55
2002	249	0.59
2003	224	0.55
2004	217	0.52
2005	214	0.51
2006	213	0.49

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-16 provides total incidents and injuries in both absolute terms and per 100 million PMT. Incidents and injuries both increased from 2004 to 2006, falling slightly from 2004 to 2005 before rising again in 2006. Adjusted for passenger use, incidents per 100 million PMT increased and injuries per 100 million PMT decreased during this time period.

Exhibit 5-16

Annual Incidents and Injuries, 2004–2006

	Incidents		Injuries	
Year	Total	Per 100 Million PMT	Total	Per 100 Million PMT
2004	24,031	58.00	20,439	49.33
2005	23,578	56.71	19,201	46.18
2006	25,572	59.07	20,857	48.17

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-17 shows fatality rates per 100 million PMT for motor bus, heavy rail, commuter rail, light rail, and demand response, the five largest transit modes in terms of PMT. Together, these modes accounted for approximately 97 percent of total PMT in 2006. (Absolute fatalities are not comparable across modes because of the

Exhibit 5-17

Annual Transit Fatalities by Mode, 1997–2006 (Per 100 Million PMT)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Motor Bus	0.66	0.73	0.59	0.57	0.54	0.45	0.62	0.46	0.46	0.59
Heavy Rail	0.34	0.25	0.36	0.30	0.24	0.47	0.25	0.34	0.22	0.13
Commuter Rail	1.07	1.01	0.94	0.74	0.87	1.03	0.70	0.80	0.90	0.73
Light Rail	0.29	1.34	1.09	1.64	1.13	0.70	0.89	1.09	1.03	0.72
Demand Response	6.85	4.78	7.20	7.98	3.79	2.99	4.97	2.66	5.28	5.61

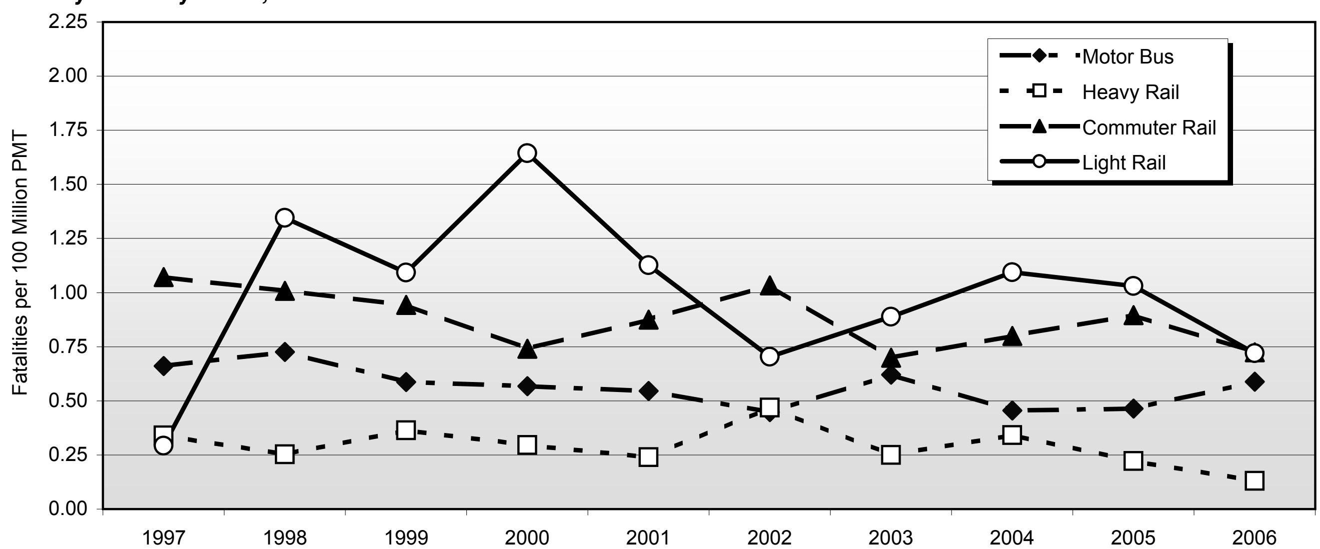
Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

wide range of passenger miles traveled on each mode and are therefore not provided.) This information is presented in *Exhibit 5-18* for all these modes except demand response. Fatalities per 100 million PMT for demand response are excluded from the graph due to their volatility.

Rail transit vehicles that travel on separate fixed guideways have historically had fewer fatalities relative to use than rail transit vehicles that share their guideway with nontransit vehicles. Motor buses, which travel at slower speeds, have also had a relatively low number of fatalities per 100 million PMT. Between 1997 and 2006, with the exception of 1997, heavy rail and motor bus had the fewest fatalities per 100 million PMT among the five largest modes. In 2006, heavy rail had 0.13 fatalities per 100 million PMT and motor bus had 0.59 fatalities per 100 million PMT; heavy rail fatalities per 100 million PMT were above those for motor bus between 1990 and 1996, but decreased significantly over these years. Commuter rail, which has frequent grade crossings with roads and shares track with freight rail vehicles, had more fatalities per 100 million PMT than heavy rail for each year from 1997 to 2006. Light rail had the highest number of fatalities per 100 million PMT among the rail modes in 7 of the 10 years from 1997 to 2006; light rail guideway is often at grade level and has minimal barriers between streets and sidewalks.

Exhibit 5-18

Fatality Rates by Mode, 1997–2006



Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

The number of fatalities per 100 million PMT on demand response systems fluctuated considerably between 1997 and 2006, ranging from 2.66 fatalities per 100 million PMT in 2004 to 7.98 in 2000. Demand response accounts for less than 1 percent of PMT; therefore, the underlying absolute number of demand response fatalities is very low, which accounts for the high degree of volatility in these numbers.

Exhibit 5-19 provides data on injuries and incidents per 100 million PMT for transportation services on the five largest modes from 2004 to 2006. In 2006, commuter rail, which provides longer trips than other modes, had 18.84 incidents per 100 million PMT and 16.50 injuries per 100 million PMT. Heavy rail had 42.24 incidents and 32.41 injuries per 100 million PMT, light rail had 61.62 incidents and 35.76 injuries per 100 million PMT, and motor buses had 78.71 incidents and 70.84 injuries per 100 million PMT. Demand response had the highest number of incidents and injuries per 100 million PMT from 2004 to 2006. Incidents on demand response systems increased from 895.24 per 100 million PMT in 2004 to 1298.07 per 100 million PMT in 2006, and injuries increased from 448.50 per 100 million PMT to 729.47 per 100 million PMT.

Exhibit 5-19

Transit Incidents and Injuries by Mode, 2004–2006

	2004	2005	2006
Incidents per 100 Million PMT			
Motor Bus	77.31	74.31	78.71
Heavy Rail	44.57	39.79	42.24
Commuter Rail	20.13	21.51	18.84
Light Rail	63.15	67.37	61.62
Demand Response	895.24	1010.24	1298.07
Injuries per 100 Million PMT			
Motor Bus	75.56	70.08	70.84
Heavy Rail	32.88	26.17	32.41
Commuter Rail	16.84	21.05	16.50
Light Rail	41.84	36.59	35.76
Demand Response	448.50	506.00	729.47

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-20 shows the number of fatalities per 100 incidents for each of the five largest transit modes from 2004 to 2006. This metric does not represent the percentage of incidents that are fatal, as some incidents result in multiple fatalities. The metric does, however, show the likelihood that fatality will result from an incident. Although commuter rail has a very low number of incidents per PMT, commuter rail incidents are far more likely to result in a fatality than incidents occurring on any other mode. Motor buses, on the other hand, have a high number of incidents per PMT, but a lower chance of having an incident result in a fatality than almost any other mode. While light rail and motor bus have similar numbers of incidents per PMT, an incident on light rail is one and a half to three times more likely to produce a fatality than an incident on a motor bus.

Exhibit 5-20

Fatalities per 100 Incidents by Mode, 2004–2006

	2004	2005	2006
Motor Bus	0.59	0.62	0.75
Heavy Rail	0.77	0.56	0.31
Commuter Rail	3.98	4.16	3.85
Light Rail	1.73	1.53	1.17
Demand Response	0.30	0.52	0.43

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Comparison

Exhibit 5-21 compares the key highway and transit statistics discussed in this chapter with the values shown in the last version of the C&P report. The first data column contains the values reported in the 2006 C&P Report, which were based on 2004 data. Where the 2004 data have been revised, updated values are shown in the second column. The third column contains comparable values based on 2006 data.

Exhibit 5-21

Comparison of Safety Statistics With Those in the 2006 C&P Report

	2004 Data		
	2006 C&P Report	Revised	2006 Data
Highway Safety			
Number of Fatalities	42,636	42,836	42,642
Fatality Rate per 100,000 People	14.52	14.59	14.24
Fatality Rate per 100 Million VMT	1.4	1.44	1.41
Number of Injuries	2,788,000		2,575,000
Injury Rate per 100,000 People	950		860
Injury Rate per 100 Million VMT	94		85
Transit Safety			
Number of Fatalities	248	217	213
Fatalities per 100 Million PMT	0.55	0.52	0.49
Number of Injuries	18,982	20,439	20,857
Injuries per 100 Million PMT	42	49.33	48.17
Number of Incidents	20,939	24,031	25,572
Incidents per 100 Million PMT	46	58	59.07

Highway fatalities decreased by 0.45 percent between 2004 and 2006, from 42,836 to 42,642. Although the number of fatalities has fallen sharply since 1966, the year when Federal legislation first addressed highway safety, there has been more limited progress in reducing the number of fatalities since 1992.

In 2006, the fatality rate per 100,000 people was 14.24, down from the 2004 fatality rate of 14.59. The fatality rate per 100 million vehicle miles traveled (VMT) declined from 1.44 in 2004 to 1.41 in 2006.

Q&A

What information is available for highway fatalities and injuries in 2007?

The information presented in the highway section of this chapter was drawn primarily from the Fatality Analysis Reporting System (FARS), which contains data on fatal traffic crashes in the 50 States, the District of Columbia, and Puerto Rico. Information in the FARS is updated periodically as submitted by the States, the District of Columbia, and Puerto Rico. For this reason, FARS data represent a "snapshot in time." The data for 2006 and previous years reported in this chapter were drawn from FARS in May 2008.

In August 2008, the National Highway Traffic Safety Administration (NHTSA) issued a *Traffic Safety Facts* summary that assesses key safety data for 2007. This document indicates that in 2007, 41,059 people died on the Nation's highways, a decrease of 3.9 percent from the total number of traffic fatalities in 2006. Also reported is a decrease in the fatality rate, from 1.42 per 100 million VMT in 2006 to 1.37 per 100 million VMT in 2007. In addition, traffic-related injuries declined from 2.58 million in 2006 to 2.49 million in 2007. The *Traffic Safety Facts* summary can be viewed at http://www-nrd.nhtsa.dot.gov/Pubs/811017.PDF.

The number of highway injuries decreased from 2.79 million in 2004 to 2.76 million in 2006. The injury rate per 100,000 people declined from 950 in 2004 to 860 in 2006, and the injury rate per 100 million VMT dropped from 94 in 2004 to 85 in 2006.

Public transit in the United States has been and continues to be a comparably safe mode of transportation, as evidenced by statistics on incidents, injuries, and fatalities as reported by public transportation agencies for the vehicles they operate directly.

Rail transit vehicles that travel on separate fixed guideways have historically had a lower number of fatalities relative to use than rail transit vehicles that share their guideways with nontransit vehicles. Buses, which travel at slower speeds, have also had low fatality rates per 100 million passenger miles traveled (PMT). Total fatalities fluctuated from 244 in 1997, to 217 in 2004, and 213 in 2006. When adjusted for passenger use, however, the fatality rate per 100 million PMT decreased, falling from 0.66 in 1997, to 0.52 in 2004, to 0.49 in 2006.

Between 2004 and 2006 incidents and injuries both increased, falling from 2004 to 2005 before rising again in 2006. When adjusted for passenger use, incidents per 100 million PMT increased and injuries per 100 million PMT decreased during this time period. In 2006, there were 25,572 incidents and 20,857 injuries on transit compared to 24,031 incidents and 20,439 injuries in 2004. When adjusted for passenger travel, there were 59.07 incidents per 100 million PMT and 48.17 injuries per 100 million PMT on transit in 2006, compared with 58.00 incidents per 100 million PMT and 49.33 injuries per 100 million PMT in 2004.

Chapter 6

Finance

Highway Finance

This section presents a detailed look at highway finance from two different perspectives. First, this chapter examines overall highway finance trends, beginning with the revenue sources that support public investment in highways and bridges across all levels of government. This is followed by a detailed analysis of capital expenditures. Second, it examines tools that are allowing transportation agencies to finance surface transportation projects when traditional finance methods may not fully cover the need. These tools include the use of Public-Private Partnerships, credit assistance, debt financing, and innovations in tolling.

A separate section within this chapter explores the financing of transit systems. This is followed by a section comparing key statistics from the highway and transit sections with the information presented in the previous edition of this report. The goal of this chapter is to comprehensively address not only highway finance as supported by traditional means, but also the trends that may impact this area in the future.

Overall Highway Finance Trends

Innovative finance plays an increasingly important role in the delivery of highway infrastructure, but the vast majority of finance is still done by more traditional means. The following section takes a comprehensive look at all transportation funding in the United States; it presents information on the revenue sources that support public investment in highways and bridges, as well as the various types of investments that are being made by all levels of government. This is followed by a discussion of the current and historic roles of Federal, State, and local governments in highway funding. The section then concludes with a more detailed analysis of capital expenditures.

Private sector investment in highways would generally show up in the "other receipts" category in the exhibits in this section, to the extent that such investment is captured in State and local accounting systems.

Current Revenue Sources

As shown in *Exhibit 6-1*, $166.0 billion was generated by all levels of government in 2006 for the purpose of highway investment. Actual cash expenditures in 2006 for highways and bridges, however, were lower, totaling $161.1 billion. The $1.6 billion shown as drawn from reserves in the Federal column indicates that the cash balance of the Highway Account of the Federal Highway Trust Fund (HTF) declined by that amount during 2006. State and local governments, however, placed $6.6 billion in reserves, which means that $5.0 billion in revenue generated for highways at all levels of government was instead saved for spending at a later point.

Highway-user charges—including motor-fuel taxes, motor-vehicle taxes and fees, and tolls—were the source of 56.3 percent of the $166.0 billion of total revenues for highways and bridges in 2006. The remaining 43.7 percent of revenues came from a number of sources, including local property taxes and assessments, other dedicated taxes, general funds, bond issues, investment income, and other miscellaneous sources. Development fees and special district assessments are included under "Investment Income and Other Receipts" in *Exhibit 6-1.*

Exhibit 6-1

Government Revenue Sources for Highways, 2006

	(Billions of Dollars)				
	Federal	**State**	**Local**	**Total**	**Percent**
User Charges					
Motor-Fuel Taxes	$26.8	$31.9	$1.4	$60.1	36.2%
Motor-Vehicle Taxes and Fees	$5.2	$19.1	$0.8	$25.2	15.2%
Tolls	$0.0	$6.7	$1.4	$8.1	4.9%
Subtotal	**$32.1**	**$57.7**	**$3.6**	**$93.4**	**56.3%**
Other					
Property Taxes and Assessments	$0.0	$0.0	$8.6	$8.6	5.2%
General Fund Appropriations	$2.4	$4.9	$19.6	$26.8	16.1%
Other Taxes and Fees	$0.3	$5.0	$4.6	$9.9	5.9%
Investment Income and Other Receipts	$0.0	$4.2	$5.3	$9.5	5.7%
Bond Issue Proceeds	$0.0	$11.9	$5.9	$17.8	10.7%
Subtotal	**$2.7**	**$26.0**	**$44.0**	**$72.6**	**43.7%**
Total Revenues	**$34.8**	**$83.7**	**$47.6**	**$166.0**	**100.0%**
Funds Drawn From (or Placed in) Reserves	$1.6	($2.8)	($3.8)	($5.0)	-3.0%
Total Expenditures Funded During 2006	**$36.3**	**$80.9**	**$43.8**	**$161.1**	**97.0%**

Sources: Highway Statistics 2006, Table HF-10, and unpublished FHWA data.

Q&A

Were all revenues generated by motor-fuel taxes, motor-vehicle taxes and fees, and tolls in 2006 used for highways?

No. The $93.4 billion identified as highway-user charges in *Exhibit 6-2* represents only 79.8 percent of total highway-user revenue, defined as all revenue generated by motor-fuel taxes, motor-vehicle taxes, and tolls. *Exhibit 6-2* shows that combined highway-user revenue collected in 2006 by all levels of government totaled $117.1 billion.

In 2006, $11.4 billion of highway-user revenue was used for transit, and $12.3 billion was used for other purposes, such as ports, schools, collection costs, and general government activities. The $0.4 billion shown as Federal highway-user revenue used for other purposes reflects the difference between total collections in 2006 and the amounts deposited into the HTF during FY 2006. Much of this difference is attributable to the proceeds of 0.1 cent of the motor-fuel tax being deposited into the Leaking Underground Storage Tank trust fund.

The $6.2 billion shown as Federal highway-user revenue used for transit includes deposits into the Transit Account of the HTF, as well as deposits into the Highway Account of the HTF that States elected to use for transit purposes.

Exhibit 6-2

Disposition of Highway-User Revenue by Level of Government, 2006

	(Billions of Dollars)			
	Federal	**State**	**Local**	**Total**
Highways	$32.1	$57.7	$3.6	$93.4
Transit	$6.2	$4.1	$1.0	$11.4
Other	$0.4	$11.8	$0.1	$12.3
Total Collected	**$38.7**	**$73.6**	**$4.8**	**$117.1**

Sources: Highway Statistics 2006, Table HF-10, and unpublished FHWA data.

The degree to which highway programs are funded by highway-user charges differs widely among the different levels of government. At the Federal level, 92.3 percent of highway revenues came from motor-fuel and motor vehicle taxes in 2006. The remainder came from general fund appropriations; motor carrier fines and penalties; and some timber sales, leasing of Federal lands, and oil and mineral royalties.

Highway-user charges also provided the largest share, 69.0 percent, of highway revenues at the State level in 2006. Bond issue proceeds were another significant source of funding, providing 14.3 percent of highway funds at the State level. The remaining 16.7 percent of State highway funding came from general fund appropriations, other State taxes and fees, investment income, and other miscellaneous revenue sources.

Many States do not permit local governments to impose motor-fuel and motor-vehicle taxes, or they cap them at relatively low levels. Therefore, at the local government level, only 7.6 percent of highway funding was provided by highway-user charges in 2006. Local general funds, property taxes, and other taxes and fees were the sources of 68.9 percent of local highway funding. Bond issue proceeds provided 12.4 percent of local highway funding, while investment income and miscellaneous receipts provided the remaining 11.1 percent.

Historical Revenue Trends

Exhibits 6-3 and *6-4* show how highway revenue sources have varied over time. *Exhibit 6-3* identifies the different sources of highway revenue since 1921 for all levels of government combined. *Exhibit 6-4* identifies the percentage of highway revenue derived from user charges by each level of government since 1957. Some of the variation in revenue sources shown in the graph portion of *Exhibit 6-3* is caused by changes in the share of funding provided by each level of government over time; this topic will be discussed later in this chapter. In the early 1920s, when local government bore much of the responsibility for highway funding, property taxes were the primary source of revenues for highways. Property taxes have, however, become a much less significant source of revenue over time. In 2000, property taxes dropped to an all-time low of 4.7 percent of total highway revenue and remained at roughly that level through 2002; in 2003, property taxes began to climb slightly, reaching 5.2 percent of total highway revenues in 2006. The share of total highway revenues generated by bond proceeds has fluctuated over time, reaching a high of 32.4 percent in 1954. Since that time, combined highway and bridge programs have become less dependent on debt financing; this share has not exceeded 11 percent of revenues since 1971.

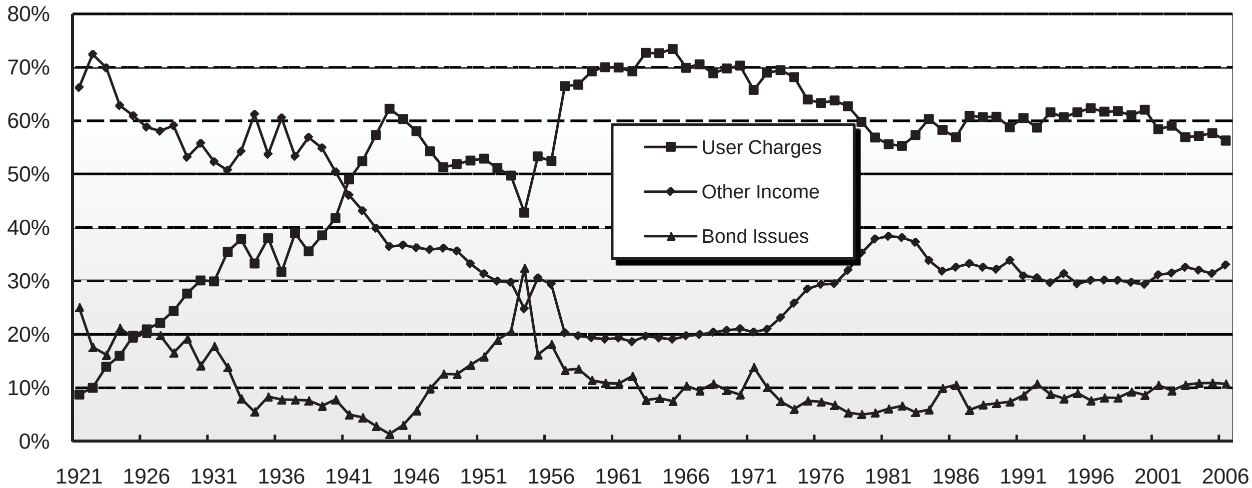
Since the passage of the Federal-Aid Highway Act of 1956 and the establishment of the Federal HTF, motor-fuel and motor-vehicle tax receipts have consistently provided a majority of the combined revenues raised for highway and bridge programs by all levels of government.

After peaking at an all-time high of 73.5 percent of highway revenues in 1965, the share represented by highway-user charges dropped to 55.2 percent in 1982. As shown in *Exhibit 6-4*, until 2000, the percentage had rebounded and stabilized in a range of about 60 to 62 percent. Since 2001, it has been slightly lower, ranging from 56 to 59 percent.

A corresponding pattern can be observed in the percentage of Federal highway revenue derived from highway-user charges as shown by the Federal line in *Exhibit 6-4*. During the early years of the HTF, over 90 percent of highway revenues at the Federal level came from fuel and vehicle taxes. From the late 1960s to early 1980s, this percentage declined, to a low of 61.5 percent in 1981. During this period, Federal motor-fuel taxes did not increase, and a growing percentage of Federal highway funding came from other sources. Since 1981, Federal motor-fuel taxes have increased significantly, and Federal general fund revenues used for highways have declined. As a result, the portion of Federal highway revenue derived from highway-user charges increased, reaching an all-time high of 96.4 percent in 1999. Since then, however, the share of Federal funding generated by highway-user charges have begun to decrease, dropping to 92.3 percent in 2006.

Exhibit 6-3

Highway Revenue Sources by Type, All Units of Government, 1921–2006



Year	Fuel and Vehicle Taxes	Tolls	Property Taxes	(Billions of Dollars) General Fund Approps.	Other Taxes and Fees	Investment Income and Other	Issue Proceeds	Total
1921	$0.1	$0.0	$0.7	$0.1	$0.0	$0.1	$0.4	$1.4
1925	0.4	0.0	0.9	0.2	0.0	0.0	0.4	2.0
1929	0.7	0.0	1.2	0.2	0.0	0.0	0.5	2.7
1933	0.7	0.0	0.6	0.4	0.0	0.0	0.2	1.9
1937	1.0	0.0	0.4	1.0	0.0	0.0	0.2	2.7
1941	1.2	0.1	0.4	0.8	0.0	0.0	0.1	2.6
1945	1.1	0.1	0.3	0.4	0.0	0.0	0.1	1.9
1949	2.1	0.1	0.4	1.0	0.0	0.1	0.5	4.3
1953	3.1	0.2	0.6	1.2	0.0	0.2	1.3	6.5
1957	5.6	0.4	0.8	0.7	0.0	0.2	1.2	9.0
1961	7.7	0.5	0.9	1.0	0.1	0.3	1.3	11.8
1965	9.8	0.7	1.1	1.1	0.2	0.4	1.1	14.3
1969	13.0	0.9	1.3	1.9	0.3	0.6	1.9	19.9
1973	17.0	1.2	1.5	3.0	0.4	1.1	2.0	26.2
1977	19.6	1.4	1.8	5.4	0.8	1.8	2.2	33.0
1981	21.8	1.8	2.5	8.8	1.4	3.7	2.6	42.5
1985	33.6	2.2	3.5	9.9	1.9	4.3	6.1	61.4
1989	41.4	2.9	4.3	10.8	2.9	5.5	5.2	72.8
1993	50.8	3.6	4.7	10.6	4.0	6.8	7.8	88.4
1997	61.6	4.7	5.3	15.1	5.0	7.0	8.8	107.4
1998	64.3	4.7	5.8	14.5	5.1	8.2	9.0	111.6
1999	69.1	5.1	5.8	17.2	6.4	6.8	11.3	121.7
2000	75.6	5.7	6.1	19.3	5.7	7.3	11.3	131.1
2001	71.8	5.9	6.3	19.1	8.0	8.0	14.0	133.1
2002	73.1	6.6	6.5	20.3	7.5	8.1	12.7	134.8
2003	73.3	5.9	7.2	21.8	8.8	7.5	14.7	139.2
2004	76.4	6.6	7.5	23.6	7.9	7.6	15.8	145.3
2005	83.4	7.7	8.2	24.3	9.1	8.0	17.2	157.8
2006	85.3	8.1	8.6	26.8	9.9	9.5	17.8	166.0

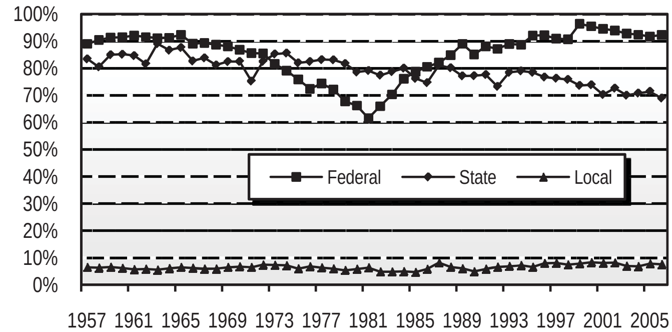
Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, Tables HF-10A and HF-10, various years.

Exhibit 6-4 shows that the share of State government highway funding contributed by highway-user charges has generally declined over time. From 1997 to 2006, the percentage dropped from 76.3 percent to 69.0 percent. Over the same period, States grew more reliant on debt financing, as bond proceeds grew from 8.6 percent to 14.3 percent of State government highway funding.

Highway-user charges have never been as significant a source of highway revenue at the local government level as at the Federal or State levels. In recent years, the share of local government highway funding derived from highway-user charges has been slightly higher than it was historically, exceeding 8 percent each year from 2000 to 2002, before dropping to 7.6 percent in 2006.

Exhibit 6-4

Percent of Highway Revenue Derived From User Charges, Each Level of Government, 1957–2006



Year	Federal	State	Local	Total
1957	89.0%	83.5%	6.5%	66.5%
1961	92.1%	84.7%	5.7%	69.9%
1965	92.4%	87.7%	6.5%	73.5%
1969	88.1%	82.5%	6.5%	69.8%
1973	81.6%	85.3%	7.3%	69.5%
1977	74.3%	83.2%	6.4%	63.8%
1981	61.5%	79.1%	6.4%	55.6%
1985	78.8%	76.2%	4.7%	58.3%
1989	89.0%	77.2%	6.1%	60.7%
1993	89.0%	78.5%	6.9%	61.6%
1997	91.0%	76.3%	8.1%	61.7%
1998	90.7%	75.9%	7.5%	61.8%
1999	96.4%	73.6%	7.9%	61.0%
2000	95.5%	73.9%	8.3%	62.0%
2001	94.6%	70.3%	8.1%	58.4%
2002	93.9%	72.6%	8.2%	59.1%
2003	92.8%	70.0%	7.0%	56.9%
2004	92.4%	70.8%	6.9%	57.1%
2005	91.7%	71.4%	7.9%	57.7%
2006	92.3%	69.0%	7.6%	56.3%

Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

Overall Highway Expenditures

Exhibit 6-1 indicates that total expenditures for highways in 2006 equaled $161.1 billion, then identifies the portion of this aggregate amount funded by each level of government. *Exhibit 6-5* classifies this total by type of expenditure and by the level of government. The "Federal," "State," and "Local" columns in *Exhibit 6-5* indicate which level of government made the direct expenditures, while "Funded by…" in the column "Current Expenditures" indicates the level of government that provided the funding for those expenditures. All amounts cited as "expenditures," "spending," or "outlays" in this report represent cash expenditures rather than authorizations or obligations.

While the Federal government funded $36.3 billion of total highway expenditures in 2006, the majority of the Federal government's contribution to highways consists of grants to State and local governments. Direct Federal spending on capital outlay, maintenance, administration, and research amounted to only $2.2 billion (about 1.4 percent). The remaining $34.1 billion was in the form of transfers to State and local governments.

State governments combined $32.8 billion of Federal funds with $65.1 billion of State funds and $2.2 billion of local funds to make direct expenditures of $100.1 billion (62.1 percent). Local governments combined $1.4 billion of Federal funds with $15.8 billion of State funds and $41.6 billion of local funds to make direct expenditures of $58.8 billion (36.5 percent).

Exhibit 6-5

Direct Expenditures for Highways, by Expending Agencies and by Type, 2006

	(Billions of Dollars)				
	Federal	State	Local	Total	Percent
Capital Outlay	**$0.5**	**$59.0**	**$19.2**	**$78.7**	**48.8%**
*Funded by Federal Government**	*$0.5*	*$32.8*	*$1.4*	*$34.6*	*21.5%*
*Funded by State or Local Govt's**	*$0.0*	*$26.2*	*$17.9*	*$44.1*	*27.4%*
Noncapital Expenditures					
Maintenance	0.2	12.6	18.6	31.3	19.4%
Highway and Traffic Services	0.0	4.7	4.4	9.1	5.7%
Administration	1.5	7.1	4.6	13.2	8.2%
Highway Patrol and Safety	0.0	7.7	6.8	14.5	9.0%
Interest on Debt	0.0	4.4	2.2	6.6	4.1%
Subtotal	**$1.7**	**$36.5**	**$36.6**	**$74.7**	**46.4%**
Total, Current Expenditures	**$2.2**	**$95.4**	**$55.8**	**$153.4**	**95.3%**
Bond Retirement	**$0.0**	**$4.6**	**$3.0**	**$7.6**	**4.7%**
Total All Expenditures	**$2.2**	**$100.1**	**$58.8**	**$161.1**	**100.0%**
*Funded by Federal Government**	*$2.2*	*$32.8*	*$1.4*	*$36.3*	*22.6%*
*Funded by State Governments**	*$0.0*	*$65.1*	*$15.8*	*$80.9*	*50.2%*
*Funded by Local Governments**	*$0.0*	*$2.2*	*$41.6*	*$43.8*	*27.2%*

** Amounts shown in italics are provided to link this table back to revenue sources shown in Exhibit 6-1. These are non-additive to the rest of the table, which classifies spending by expending agency.*

Sources: Highway Statistics 2006, Table HF-10, and unpublished FHWA data.

Q&A

How was the $36.3 billion figure for Federal contributions to total highway expenditures derived, and why does this figure differ from amounts that appear in other documents (e.g., the President's Budget)?

The Federal expenditures shown in this report are intended to reflect the highway-related activities of all Federal agencies, rather than just those of the traditional transportation agencies such as FHWA. The figures shown in this report tie back to data in *Highway Statistics*,[1] which are linked to data for highway expenditures on an agency-by-agency basis[2] at the Federal level. These data represent cash outlays, rather than obligations (which are more relevant in terms of the annual Federal budget) or authorizations (which are more relevant in terms of multiyear authorization bills). Since the financial data reported by State and local governments are compiled on a cash basis, this report uses the same basis for Federal expenditures to ensure consistency.

The Federal figures[2] rely on data from a mix of Federal, State, and local sources. In some cases, this table captures Federal funding for highways that are not otherwise tracked at the Federal level. For example, under current law, 25 percent of the receipts derived from Federal timber sales are to be paid to States for public roads and schools in the counties where forests are situated. At the time these payments are made, it is unknown what portion will ultimately be used for roads as opposed to schools; however, once States have expended these funds, they report to FHWA what portion was used for roads so that this information may be included.

Note that the Federal highway funding figures in this report exclude any amounts funded from the Highway Account of the Federal HTF that were used for transit purposes as identified in *Highway Statistics*.[1] Such amounts would appear as Federal funding for transit in this report.

The $34.6 billion Federal contribution to total capital expenditures represents total Federal highway expenditures of $36.3 billion, less direct Federal expenditures for noncapital purposes such as maintenance on Federally owned roads, administrative costs, and research.

[1] *Highway Statistics*, Tables HF 10 and HF-10A.

[2] *Highway Statistics*, Tables FA-5 and FA-5R.

Types of Highway Expenditures

Current highway expenditures can be divided into two broad categories: noncapital and capital. Noncapital highway expenditures include maintenance of highways, highway and traffic services, administration, highway law enforcement, highway safety, and interest on debt. Highway capital outlay consists of those expenditures associated with highway improvements. Such improvements include land acquisition and other right-of-way costs; preliminary and construction engineering; new construction, reconstruction, resurfacing, rehabilitation, and restoration; and installation of guardrails, fencing, signs, and signals. Bond retirement is not part of current expenditures, but it is included in the figures cited for total highway expenditures in this report.

> Q&A
>
> **What basis is used for distinguishing between capital expenditures and maintenance expenditures?**
>
> The classification of the revenue and expenditure items in this report is based on definitions contained in *A Guide to Reporting Highway Statistics*, the instructional manual for States providing financial data for the *Highway Statistics* publication. This manual indicates that the classification of highway construction and maintenance expenditures should be based on criteria provided in the American Association of State Highway and Transportation Officials publication, *AASHTO Maintenance Manual—1987*.
>
> Other definitions of maintenance are used by different organizations. Some resurfacing, restoration, and rehabilitation projects that meet this report's definition of capital outlay might be classified as maintenance activities in internal State or local accounting systems.

As shown in *Exhibit 6-5*, all levels of government spent $78.7 billion on capital outlay in 2006, or 48.8 percent of total highway expenditures. Highway capital outlay expenditures are discussed in more detail later in this chapter.

> Q&A
>
> **How are "maintenance" and "highway and traffic services" defined in this report?**
>
> Maintenance in this report includes routine and regular expenditures required to keep the highway surface, shoulders, roadsides, structures, and traffic control devices in usable condition. This includes completing spot patching and crack sealing of roadways and bridge decks and maintaining and repairing highway utilities and safety devices such as route markers, signs, guardrails, fence, signals, and highway lighting.
>
> Highway and traffic services include activities designed to improve the operation and appearance of the roadway. This includes items such as the operation of traffic control systems, snow and ice removal, highway beautification, litter pickup, mowing, toll collection, and air quality monitoring.

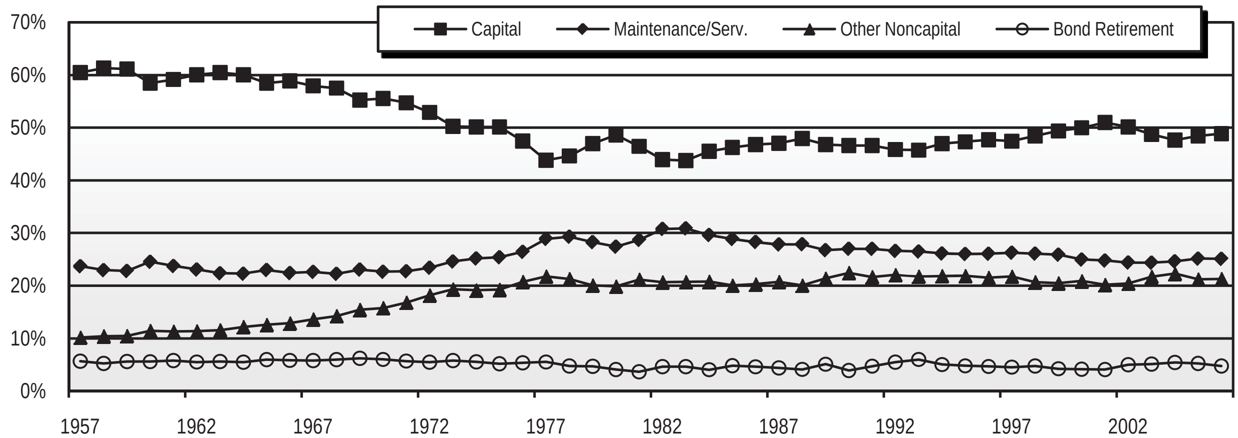
Current non-capital expenditures consumed $74.7 billion (46.4 percent), while the remaining $7.6 billion (4.7 percent) went for bond redemption. As most Federal funding for highways goes for capital items, noncapital expenditures are funded primarily by State and local governments. In 2006, spending by local governments on noncapital expenditures slightly exceeded spending by State governments on noncapital expenditures, with local governments allocating $36.6 billion and State governments spending $36.5 billion. Local government expenditures for the maintenance subset of noncapital expenditures comprised $18.6 billion (about 59.3 percent) of the $31.3 billion total.

Historical Expenditure and Funding Trends

Exhibits 6-6 and *6-7* provide historical perspective for the 2006 values shown in *Exhibit 6-5*. *Exhibit 6-6* shows how the composition of highway expenditures by all levels of government combined has changed over time. *Exhibit 6-6* shows the amounts provided by each level of government to finance those expenditures and the share of funding provided by the Federal government for total highway expenditures and for highway capital outlay.

Exhibit 6-6

Expenditures for Highways by Type, All Units of Government, 1957–2006



(Billions of Dollars)

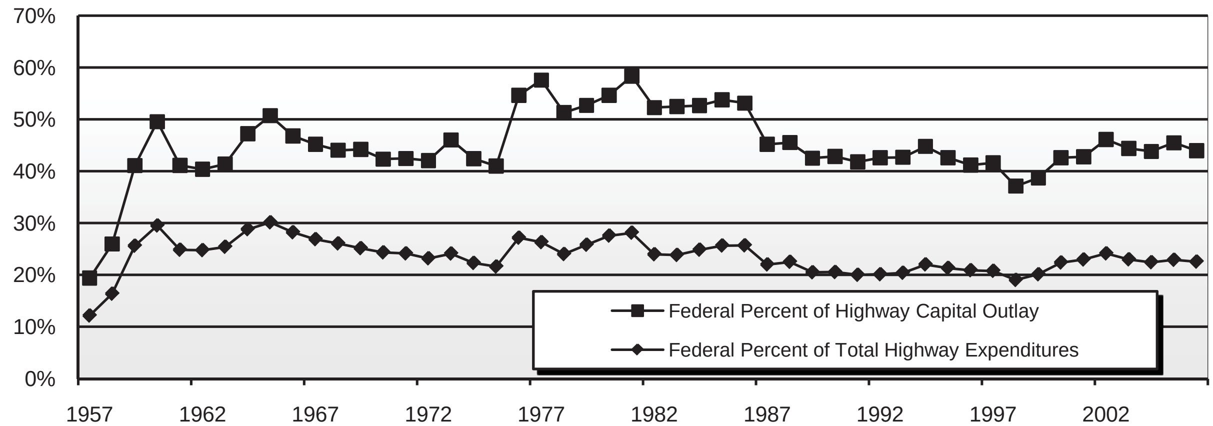
			Other Noncapital					
Year	Capital Outlay	Maintenance and Services	Administration	Highway Patrol and Safety	Interest on Debt	Total Other Noncapital	Debt Retirement	Total
1957	$5.6	$2.2	$0.4	$0.3	$0.3	$0.9	$0.5	$9.3
1961	$6.8	$2.7	$0.5	$0.3	$0.4	$1.3	$0.7	$11.5
1965	$8.4	$3.3	$0.8	$0.5	$0.5	$1.8	$0.9	$14.3
1969	$10.4	$4.3	$1.1	$1.1	$0.7	$2.9	$1.2	$18.8
1973	$12.2	$5.9	$1.7	$1.9	$1.0	$4.7	$1.4	$24.2
1977	$13.1	$8.6	$2.4	$2.8	$1.3	$6.5	$1.6	$29.8
1981	$19.7	$12.2	$3.4	$3.9	$1.7	$9.0	$1.6	$42.4
1985	$26.6	$16.6	$4.2	$5.2	$2.1	$11.5	$2.8	$57.5
1989	$33.1	$19.0	$5.7	$6.6	$2.8	$15.2	$3.6	$70.9
1993	$39.5	$22.9	$7.9	$7.2	$3.7	$18.8	$5.2	$86.4
1997	$48.4	$26.8	$8.3	$9.8	$4.2	$22.2	$4.6	$102.0
1998	$52.3	$28.2	$8.5	$9.4	$4.4	$22.3	$5.1	$108.0
1999	$57.2	$30.0	$9.0	$10.4	$4.4	$23.7	$4.9	$115.9
2000	$61.3	$30.6	$10.0	$11.0	$4.6	$25.6	$5.1	$122.7
2001	$66.7	$32.4	$10.2	$11.4	$4.8	$26.4	$5.3	$130.8
2002	$68.2	$33.2	$10.7	$11.7	$5.4	$27.8	$6.8	$135.9
2003	$70.0	$35.0	$12.0	$13.5	$5.7	$31.2	$7.4	$143.6
2004	$70.3	$36.3	$12.7	$14.3	$5.8	$32.9	$8.0	$147.5
2005	$74.1	$38.5	$12.0	$14.2	$6.3	$32.5	$8.0	$153.2
2006	$78.7	$40.4	$13.2	$14.5	$6.6	$34.3	$7.6	$161.1

Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

The increased Federal funding for highways available under the Transportation Equity Act for the 21st Century (TEA-21) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) contributed to a 58.0 percent increase (from $102.0 billion to $161.1 billion in nominal dollars) in total highway spending by all levels of government between 1997 and 2006. Capital outlay by all levels of government increased by 62.7 percent in nominal dollar terms over the same period, from $48.4 billion to $78.7 billion.

Exhibit 6-7

Funding for Highways by Level of Government, 1957–2006



	Funding for Total Highway Expenditures					Funding for Capital Outlay		
	(Billions of Dollars)				Percent	(Billions of Dollars)		Percent
Year	Federal	State	Local	Total	Federal	Federal	Total	Federal
1957	$1.1	$6.1	$2.0	$9.3	12.2%	$1.1	$5.6	19.4%
1961	$2.9	$6.2	$2.4	$11.5	24.8%	$2.8	$6.8	41.1%
1965	$4.3	$7.3	$2.7	$14.3	30.1%	$4.2	$8.4	50.7%
1969	$4.7	$10.4	$3.7	$18.8	25.1%	$4.6	$10.4	44.2%
1973	$5.8	$13.8	$4.6	$24.2	24.1%	$5.6	$12.2	46.0%
1977	$7.8	$15.1	$6.9	$29.8	26.3%	$7.5	$13.1	57.6%
1981	$11.9	$20.1	$10.4	$42.4	28.1%	$11.5	$19.7	58.4%
1985	$14.7	$27.9	$14.9	$57.5	25.7%	$14.3	$26.6	53.8%
1989	$14.5	$36.4	$19.9	$70.9	20.5%	$14.1	$33.1	42.5%
1993	$17.6	$46.5	$22.3	$86.4	20.4%	$16.9	$39.5	42.7%
1997	$21.2	$54.2	$26.6	$102.0	20.8%	$20.1	$48.4	41.6%
1998	$20.5	$59.7	$27.8	$108.0	19.0%	$19.4	$52.3	37.1%
1999	$23.3	$61.0	$31.7	$116.0	20.1%	$22.1	$57.2	38.7%
2000	$27.5	$62.7	$32.6	$122.7	22.4%	$26.1	$61.3	42.6%
2001	$30.0	$66.3	$34.5	$130.8	23.0%	$28.5	$66.7	42.8%
2002	$32.8	$69.0	$34.1	$135.9	24.1%	$31.5	$68.2	46.1%
2003	$33.0	$71.9	$38.7	$143.6	23.0%	$31.1	$70.0	44.4%
2004	$33.1	$72.8	$41.6	$147.5	22.4%	$30.8	$70.3	43.8%
2005	$35.1	$75.3	$42.8	$153.2	22.9%	$33.7	$74.1	45.5%
2006	$36.3	$80.9	$43.8	$161.1	22.6%	$34.6	$78.7	44.0%

Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

The percentage of total highway expenditures that went for capital outlay peaked at 61.3 percent in 1958, the start of the Interstate era. Subsequently, capital outlay's share of total spending gradually declined to a low of 43.8 percent in 1983. As shown in *Exhibit 6-6*, this share climbed up above 50 percent in 2001, but has subsequently fallen back below this level. In 2006, about 48.9 percent of all highway expenditures were used for capital improvements.

Exhibit 6-7 shows that the portion of total highway funding provided by the Federal government rose from 20.8 percent in 1997 to 22.6 percent in 2006. The Federal share of capital funding also increased significantly (from 41.6 percent to 44.0 percent) over this same period. Federal cash expenditures for capital purposes increased from $20.1 billion in 1997 to $34.6 billion in 2006, while State and local capital investment increased from $28.3 billion to $44.1 billion.

Federal support for highways increased dramatically following the passage of the Federal-Aid Highway Act of 1956 and the establishment of the HTF. The Federal share of total funding peaked in 1965 at 30.1 percent. Since that time, the Federal percentage of total funding gradually declined, dropping to a low of 19.0 percent in 1998. The Federal percentage of total funding rose steadily from 1998 until 2002 when it reached 24.1 percent, as the increased obligation authority provided under TEA-21 began to translate into higher cash outlays, but has generally declined since then. The Federally funded portion of capital outlay by all levels of government rose above 40 percent in 1959, peaking at 58.4 percent in 1981. From 1987 through 1997, the Federal share remained in a range of 41 to 46 percent. The Federal percentage of capital outlay dropped below this range in 1998, falling to 37.1 percent, but returned to this range in 2000 and has remained in it since.

> **Q&A**
>
> **Do the relative Federal, State, and local shares of funding described in this chapter equate to a comparable relative degree of influence?**
>
> No. Significant intergovernmental transfers of funds occur from the Federal government to State and local governments, from State governments to local governments, and from local governments to State governments. Depending on the specific grant program, recipients have a varying degree of autonomy and discretion in how they use the funds. The relative degree of influence that each level of government has on what individual projects are funded and what types of highway expenditures are made is not necessarily consistent with the share of highway funding that each level of government provides.

Spending by all levels of government on maintenance and traffic services increased by 51.0 percent in nominal dollar terms from 1997 to 2006, but declined as a percentage of total highway spending, since other types of expenditures grew even faster. As shown in *Exhibit 6-6*, maintenance and traffic services' share of total highway spending dropped to 25.1 percent. Spending on other noncapital expenditures, including highway law enforcement and safety, administration and research, and interest payments, declined from 21.8 percent of total spending to 21.3 percent. Debt retirement expenditures were the fastest-growing category of expenses between 1997 and 2006, but the rate of spending growth has declined since 2004.

Constant Dollar Expenditures

This report uses two indices for converting nominal dollar highway spending to constant dollars; the FHWA Composite Bid Price Index (BPI) is used for converting highway capital expenditures, while the Consumer Price Index (CPI) is used for converting noncapital highway spending. For some historic periods the BPI has grown faster than the CPI, while in others the CPI

> **Q&A**
>
> **What factors have contributed to the increase in the BPI from 2004 to 2006?**
>
> The leading factors for the increase include strong growth in residential construction and global competition for construction materials. Transportation construction is one aspect of the national construction picture.
>
> Among highway construction materials, the largest price increases have been associated with diesel fuel, steel, and concrete. Worldwide demand from China, Europe, India, and the United States has put pressure on the refining and producing capacities for these construction materials. In the United States, according to the Energy Information Agency, the transition to low-sulfur diesel fuel has affected diesel fuel production and distribution costs.
>
> In addition to higher energy costs, a number of diverse factors are impacting construction costs. These include localized material shortages for specific construction products; consolidation in the highway industry (number of prime contractors, ownership of quarries, etc.); increased construction market opportunities in other areas, such as hurricane recovery reconstruction programs; the downsizing of the workforce due to instability of transportation funding prior to August 2005; spot shortages of skilled labor; regulatory restrictions, such as environmental permits for plants and quarries; and hurricane-related issues increasing non-highway construction demand.

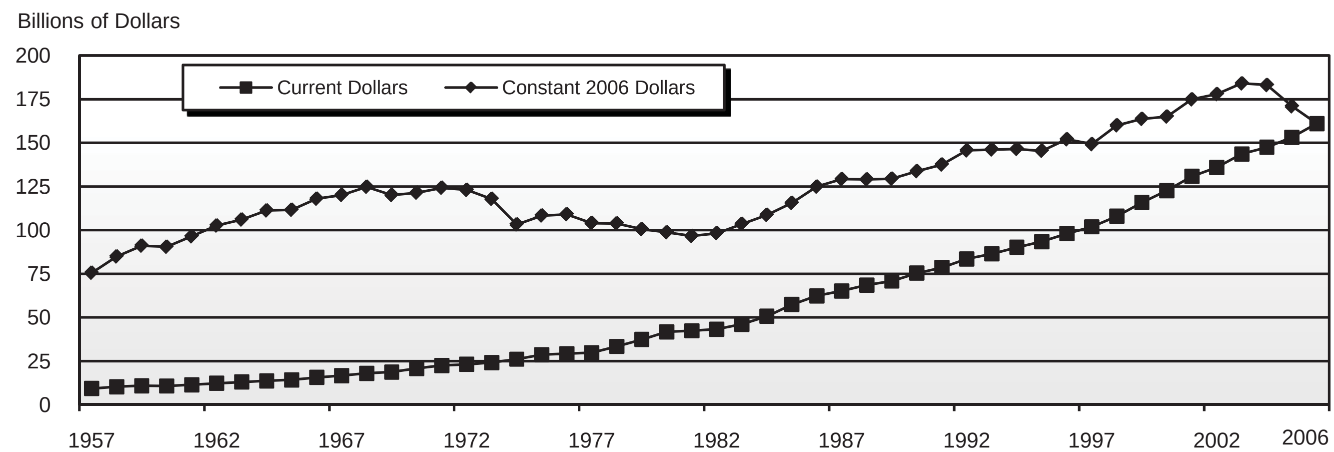
has grown faster. The BPI tends to be more volatile than the CPI, as it is affected by industry-specific trends as well as the general trends within the overall economy. This volatility was demonstrated in the period between 2004 and 2006, as sharp increases in the prices of materials such as steel, asphalt, and cement caused the BPI to increase by 43.3 percent, compared to a 6.7 percent increase in the CPI.

Exhibit 6-8 compares highway expenditures in current (nominal) and constant (real) dollars over time. While highway expenditures have grown in current dollar terms in each of the years from 1960 through 2006, constant dollar expenditures show a different pattern. In constant dollar terms, total highway expenditures reached a plateau in 1971, and did not keep pace with inflation from 1972 through 1981. Since 1981, constant dollar highway spending has increased; and by 1986, it had moved back above the 1971 level. Constant dollar spending reached an all time high in 2003, then dropped sharply to below 1999 levels.

Despite the recent sharp decline in the purchasing power of highway capital investment, overall highway expenditures grew more quickly than inflation between 1997 and 2006. As noted earlier, total highway expenditures increased by 58.0 percent from $102.0 billion in 1997 to $161.1 billion in 2006, which equates to an average annual growth rate of 5.2 percent in nominal terms. Over the same period, the BPI increased at an average annual rate of 6.0 percent, and the CPI increased at an average annual rate of 2.6 percent. In constant dollar terms total highway expenditures grew by 7.9 percent from 1997 to 2006, equating to an average annual growth rate of 0.8 percent.

Exhibit 6-8

Total Highway Expenditures in Current and Constant 2006 Dollars, All Units of Government, 1957–2006

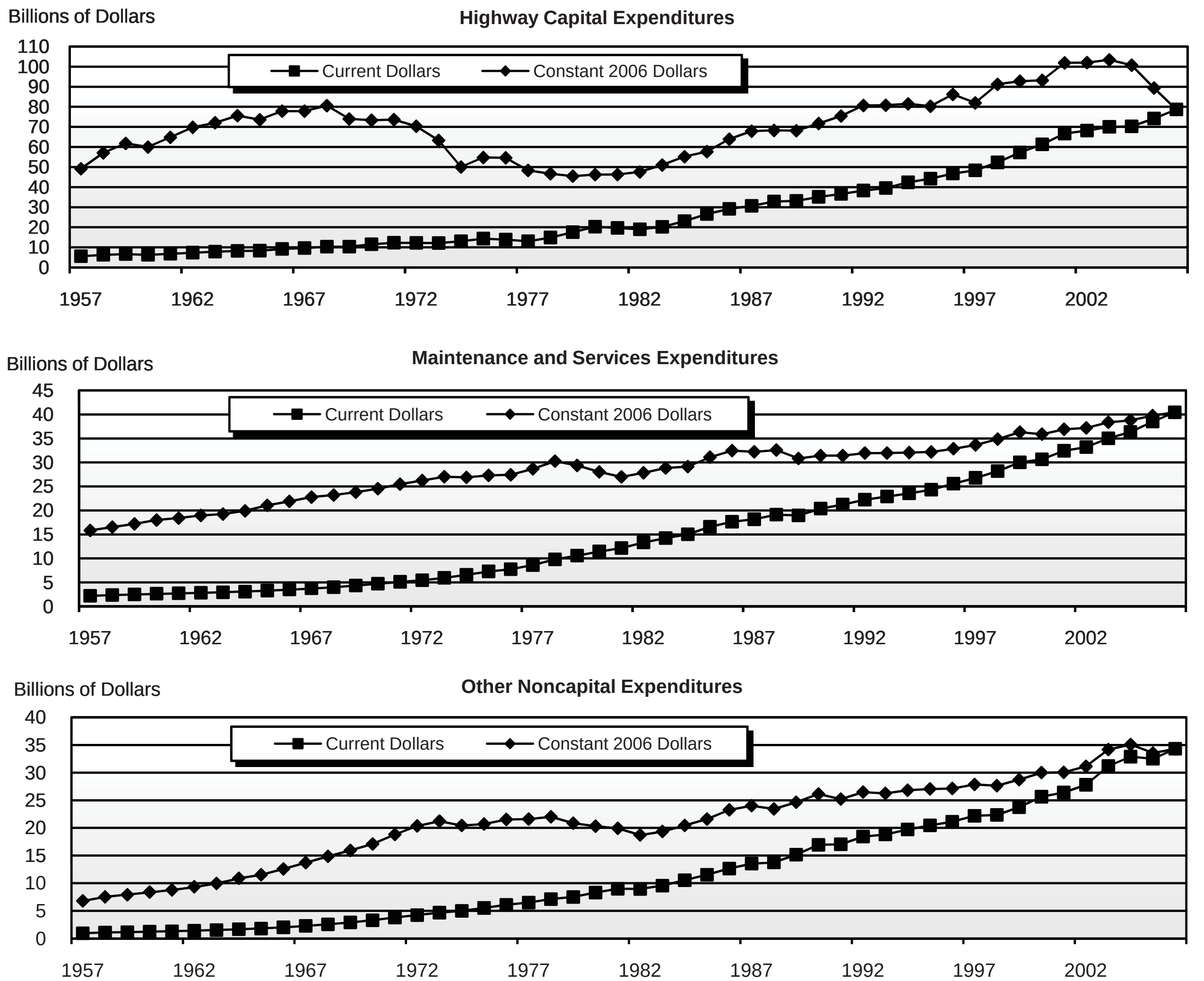


Sources: Bureau of Labor Statistics Consumer Price Index (CPI), various years; PriceTrends for Federal-aid Highway Construction, various years. Tables HF-10A, HF-10 and PT-1.

Exhibit 6-9 compares current dollar and constant dollar spending for capital outlay, maintenance and traffic services, and other noncapital expenditures (including highway law enforcement and safety, administration and research, and interest payments). As noted earlier, highway capital expenditures by all levels of government increased more quickly than noncapital expenditures, increasing 62.7 percent from $48.4 billion in 1997 to $78.7 billion in 2006, which equates to an average annual growth rate of 5.6 percent in nominal dollar terms. Because this rate of increase is smaller than the increase in the BPI over this period, highway capital expenditures fell by 4.0 percent from 1997 to 2006, equating to an average annual decline of 0.8 percent. In constant dollar terms, highway capital expenditures in 2006 were at their lowest level since 1991.

Exhibit 6-9

Highway Capital, Maintenance and Services, and Other Noncapital Expenditures in Current and Constant 2006 Dollars, All Units of Government, 1957–2006



Sources: Bureau of Labor Statistics Consumer Price Index (CPI), various years; Price Trends for Federal-aid Highway Construction, various years.

Q&A

Are the recent increases observed in the BPI unprecedented?

No. The increase in the BPI between 2004 and 2006 was of approximately the same magnitude as the increase from 1977 to 1979, and smaller than its growth from 1972 to 1974.

Other indices such as the Bureau of Labor Statistics' (BLS') Producer Price Index Industry Data for Highway and Street Construction also show large increases in this general time frame. Between 2003 and 2006, this index rose 35.3 percent, compared to a 47.7 percent increase for the same period in the BPI. Sharp increases in steel prices beginning in 2003 were followed by increases in petroleum, concrete, and other highway construction materials.

The BLS index cited above increased by an additional 5.8 percent in 2007 and 13.8 percent in 2008. However, after peaking in July 2008, the index has subsequently declined back close to its 2007 level. No 2007 or 2008 data for the BPI are available, because the index has been discontinued. A replacement index is currently being developed that will draw upon bid price data generated by States for both State-only and Federal-aid projects. The next edition of this report will utilize this new index to recalculate historic constant dollar highway expenditure data.

In constant dollar terms based on the CPI, spending for maintenance and traffic services reached an all time high in 2006, increasing 20.2 percent (2.1 percent per year) over the nine-year period beginning in 1997. Other noncapital expenditures grew by 23.1 percent (3.3 percent per year) in constant dollar terms over this same period.

Total highway expenditures funded by State and local governments, which includes a mix of capital and noncapital spending, grew by 9.6 percent (1.0 percent per year) in constant dollar terms from 1997 to 2006. Highway capital spending funded by State and local governments fell by 7.8 percent (0.9 percent per year) in constant dollar terms over this period. Expenditures funded by the Federal government, which are more heavily weighted towards capital items, grew by 2.5 percent in constant dollar terms (0.3 percent per year) from 1997 to 2006. Federally funded highway capital spending grew by 1.4 percent (0.2 percent per year) over this period.

Looking back further to 1981, the growth of capital expenditures and noncapital expenditures is more consistent in constant dollar terms. Over this 25-year period, highway capital outlay grew at an average annual rate of 5.7 percent from $19.0 to $78.7 billion in nominal dollars; in constant dollar terms this equates to a 70.0 percent increase (2.1 percent per year). Over this same period, maintenance and traffic services grew by 49.8 percent in constant dollar terms (1.6 percent per year), and other noncapital expenditures grew by 72.2 percent in constant dollar terms (2.2 percent per year).

Constant Dollar Expenditures per Vehicle Mile Traveled

While not all types of highway expenditures would necessarily be expected to grow in proportion to vehicle miles traveled (VMT), increases in VMT do increase the wear and tear on existing roads, leading to higher capital and maintenance costs. The addition of new lanes and roads to accommodate additional traffic results in one-time capital costs, as well as recurring costs for rehabilitation and maintenance. Traffic supervision and safety costs are also related in part to traffic volume. As the highway system has grown and become more complex, the cost of administering the system has grown as well.

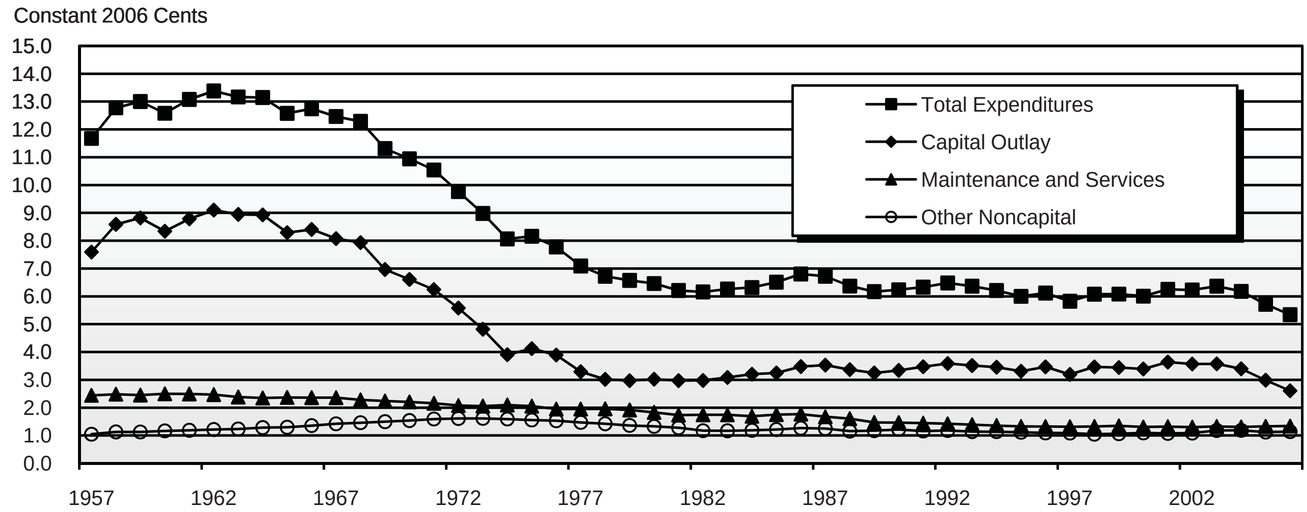
In current dollar terms, total expenditures per VMT have grown steadily over time. Between 1997 and 2006, expenditures per VMT rose from 4.0 cents to 5.3 cents. However, expenditures per VMT in constant dollars fell by 8.3 percent during this period. The initial peak in total expenditures per VMT in constant dollars during the early 1960s corresponds to the significant level of new construction and rapid Interstate Highway System expansion during that timeframe. This was followed by a steady decline in total constant dollar expenditures per VMT during the 1960s and 1970s, with the rate of decline slowing during the 1980s and early 1990s but reaccelerating after 2003. Capital outlay per VMT fell by 18.4 percent between 1997 and 2006 in constant dollar terms. Spending on maintenance and traffic services increased by 2.2 percent over this same period in terms of constant cents per VMT basis, while constant spending per VMT on other noncapital items rose 4.7 percent. These data are shown in *Exhibit 6-10*.

Highway Capital Outlay Expenditures

State governments directly spent $59.0 billion on highway capital outlay in 2006. *Exhibit 6-11* shows how States applied this $59.0 billion to different functional systems. It also includes an estimate of how the total $78.7 billion spent by all levels of government was applied. State government capital outlay is concentrated on the higher-order functional systems, while local governments apply the larger part of their capital expenditures to lower-order systems.

Exhibit 6-10

Highway Expenditures per Vehicle Mile Traveled, All Units of Government, 1957–2006



Sources: Highway Statistics Summary to 1995, Tables HF-210 and VM-203; Highway Statistics, various years, Tables HF-10A, HF-10 and VM-3.

Exhibit 6-11

Highway Capital Outlay by Functional System, 2006

Functional Class	Direct State Capital Outlay (Billions of Dollars)	Capital Outlay, All Jurisdictions: Total (Billions of Dollars)	Capital Outlay, All Jurisdictions: Per Lane Mile (Dollars)	Capital Outlay, All Jurisdictions: Per VMT (Cents)
Rural Arterials and Collectors				
Interstate	$4.2	$4.2	$33,709	1.6
Other Principal Arterial	9.5	9.5	38,449	4.1
Minor Arterial	4.4	5.0	17,567	3.0
Major Collector	3.1	4.4	5,193	2.3
Minor Collector	0.4	1.2	2,343	2.1
Subtotal	**$21.6**	**$24.3**	**$12,009**	**2.7**
Urban Arterials and Collectors				
Interstate	12.4	12.4	140,443	2.6
Other Freeway and Expressway	5.3	5.5	110,037	2.5
Other Principal Arterial	8.5	10.6	48,082	2.3
Minor Arterial	3.5	6.4	24,240	1.7
Collector	0.9	3.3	14,206	1.9
Subtotal	**$30.5**	**$38.1**	**$44,679**	**2.2**
Subtotal, Rural and Urban	**$52.0**	**$62.4**	**$21,697**	**2.4**
Rural and Urban Local	**$7.0**	**$16.3**	**$2,936**	**4.1**
Total, All Systems	**$59.0**	**$78.7**	**$9,343**	**2.6**
*Funded by Federal Government**	*$32.8*	*$34.6*	*$4,109*	*1.1*

** Amounts shown in italics are non-additive to the rest of the table.*

Sources: Highway Statistics 2006, Table SF-12, and unpublished FHWA data.

Total highway capital expenditures by all levels of government amounted to $9,343 per lane mile in 2006, or 2.6 cents per VMT. Capital outlay per lane mile was generally greatest for the higher-order functional systems and was greater on urban roads than rural roads.

Capital outlay per VMT ranged from 4.1 cents on rural other principal arterials to 1.6 cents on rural Interstates. Capital outlay per lane mile was greater on urban roads than rural roads; however, when measured by VMT, outlay per VMT was greater on rural routes than urban routes. Between 2004 and 2006, capital outlay per VMT grew from 2.4 cents to 2.7 cents on rural roads, while it remained steady on urban roads at 2.2 cents.

Capital Outlay by Improvement Type

States provide the FHWA with detailed data on what they spend on arterials and collectors, classifying expenditures on each functional system into 17 improvement types. For this report, these improvement types have been allocated among three groups: System Rehabilitation, System Expansion, and System Enhancement.

Q&A

How are "system rehabilitation," "system expansion," and "system enhancement" defined in this report?

System rehabilitation consists of capital improvements on existing roads and bridges that are intended to preserve the existing pavement and bridge infrastructure. These activities include reconstruction, resurfacing, pavement restoration or rehabilitation, widening of narrow lanes or shoulders, bridge replacement, and bridge rehabilitation. Also included is the portion of widening (lane addition) projects estimated to be related to reconstructing or improving existing lanes. System rehabilitation does not include routine maintenance costs. As shown in Exhibit 6-5, an additional $31.3 billion was spent by all levels of government in 2006 on routine maintenance.

System expansion includes construction of new roads and new bridges and addition of new lanes to existing roads. This includes all "New Construction," "New Bridge," "Major Widening," and most of the costs associated with "Reconstruction-Added Capacity," except for the portion of these expenditures estimated to be related to improving the existing lanes of a facility. As used in this report, "System Expansion" is the functional equivalent to "Capacity Expansion" used in some previous editions. The term was modified because some system rehabilitation and system enhancement improvements may result in added capacity without the addition of new lanes.

System enhancement includes safety enhancements, traffic operations improvements such as the installation of intelligent transportation systems, and environmental enhancements.

Exhibit 6-12 shows the distribution of the $52.0 billion in State expenditures among these three categories. Detailed data on Federal government and local expenditures are unavailable, so the combined $62.4 billion of capital outlay on arterials and collectors by all levels of government was classified based on the State expenditure patterns. Similarly, little information is available on the types of improvements being made by all levels of government on local functional system roads. To develop an estimate for the improvement type breakdown for the $78.7 billion invested on all systems in 2006, it was assumed that expenditure patterns were roughly equivalent to those observed for rural minor collectors.

In 2006, about $40.4 billion was spent on system rehabilitation (51.3 percent of total capital outlay). As defined in this report, system rehabilitation activities include capital improvements on existing roads and bridges that are designed to preserve the existing pavement and bridge infrastructure. These improvements do not include routine maintenance.

About $16.2 billion—20.6 percent of total capital outlay—was spent on the construction of new roads and bridges in 2006. An additional $13.8 billion, or 17.6 percent, was used to add lanes to existing roads. Another $8.2 billion, or 10.5 percent, was spent on system enhancement, including safety enhancements, traffic operations improvements, and environmental enhancements.

Exhibit 6-12

Highway Capital Outlay by Improvement Type, 2006

(Billions of Dollars)

	System Rehabilitation	System Expansion: New Roads and Bridges	System Expansion: Existing Roads	System Enhancement	Total
Direct State Expenditures on Arterials and Collectors					
Right-of-Way		$2.0	$1.8		$3.8
Engineering	$3.3	1.3	1.2	$0.6	6.3
New Construction		7.5			7.5
Relocation			1.0		1.0
Reconstruction—Added Capacity	1.8		4.2		6.0
Reconstruction—No Added Capacity	4.0				4.0
Major Widening			2.6		2.6
Minor Widening	0.9				0.9
Restoration and Rehabilitation	8.6				8.6
Resurfacing	0.3				0.3
New Bridge		0.8			0.8
Bridge Replacement	3.5				3.5
Major Bridge Rehabilitation	1.0				1.0
Minor Bridge Work	1.9				1.9
Safety				1.5	1.5
Traffic Management/Engineering				1.0	1.0
Environmental and Other				1.4	1.4
Total, State Arterials and Collectors	**$25.4**	**$11.5**	**$10.8**	**$4.3**	**$52.0**
Total, Arterials and Collectors, All Jurisdictions (estimated)*					
Highways and Other	23.1	12.1	12.9	5.5	53.6
Bridges	7.9	0.9			8.8
Total, Arterials and Collectors	**$31.1**	**$13.0**	**$12.9**	**$5.5**	**$62.4**
Total Capital Outlay on All Systems (estimated)*					
Highways and Other	30.2	15.0	13.8	8.2	67.3
Bridges	10.1	1.2			11.4
Total, All Systems	**$40.4**	**$16.2**	**$13.8**	**$8.2**	**$78.7**
Percent of Total	**51.3%**	**20.6%**	**17.6%**	**10.5%**	**100.0%**

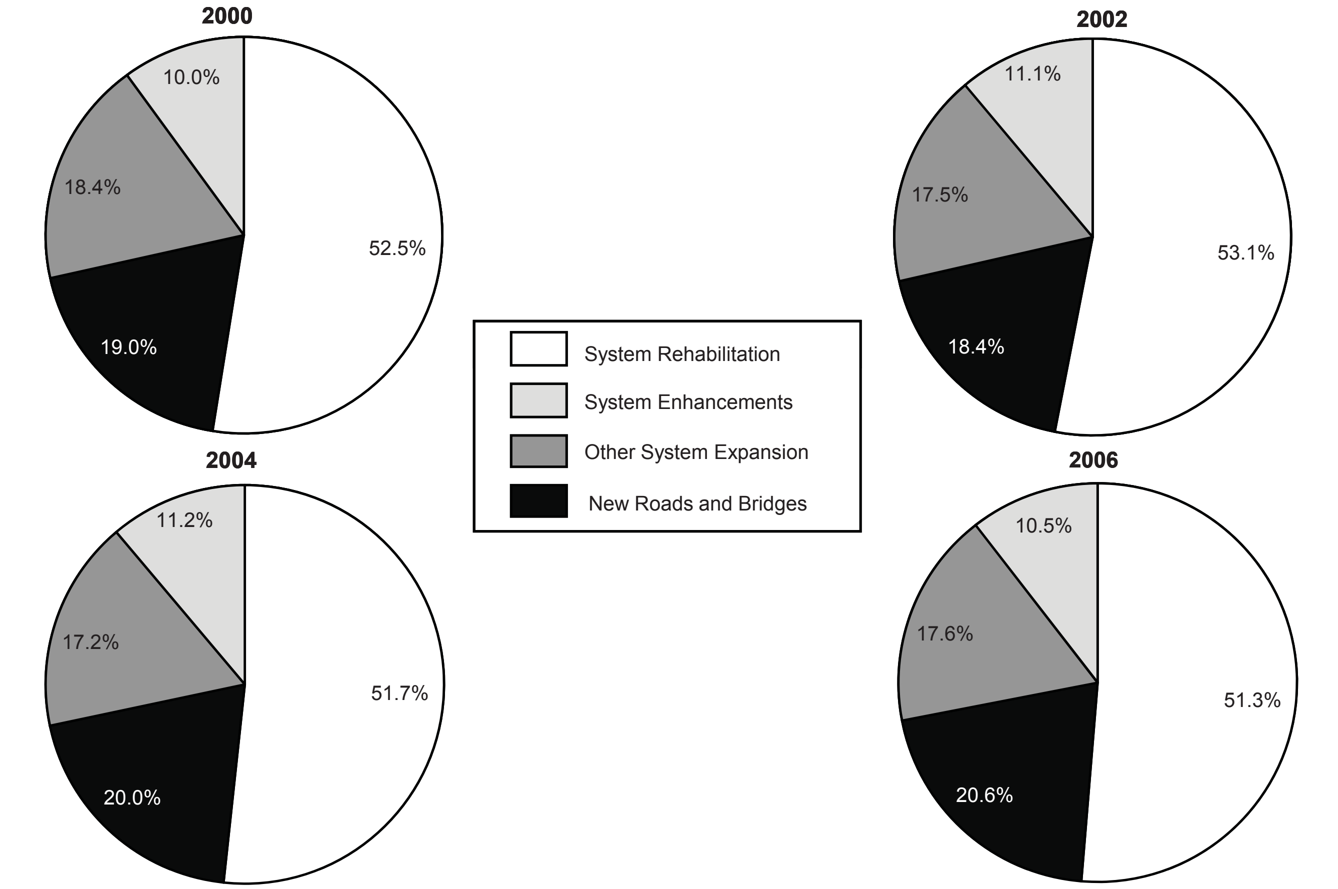
** Improvement type distribution was estimated based on State arterial and collector data.*

Sources: Highway Statistics 2006, Table SF-12A, and unpublished FHWA data.

Exhibit 6-13 depicts the change over time in the share of capital outlay devoted to these major categories. The overall share of highway capital improvements going toward system rehabilitation slightly decreased between 2000 and 2006, declining to 51.3 percent. The share devoted to system enhancements increased between 2000 and 2006, growing to 10.5 percent. Expenditures for new roads and bridges relative to other improvement expenditures increased from 19.0 percent in 2000 to 20.6 percent in 2006.

Exhibit 6-13

Highway Capital Outlay by Improvement Type: 2000, 2002, 2004, and 2006



Sources: Highway Statistics, various years, Table SF-12A, and unpublished FHWA data.

Q&A

Are the data shown in *Exhibit 6-13* consistent with comparable information provided in previous editions of this report?

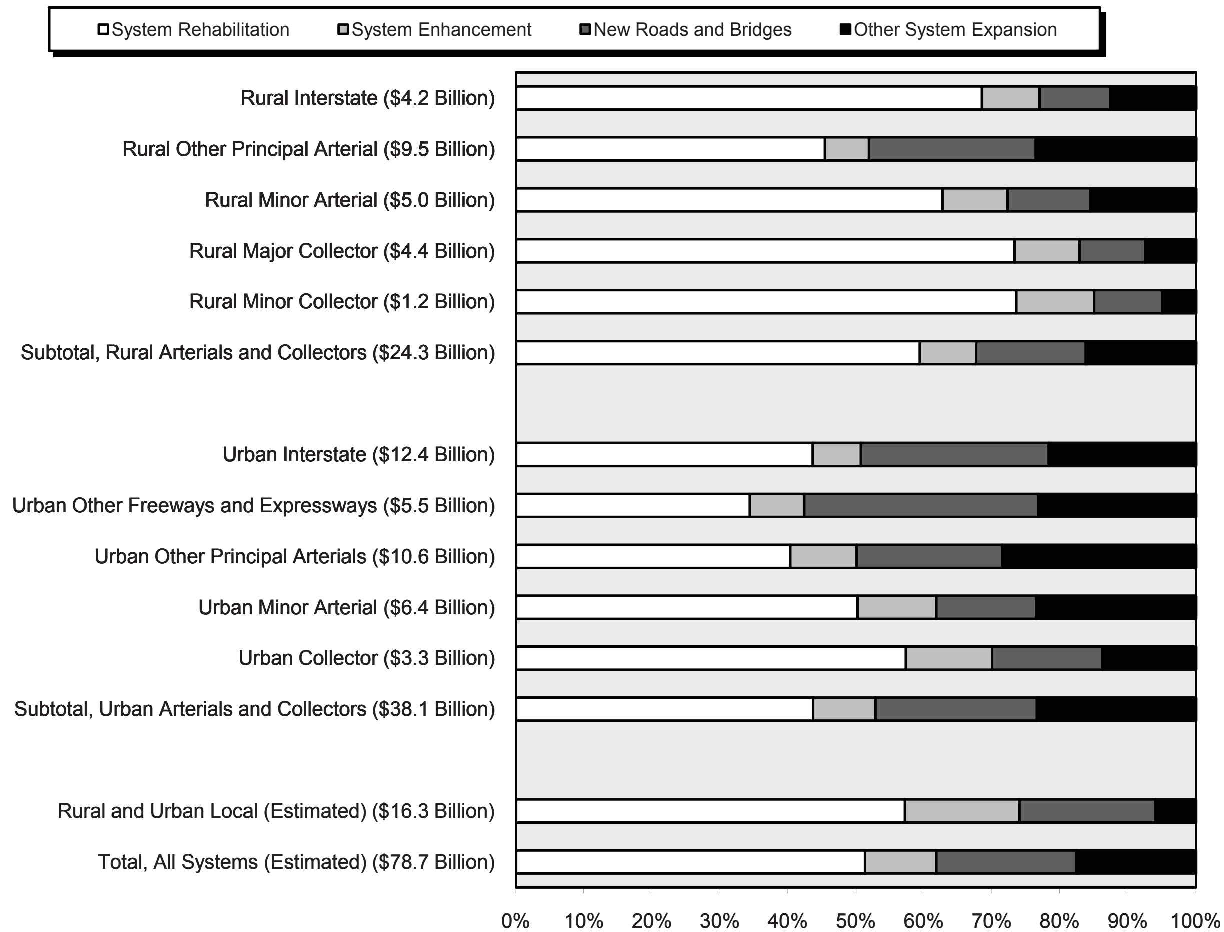
No. The information for 2002 and 2004 have been revised to correct errors in the underlying data for these years. In addition, the methodology used to estimate the distribution of local functional class expenditures was modified for each of the years depicted in the exhibit. As a result of this change, the estimated percentages for system enhancements and new roads and bridges increased, while the estimated percentages for other system expansion and system rehabilitation decreased.

Exhibit 6-14 shows significant variations in the types of capital expenditures made by States on different functional systems. The portion of capital outlay devoted to system rehabilitation ranges from 34.4 percent on urban other principal arterials to 73.6 percent on rural major collectors. Overall, system rehabilitation's share on arterials and collectors in rural areas (59.4 percent) was greater than in urban areas (43.7 percent).

System expansion expenditures also vary significantly by functional class. The portion of capital used for construction of new roads and bridges is highest on urban other freeways and expressways, at 34.4 percent, while urban other principal arterials have the largest share going to other system expansion improvements, at 28.5 percent. Urban other freeways and expressways have over 57.6 percent of capital investment devoted to system expansion).

Exhibit 6-14

Distribution of Capital Outlay by Improvement Type and Functional System, 2006



Sources: Highway Statistics 2006, Table SF-12A, and unpublished FHWA data.

Constant Dollar Expenditures by Improvement Type

As noted earlier, inflation has greatly reduced the relative purchasing power of transportation dollars. Between 1997 and 2006, highway capital outlay expenditures declined by 4.0 percent in constant dollar terms. Investment in system expansion—such as the widening of roads and the construction of new facilities—decreased by 14.2 percent in constant dollar terms, reflecting the increased cost of materials. At the same time, spending on other improvements increased. In constant dollar terms, investment in system enhancement increased by 22.7 percent, while funding for system rehabilitation grew by 0.4 percent.

Capital Outlay on the National Highway System

The National Highway System (NHS), which is described more fully in Chapter 2, includes the Interstate Highway System and other roads important to the nation's economy, defense, and mobility. *Exhibit 6-15* identifies the distribution of the $37.1 billion of capital outlay on the NHS in 2006 by functional system. Approximately $13.5 billion was invested on rural arterials and collectors that year, and another $23.3 billion was spent on urban arterials and collectors. An estimated $0.3 billion was spent on NHS routes functionally classified as rural local or urban local, which would mainly consist of intermodal connectors and STRAHNET Connectors.

Exhibit 6-15

Highway Capital Outlay on the NHS by Functional System, 2006

Functional Class	Total (Billions of Dollars)	Percent of Total NHS
Rural Arterials and Collectors		
Interstate	$4.2	11.3%
Other Principal Arterial	$8.2	22.1%
Minor Arterial	$0.6	1.7%
Major Collector	$0.4	1.2%
Minor Collector	$0.0	0.0%
Subtotal	**$13.5**	**36.3%**
Urban Arterials and Collectors		
Interstate	$12.4	33.3%
Other Freeway and Expressway	$4.9	13.3%
Other Principal Arterial	$5.5	14.7%
Minor Arterial	$0.4	1.2%
Collector	$0.2	0.4%
Subtotal	**$23.3**	**62.9%**
Subtotal, Rural and Urban	**$36.8**	**99.2%**
Rural and Urban Local	**$0.3**	**0.8%**
Total, All Systems	**$37.1**	**100.0%**

Sources: Highway Statistics 2006 and unpublished FHWA data.

Exhibit 6-16 categorizes capital spending on the NHS by type of improvement. System rehabilitation expenditures of $16.6 billion constituted 44.7 percent of total NHS capital spending in 2006. The $17.7 billion spent for system expansion represented 47.7 percent of total NHS capital spending, while the $2.8 billion spent for NHS system enhancement constituted 7.6 percent. Between 2004 and 2006, there was an increase in the relative share of spending directed to NHS rehabilitation projects (up from 43.5 percent), an increase in the share of spending for NHS expansion (up slightly from 47.6 percent), and a decrease in the share of spending for NHS enhancement (down from 8.9 percent).

The $37.1 billion spent for capital improvements to the NHS in 2006 constituted 47.1 percent of the $78.7 billion that all governments expended on highway capital projects that year. Approximately 38.8 percent of total highway rehabilitation investment on all roads was directed toward the NHS, including 16.7 percent directed toward rural NHS routes and 22.0 percent directed toward urban NHS routes.

Exhibit 6-16

NHS Capital Expenditures, 2006

	Total Invested (Billions of Dollars)			Total NHS Capital Spending	NHS Percent of Total Capital Expenditures for All Highways		
	Rural	Urban	Total		Rural	Urban	Total
System Rehabilitation							
Highway	$6.0	$6.2	$12.3	33.1%	19.7%	20.3%	40.1%
Bridge	$1.1	$3.2	$4.3	11.6%	9.2%	26.4%	35.6%
Subtotal	**$7.2**	**$9.4**	**$16.6**	**44.7%**	**16.7%**	**22.0%**	**38.8%**
System Expansion							
Additions to Existing Roadways	$2.6	$5.5	$8.1	21.8%	18.8%	39.7%	58.5%
New Routes	$2.6	$6.3	$8.9	24.0%	19.1%	46.2%	65.3%
New Bridges	$0.1	$0.6	$0.7	1.9%	13.2%	57.0%	70.1%
Subtotal	**$5.3**	**$12.3**	**$17.7**	**47.7%**	**18.8%**	**43.4%**	**62.2%**
System Enhancements	**$1.0**	**$1.8**	**$2.8**	**7.6%**	**12.9%**	**24.7%**	**37.6%**
Total Investment	**$13.5**	**$23.6**	**$37.1**	**100.0%**	**17.1%**	**30.0%**	**47.1%**

Sources: Highway Statistics 2006, Table SF-12A, and unpublished FHWA data.

Of total highway system expansion investment on all roads in 2006, approximately 62.2 percent was directed toward the NHS, including 18.8 percent directed toward rural NHS routes and 43.4 percent directed toward urban NHS routes. Approximately 37.6 percent of total capital expenditures classified as system enhancements in 2006 were directed toward NHS routes.

Capital Outlay on the Interstate Highway System

Of the $37.1 billion spent by all levels of government for the capital improvements to the NHS in 2006, 44.6 percent was used on the Interstate component of the NHS. *Exhibit 6-17* describes how the $16.5 billion of Interstate capital spending in 2006 was distributed by type of improvement. In 2006, all levels of government combined directed 49.9 percent of their Interstate-related expenditures to system rehabilitation, 42.6 percent to system expansion, and 7.4 percent to system enhancement. Between 2004 and 2006, there was a decrease in the relative share of spending directed to Interstate rehabilitation projects (down from 50.8 percent), an increase in the share of spending for Interstate expansion (up from 40.9 percent), and a slight increase in the share of spending for Interstate enhancement (up from 8.3 percent).

Exhibit 6-17

Interstate Capital Expenditures, 2006

	Total Invested (Billions of Dollars)			Percent of Total Interstate Capital Spending	Percent of Total for All Functional Classes		
	Rural	Urban	Total		Rural	Urban	Total
System Rehabilitation							
Highway	$2.5	$3.2	$5.8	34.8%	8.3%	10.5%	18.8%
Bridge	$0.3	$2.2	$2.5	15.1%	2.8%	17.9%	20.7%
Subtotal	**$2.9**	**$5.4**	**$8.3**	**49.9%**	**6.7%**	**12.6%**	**19.3%**
System Expansion							
Additions to Existing Roadways	$0.5	$2.7	$3.2	19.4%	3.8%	19.4%	23.2%
New Routes	$0.4	$3.1	$3.5	21.3%	3.0%	22.8%	25.8%
New Bridges	$0.0	$0.3	$0.3	1.9%	2.6%	29.9%	32.6%
Subtotal	**$1.0**	**$6.1**	**$7.1**	**42.6%**	**3.4%**	**21.4%**	**24.8%**
System Enhancements	**$0.4**	**$0.9**	**$1.2**	**7.4%**	**4.7%**	**11.7%**	**16.4%**
Total Investment	**$4.2**	**$12.4**	**$16.5**	**100.0%**	**5.3%**	**15.7%**	**21.0%**

Sources: Highway Statistics 2006, Table SF-12A, and unpublished FHWA data.

Exhibit 6-18 examines these changes in greater detail. Most notably, increased funding for Interstate expansion projects was targeted in urban areas. Between 2004 and 2006, there was a 39.7 percent increase in spending for system expansion projects on urban Interstates, and a 22.6 percent decline in Interstate expansion activities in rural areas. Overall, between 2004 and 2006, there was a 26.2 percent increase in capital spending on urban Interstates, and a 7.5 percent increase on rural Interstates.

It is important to note that, for any particular functional class (such as rural Interstates) and any particular type of capital improvement (such as the bridge component of system rehabilitation), year-to-year spending is much more variable than for total capital investment of all types. Year-to-year investment can be more easily affected by large individual projects that happen to have a high level of cash outlays in a given year. The changes in expenditure patterns observed between 2004 and 2006, therefore, may not represent a long-term trend. This comparison is included primarily to help put into perspective the comparisons of 2006 spending with the future capital investment scenarios discussed in Part II of this report.

Exhibit 6-18

Interstate Capital Expenditures, 2006 and 2004

	2004 (Billions of Dollars)			2006 (Billions of Dollars)			Percent Change 2006/2004		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
System Rehabilitation									
Highway	$1.9	$2.8	$4.7	$2.5	$3.2	$5.8	31.4%	16.6%	22.7%
Bridge	$0.4	$1.8	$2.3	$0.3	$2.2	$2.5	-21.1%	18.3%	10.8%
Subtotal	**$2.4**	**$4.6**	**$7.0**	**$2.9**	**$5.4**	**$8.3**	**21.9%**	**17.3%**	**18.8%**
System Expansion									
Additions to Existing Roadways	$0.7	$2.2	$2.9	$0.5	$2.7	$3.2	-24.2%	21.4%	10.5%
New Routes	$0.5	$2.0	$2.5	$0.4	$3.1	$3.5	-19.5%	57.1%	41.4%
New Bridges	$0.0	$0.2	$0.2	$0.0	$0.3	$0.3	-32.5%	73.6%	54.1%
Subtotal	**$1.2**	**$4.4**	**$5.6**	**$1.0**	**$6.1**	**$7.1**	**-22.6%**	**39.7%**	**25.9%**
System Enhancements	**$0.3**	**$0.8**	**$1.1**	**$0.4**	**$0.9**	**$1.2**	**19.2%**	**5.1%**	**8.8%**
Total Investment	**$3.9**	**$9.8**	**$13.7**	**$4.2**	**$12.4**	**$16.5**	**7.5%**	**26.2%**	**20.9%**

Sources: Highway Statistics 2006, Table SF-12A, and unpublished FHWA data.

Innovative Finance

In recent years, governments throughout the United States have experimented with new ways of financing transportation projects. As costs have increased for many of these projects, officials have often tried to replicate some of the most successful strategies of the private sector. Some officials have taken this approach much further, engaging the private sector as an active partner in delivering projects. As a result, innovative finance is a far more advanced element of transportation policy than it was 5 or 10 years ago. This section describes how innovative finance is complementing traditional methods of paying for the Nation's surface transportation projects.

Innovative finance includes a combination of specially designed techniques that aid traditional funding methods in providing financing for transportation projects. These techniques open up new streams of revenue, helping to retire debt obligations; and reduce financing and related costs, freeing up savings for other projects. While these methods are commonly used in the private sector, they are relatively new to Federally aided transportation funding.

Innovative finance concepts have evolved over time. The Intermodal Surface Transportation Efficiency Act (ISTEA) and TEA-21 laid the foundations for several new concepts designed to fund transportation investment. SAFETEA-LU has continued the development of innovative financing mechanisms. SAFETEA-LU advanced the use of Public-Private Partnerships (PPPs), credit assistance, and innovative debt financing as tools in transportation finance.

Public-Private Partnerships

There is a long history of the private sector providing transportation service. In the late 1700s and early 1800s, private toll roads opened the interior United States to commerce and settlement. More recently, commercial and residential developers have helped finance local roads so that new projects could be built. These developers have either built the roads themselves, or paid impact fees that local governments used to complete new routes.

While private sector investment has slowed somewhat since the advent of public financing for highways, there has been renewed interest in private sector involvement as transportation budgets have been stretched. Additionally, private sector arrangements are central to many projects that involve freight transportation, since nearly all service providers and many elements of freight infrastructure are private.

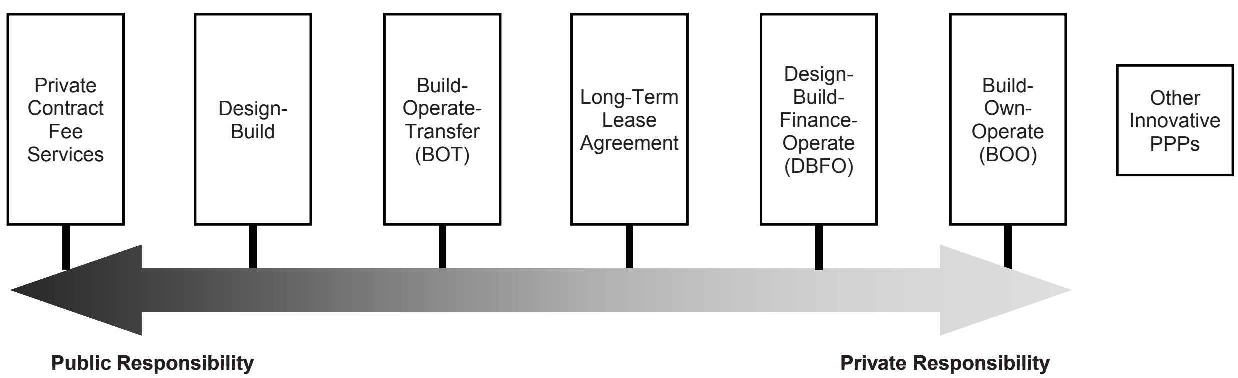
> **Q&A**
>
> **Are PPPs limited to the transportation sector?**
>
> No. PPPs are used regularly in several sectors, including water and wastewater, education, health care, corrections, parks and recreation, and technology.

Today, a variety of public-private partnerships (PPPs) are being used to provide transportation services. A public-private partnership is a broad term that refers to contractual agreements formed between public and private sector partners. Under this arrangement, the private sector steps out of its traditional role and becomes more active in making decisions as to how a project will be accomplished.

Public-private partnerships can be applied to a large range of transportation functions across all modes. These functions may include project conceptualization, design, finance, construction, maintenance, toll collection, and project maintenance. *Exhibit 6-19* describes the more common PPP options currently being used in the United States. It shows how the range of responsibilities shifts from the public to the private sectors depending on different PPP options, which are described below. *Exhibit 6-20* provides a list of the PPPs being implemented across the United States, either on existing facilities or new capacities.

Exhibit 6-19

Public-Private Partnership Options and Range of Responsibility



Source: Federal Highway Administration.

Private Contract-Fee Services

Many public agencies are transferring responsibility for services they would typically perform to private sector companies. Agencies that use private contract-fee services can tap private sector technical, management, and financial planning expertise in new ways. This often reduces the work burden for agency staff, and it can provide access to innovative technology and specialized expertise. Maintenance, operations, and finance are three areas where this approach is often used.

As an example of this model, the South Carolina Department of Transportation has implemented a statewide program to accelerate the completion of 200 highway improvement projects in 7 years, instead of 27. Because the State did not want to add new personnel, the Department of Transportation entered into partnerships with two private construction and resource management firms. It was agreed that these companies would work on strategic planning, financial management, design, and construction activities.

Exhibit 6-20

Summary of Public-Private Partnerships, as of Summer 2008

PPP	Location	Status
Existing Facility		
Chicago Skyway	Illinois	Closed
Indiana Toll Road	Indiana	Closed
Pocahontas Parkway	Virginia	Closed
Northwest Parkway	Colorado	Closed
Dulles Greenway	Virginia	Closed
Pennsylvania Turnpike	Pennsylvania	Request for Quotation (RFQ) Issued
Greenville Southern Connector	South Carolina	RFQ Issued
New Capacity *		
Trans-Texas Corridor (TTC) -35	Texas	Concession Awarded
SH-130 Segments 5 and 6	Texas	Closed
I-69/TTC	Texas	Request For Proposals (RFP) Issued
I-635	Texas	RFP Issued
North Tarrant Express	Texas	Bidders Shortlisted
Dallas/Fort Worth (DFW) Connector	Texas	Bidders Shortlisted
SH-161	Texas	Bidders Shortlisted
US-281/Loop 1604	Texas	Bidders Shortlisted
Capital Beltway High-Occupancy Toll (HOT) Lanes	Virginia	Closed
I-95/I-395 HOT Lanes	Virginia	Interim Agreement Executed
US Route 460	Virginia	Bidders Shortlisted
Midtown Corridor Tunnel	Virginia	Expressions of Interest Submitted
Port of Miami Tunnel	Florida	Preferred Bidder Selected
I-595 Improvements	Florida	Bidders Shortlisted
First Coast Outer Beltway	Florida	RFQ Issued
Northwest Corridor	Georgia	Development Agreement Executed
I-285 Northwest Truck-Only Toll (TOT) Lanes	Georgia	Evaluation of Proposers
GA-400 Crossroads Region	Georgia	Evaluation of Proposal
I-20 Managed Lanes	Georgia	Pre-Solicitation
Missouri Safe and Sound Bridge Program	Missouri	Preferred Bidder Selected
Oakland Airport Connector	California	RFP Issued
Knik Arm Crossing Project	Alaska	Bidders Shortlisted
Denver Regional Transportation District (RTD)	Colorado	RFQ Expected
I-73	South Carolina	Request for Conceptual Proposals

* *List of projects may not be exhaustive.*

Source: Federal Highway Administration.

Design-Build

With the second model, Design-Build delivery, design and construction phases are merged into a single contract. The design-builder assumes responsibility for the majority of the design work and all construction activities, together with the risks associated with providing these services, for a fixed fee. When using Design-Build delivery, owners usually retain responsibility for financing, operating, and maintaining the project. While Design-Build procurement has been more prevalent in private sector work, it is also gaining acceptance among many public agencies. SAFETEA-LU advanced the use of Design-Build delivery by eliminating an FHWA requirement that prohibited agencies from issuing requests for proposals and entering into contracts until after environmental approval. This had been a particular problem for PPPs, since there are many advantages in having the private sector partner involved in the environmental review process.

The 2006 edition of the C&P report listed the Design-Bid-Build model on the continuum of public-private partnerships. Why has it been removed from this edition of the report?

Q&A

The Federal government does not consider the Design-Bid-Build model a PPP because it fails to go beyond the "traditional" arrangement for implementing projects.

The Design-Bid-Build model was used for much of the Twentieth Century. A Design-Bid-Build model segregates design and construction responsibilities by awarding them to an independent private engineer and a separate private contractor. The delivery process is separated into three linear phases: (1) design, (2) bid, and (3)construction. During the initial design phase, a transportation agency awards a design contract to an engineer or architect, who completes a final project design and supporting documentation. In the second phase, the owner uses this documentation to assemble construction bid documents. Pre-qualified contractors are invited to submit competitive, lump-sum bids; and the owner awards the construction contract to the contractor submitting the lowest responsible bid or total contract price. In the construction phase that follows, the owner retains responsibility for monitoring the contractor's performance.

Alaska's Anton Anderson Memorial Tunnel is an example of both the private contract-fee service model and the Design-Build model. To convert the former railroad tunnel for both rail and highway use, the Alaska Department of Transportation and Public Facilities awarded a Design-Build contract. Once the project was finished, the State outsourced the operation of the tunnel to a private highway asset management and operations company. Since the tunnel opened in 2000, that firm's responsibilities have included toll collection and administration, emergency response, snow removal, maintenance, and the complex procedures by which the tunnel switches between train and automobile use.

Build-Operate-Transfer/Design-Build-Operate-Maintain

The third model, "turnkey procurement," is more formally known as Build-Operate-Transfer (BOT)/ Design-Build-Operate-Maintain (DBOM). This approach combines responsibility for usually separate functions—design, construction, and operations and maintenance—under a single entity. One advantage of this approach is that the private sector team is required to establish a long-term maintenance program up front, together with estimates of the associated costs. This might reduce the likelihood that problems with the physical performance of the infrastructure asset will go unnoticed, saving money in the long run.

Recent improvements to Massachusetts Route 3 were completed through a BOT/DBOM contract. Under a traditional public process, the improvements would have required five different contract packages and taken 12 to 15 years to complete. Instead, the State used a BOT/DBOM approach, cutting the construction time in half. Through a competitive process, the Massachusetts Highway Department selected a private developer to finance, design, and build the project, then operate and maintain the facility for 30 years. The developer may generate nonproject revenues through ancillary development in the corridor. The developer also shares in the sale of fiber optic rights and the sublease of a service plaza.

Long-Term Lease Arrangements

The fourth model, that which is used in long-term lease arrangements, involves the leasing of an existing, publicly financed toll facility to a private sector concessionaire for a certain period of time. The transportation agency awards long-term leases on a competitive basis, picking the most attractive offer. The amount of the concession fee is typically the most important factor, but other criteria may include the length of the concession period and the creditworthiness and professional qualifications of the bidders. Once the award is made, the concessionaire pays the upfront concession fee, then has the right to collect tolls on the facility for a specified time period. In exchange, the private partner must operate and maintain the road, often making improvements.

Long-term lease arrangements are among the most visible, hotly debated innovations in transportation today. Supporters argue that long-term leases are among the fastest ways to improve transportation services in an era when public funding is limited and citizens are often reluctant to pay higher taxes. By transferring toll setting responsibilities to the private sector, they argue, the process is depoliticized. They also argue that the large, up-front concession fees can be used to fund badly needed transportation projects elsewhere. Opponents of long-term lease arrangements, however, claim that the public can lose control over toll rates, and that tolls may become potentially burdensome. Opponents also argue that, in the long run, the public agency loses a consistent stream of revenue.

> **Q&A**
>
> **What terms and conditions can help preserve some public control over facilities that are part of long-term lease arrangements?**
>
> There are several ways a long-term lease arrangement can be structured to preserve some public control. Transportation agencies can provide oversight of the private sector partner's performance, and require specific capital reinvestment, safety, and customer services requirements in their lease agreements. Other regulations can be enacted to ensure that the lease proceeds are used to support transportation improvements in prescribed areas. Provisions can also be incorporated requiring sharing of excess revenues between the public and private entities if toll revenues exceed some predetermined level.

Over the past several years, there have been several high-profile long-term lease arrangements. In 2005, the City of Chicago announced that it had entered into an agreement with a consortium to lease the 7.8-mile Chicago Skyway Toll Bridge System for 99 years. Under the lease agreement, the consortium paid the City of Chicago $1.83 billion for the right to operate and collect tolls on the Chicago Skyway. The privatization of the Skyway, an existing toll road, was the first agreement of its kind in the United States. The lease agreement established maximum toll rates and set facility performance standards. The consortium is responsible for all operating and maintenance costs of the Skyway and will have the right to all toll revenue. In this particular example, the toll road concession revenues were treated as general revenues to the city, rather than being dedicated to highway or transit improvements.

In 2006, the same consortium entered into an agreement with the Indiana Finance Authority to take over operations of the 157-mile Indiana Toll Road for the next 75 years. The concession agreement established toll rates and possible increases, and it placed limits on the return on investment for the concessionaire. The $3.8 billion concession fee will provide funding for about 200 transportation projects around the State, including the construction of Interstate 69 between Evansville and Indianapolis.

Also in 2006, the Virginia Department of Transportation executed agreements to turn over the Pocahontas Parkway to a private concessionaire for 99 years. Under the terms of those agreements, the concessionaire acquired the sole right to enhance, manage, operate, maintain, and collect tolls on the Parkway. The $548 million concession fee relieved the Virginia Department of Transportation from all debt related to the construction of the Pocahontas Parkway. This arrangement—combined with credit from the Transportation Infrastructure Finance and Innovation Act (TIFIA) program—will also lead to the construction of a four-lane extension to Richmond International Airport.

All three of these projects involved foreign investors. The PPP markets in Europe and Australia are more mature than those in the United States, and experienced investors from both continents are actively seeking out new opportunities in the United States. Several American financial institutions, however, are now establishing infrastructure investment funds. The new authority provided by SAFETEA-LU to issue tax exempt private activity bonds for transportation projects may encourage American investors to expand their activity in the domestic toll road market.

How have other countries used PPPs to provide transportation services? Q&A

PPPs are central to the transportation policies of several European countries. In these countries, highway agencies are beginning to take on the role of network operator rather than provider of services.

The United Kingdom has some of the most extensive experience with PPPs, where they became popular in the early 1990s as local governments struggled with maintenance and reconstruction costs. Improvements were often delayed and, when construction finally began, limited public funds meant that completion was often delayed. Since that time, the use of PPPs has proven to be a remarkable remedy. A survey by the United Kingdom Treasury showed that of 61 PPP projects, nearly 90 percent were completed early or on time. Projects that were not completed on time were completed within three months of the scheduled date.

In France, long-term lease arrangements have been used for more than three decades. Portugal is aggressively using long-term lease arrangements as part of its long-term transportation strategic plan, and eventually aims to have 90 percent of its national network administered by concessions.

Design-Build-Finance-Operate

The fifth model, the Design-Build-Finance-Operate (DBFO) approach, bundles together all design, construction, finance, and operation activities, transferring these functions to private sector partners. There is a great deal of variety in DBFO arrangements in the United States, especially in the degree to which financial responsibilities are actually transferred to the private sector. One commonality among all DBFO projects is that they are either partly or wholly financed by debt leveraging revenue streams dedicated to the project. Tolls are the most common revenue source; however, other finance mechanisms may include lease payments and vehicle registration fees. Future revenue is leveraged to issue bonds or other debt that provides funds for capital and project development costs. They are also often supplemented by public sector grants, either through direct funding or in-kind contributions such as donations of right-of-way. In some cases, private partners are required to make equity investments as well.

One example of a DBFO project is California State Road 125, commonly known as the South Bay Expressway. This connects the only commercial port of entry in San Diego to the regional freeway network. The southern section of S.R. 125, stretching about ten miles, was constructed as a privately financed and operated toll road with electronic toll collection. A limited partnership holds a franchise with the State under which it financed and built the highway. When the road was finished in 2007, the State took ownership, but the limited partnership leased the facility back from the State. The limited partnership will operate and maintain the road for five years. After that period, control will revert to the State at no cost.

Build-Own-Operate

The sixth model, Build-Own-Operate (BOO), completely removes the public sector from the transportation project. Under this approach, a private company is granted the right to develop, finance, design, build, own, operate, and maintain a transportation project, owning the project outright and retaining the operating revenue risk and all of the surplus operating revenue. This approach is most common in the power and telecommunications industries.

A major section of the Foley Beach Express was built using BOO principles. This limited access, four-lane route stretches for about 14 miles in southern Alabama. Six miles of the route—including a major bridge over the Intracoastal Waterway—were completely financed, designed, and constructed by a private company. The company operates and maintains the facility today.

Other Public-Private Partnerships

There are some types of PPPs that do not necessarily correspond to the six models outlined above. They demonstrate the variety of ways in which the public and private sectors can meet modern transportation needs.

Construction of a major section of the King Coal Highway involves an innovative partnership between the West Virginia Department of Transportation, a local redevelopment authority, and coal companies. The State is using excess materials generated by the mining process to construct the foundation for the highway. Because regulatory agencies are more likely to allow permits for coal removal if there is a constructive use for excess material, coal companies have benefited from this level of participation. It is estimated that this collaborative process has cut costs by 50 percent for the initial section of the highway.

Another innovative partnership is the Heartland Corridor initiative, the first time the private freight rail industry has worked with the U.S. Department of Transportation to develop and finance a rail improvement project. Among other improvements, the Heartland Corridor initiative involves raising tunnel clearances and removing overhead obstructions that block the transportation of double-stacked containers. The project includes $44 million from a major private railroad, and its completion is expected to improve freight transportation between the Eastern Seaboard and the Midwest.

The Chicago Region Environmental and Transportation Efficiency Program (CREATE) is a similar collaborative effort. Six of the seven major railroads operating in North America pass through Chicago, and all of them are partners in the CREATE Program. Working with AMTRAK and State and local governments, the private railroads plan to make a $212 million equity contribution towards a $1.5 billion capital improvement program. The project involves grade separation projects and extensive upgrades of tracks, switches, and signal systems.

Q&A

How has the U.S. Department of Transportation advanced the use of PPPs?

In the last few years, the U.S. Department of Transportation has implemented several initiatives to help remove barriers and increase the role of the private sector in highway construction, operation, and maintenance.

One major initiative is Special Experimental Project No. 15 (SEP-15), which identifies regulations that inhibit the creation of PPPs and private investment in transportation improvements and aims to develop new procedures and approaches to address these impediments. SEP-15 addresses, but is not limited to, four major components of project delivery: innovative contracting, compliance with environmental requirements, right-of-way acquisition, and project finance. Nine projects have been preliminarily accepted into this program.

The Department has sponsored numerous workshops to share knowledge between State governments and the private sector. The Department has developed case studies on how States and local governments have overcome institutional barriers to PPP implementation, and published the Manual for Using Public-Private Partnerships on Highway Projects, which is a one-stop resource for States interested in pursuing PPPs.

The Department has published a Web site that contains links to many PPP resources and a checklist of 28 key elements that States can use to implement enabling legislation for PPP projects. This checklist can be found at http://www.fhwa.dot.gov/ppp/legislation.htm.

Credit Assistance

Another innovative finance tool is the use of credit assistance. Federal credit assistance for transportation projects takes various forms, and it can provide an efficient way to utilize scarce Federal budget authority. Secured—or direct—loans and loan guarantees to project sponsors provide the necessary capital to advance a project. Credit enhancement, including standby lines of credit, make Federal funds available on a contingency basis, reducing the risk to investors and allowing project sponsors to borrow at lower interest rates. These projects typically involve partnerships between the public and private sectors.

The following section describes two of the most significant Federal credit assistance initiatives introduced in recent years: the Transportation Infrastructure and Finance Innovation Act (TIFIA) and the State Infrastructure Bank (SIB) programs. Section 129(a) loans are also discussed.

Transportation Infrastructure and Finance Innovation Act

The Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) provides Federal credit assistance for major transportation projects of national importance. The TIFIA credit program is designed to fill market gaps and leverage substantial investment by the private sector. There are three distinct types of financial assistance. First, direct Federal loans offer flexible repayment terms and provide combined construction and permanent financing of capital costs. Second, loan guarantees provide full-faith-and-credit guarantees by the Federal government to institutional investors, such as pension funds, which make loans for projects. Third, standby lines of credit may be drawn upon to supplement project revenue, if needed, during the first ten years a project is operating.

The TIFIA program is designed for major projects. Eligible projects must cost at least $50 million or one-third of the State's annual apportionment of Federal-aid funds, whichever is less (for Intelligent Transportation Systems, the minimum cost is $15 million). The borrower must have an associated revenue stream—such as tolls or local sales taxes—that can be used to repay the debt issued for the project. Qualified projects are evaluated by the U.S. Secretary of Transportation based on the extent to which they generate economic benefits, leverage private capital, promote innovative technologies, and meet other program objectives.

Exhibit 6-21 describes the 17 projects that have received commitments of TIFIA credit assistance. TIFIA projects include highway toll roads and bridges, transit systems, rail stations, ferry terminals, and intermodal facilities. Together, these projects represent more than $24.4 billion in infrastructure investment in the United States. The 19 credit agreements executed or under negotiation amount to about $6.6 billion in Federal credit assistance. TIFIA assistance has ranged from $42 million for the Warwick Intermodal Station in Rhode Island to about $917 million for the Central Texas Turnpike. No TIFIA borrower has defaulted on a loan repayment, and five borrowers have retired their TIFIA loans either by early repayment or refinancing.

State Infrastructure Banks

Another innovative finance tool is the use of State Infrastructure Banks (SIBs). Section 350 of the NHS Designation Act of 1995 authorized the U.S. Department of Transportation to establish the State Infrastructure Bank Pilot Program. This program provides increased financial flexibility for infrastructure projects by offering direct loans and loan guarantees. SIBs are capitalized with Federal and State funds. Some States augment these operating reserves through a variety of methods, including special appropriations and debt issues. Each SIB operates as a revolving fund and can finance a wide variety of surface transportation projects. As loans are repaid, additional funds become available to new loan applicants.

Under the NHS Act, 31 States established SIBs. TEA-21 limited the use of newly authorized funds for SIB capitalization to four States, of which only two actually operated under the TEA-21 provisions; the remaining States participating in the SIB program operated under NHS Act provisions and were not allowed to capitalize SIBs with TEA-21 funds. Additional capitalizing has been done with State funds.

SAFETEA-LU established a new SIB program under which all States and territories are authorized to enter into cooperative agreements with the Department. These agreements allow for the creation of infrastructure revolving funds that could be capitalized with Federal transportation funds from fiscal years 2005 through 2009. Three SIB accounts may be established—highways, transit, and rail. Under SAFETEA-LU, States that established SIBs authorized by TEA-21 and the NHS Act may continue to operate those SIBs.

Exhibit 6-21

Summary of TIFIA Projects, as of Spring 2009

Project	Location	Project Type	Project Cost (Millions of Dollars)	Type of TIFIA Assistance	Credit Amount (Millions of Dollars)	Revenue Pledge
Active Credit Agreements						
Miami Intermodal Center	Florida	Intermodal	$1,350	Direct Loan	$270	User Charges
Washington Metro	DC, VA, MD	Transit	$2,324	Guarantee	$600	Interjurisdictional Funding Agreements
Central Texas Turnpike	Texas	Highway	$3,181	Direct Loan	$916.76	User Charges
South Bay Expressway	California	Highway	$653	Direct Loan	$140	User Charges
183 A Toll Road	Texas	Highway	$331	Direct Loan	$66	User Charges
LA-1 Project	Louisiana	Highway	$247	Direct Loan	$66	User Charges
Warwick Intermodal Station	Rhode Island	Intermodal	$222	Direct Loan	$42	User Charges
Pocahontas Parkway/Richmond Airport	Virginia	Highway	$748	Direct Loan	$150	User Charges
Capital Beltway/I-495 HOT Lanes Project	Virginia	Highway	$1,998	Direct Loan	$589	User Charges
SH 130 Corridor	Texas	HIghway	$1,360	Direct Loan	$430	User Charges
Intercounty Connector	Maryland	Highway	$2,466	Direct Loan	$516	User Charges
I-595 Corridor Roadway Improvements	Florida	Highway	$1,834	Direct Loan	$603	Availability Payments
Subtotal Active					**$4,388.76**	
Commitments Awaiting Credit Agreements						
Triangle Expressway Project	North Carolina	Highway	$1,252	Direct Loan	$413	User Charges
IH 635 Managed Lanes	Texas	Highway	$2,678	Direct Loan	$800	User Charges
Subtotal Awaiting					**$1,213.00**	
Retired Credit Agreements						
Tren Urbano	Puerto Rico	Transit	$2,250	Direct Loan	$300	Tax Revenues
Cooper River Bridge	South Carolina	Highway	$677	Direct Loan	$215	Infrastructure Bank Loan Repayments
Staten Island Ferries	New York	Transit	$482	Direct Loan	$159.23	Tobacco Settlement Revenues
Reno Rail Corridor	Nevada	Intermodal	$280	Direct Loan	$51	Room and Sales Tax
Miami Intermodal Center FDOT*	Florida	Intermodal		Direct Loan	$269.08	Tax Revenues
Subtotal Retired					**$993.80**	
Total			**$24,333**		**$6,595.56**	

**Project cost included in Miami Intermodal Center.*

Source: Federal Highway Administration.

States participating in the new SIB program established by SAFETEA-LU may capitalize their SIB highway account with up to 10 percent of the funds apportioned to the State for the National Highway System Program, the Surface Transportation Program, the Highway Bridge Program, and the Equity Bonus. Their SIB transit account may be capitalized with up to 10 percent of the funds made available for capital projects under Urbanized Area Formula Grants, Capital Investment Grants, and Formula Grants for Other Than Urbanized Areas for FY 2005 through FY 2009.

Exhibit 6-22 reflects the number of SIBs loans and loan agreements by State. As of June 2007, $6.2 billion in loan agreements had been made by 32 States and Puerto Rico, of which $4.3 billion had been disbursed for 596 loan agreements.

Exhibit 6-22

State Infrastructure Bank Loan and Loan Agreements by State, as of June 30, 2007

State	Number of Agreements	Loan Agreement Amount (Thousands of Dollars)	Disbursements to Date (Thousands of Dollars)
Alaska	1	$2,737	$2,737
Arizona	56	$612,090	$515,504
Arkansas	1	$31	$31
California	2	$1,120	$1,120
Colorado	4	$4,400	$1,900
Delaware	1	$6,000	$6,000
Florida	59	$989,871	$228,922
Indiana	2	$6,000	$6,000
Iowa	2	$2,879	$2,879
Maine	23	$1,635	$1,635
Michigan	44	$33,635	$29,307
Minnesota	17	$122,476	$112,295
Missouri	23	$149,400	$106,400
Nebraska	2	$6,792	$6,792
New Mexico	4	$25,216	$17,815
New York	10	$27,700	$27,700
North Carolina	6	$1,279	$1,279
North Dakota	2	$3,891	$3,891
Ohio	96	$286,839	$199,382
Oregon	20	$34,773	$33,577
Pennsylvania	104	$61,973	$50,354
Puerto Rico	1	$15,000	$15,000
Rhode Island	1	$1,311	$1,311
South Carolina	13	$3,311,000	$2,430,000
South Dakota	3	$28,776	$28,776
Tennessee	1	$1,875	$1,875
Texas	68	$310,888	$290,642
Utah	1	$2,888	$2,888
Vermont	4	$1,805	$1,427
Virginia	1	$18,000	$17,989
Washington	3	$2,376	$487
Wisconsin	7	$3,051	$3,051
Wyoming	14	$112,332	$112,332
Total	**596**	**$6,190,039**	**$4,261,298**

Source: Federal Highway Administration.

Section 129 Loans

Prior to 1991, States were only allowed to use Federal-aid highway funds on a “grant” reimbursement basis. Section 129(a) of Title 23 allows States to recycle Federal-aid highway funds by lending them out to pay for projects with dedicated revenue streams, obtaining repayments from project revenue, and then reusing the repaid funds on other highway projects. For example, a State may directly lend apportioned funds—not exceeding more than 80 percent of the project cost—to projects that generate a toll or that have some other dedicated revenue such as excise, sales, property, and motor-vehicle taxes and other beneficiary fees, as long as the project sponsor pledges revenues from a dedicated source for repayment of the loan. These types of loans are attractive to private investors because they can be used to offset up-front capital requirements, such as right-of-way acquisition, physical construction, or engineering costs that might otherwise have to be borrowed at higher interest rates on the open market. Only those costs incurred after a loan is authorized by the FHWA are eligible for reimbursement from loan proceeds; costs incurred prior to the authorization of the loan are not eligible for reimbursement.

Section 129 loans allow States get more value out of annual apportionments. Since Federal funds are initially cycled through a Section 129 loan that must comply with Federal requirements and laws that are attached to Federal-aid highway projects, the funds obtained by the State from loan repayment no longer retain characteristics of Federal funds. Therefore, repaid funds may be used without complying with Federal requirements and laws normally attached to Federal-aid projects, freeing them up for use on any project eligible for funding under Title 23.

Debt Financing

Because of their complexity, cost, and lengthy design and construction periods, transportation projects are often financed by issuance of bonds. Bonds are traditionally repaid over several years by State and local taxes or revenue generated from highway user fees. Recent Federal legislation, however, has introduced new ways that project sponsors can take advantage of debt financing.

Grant Anticipation Revenue Vehicle

Highway and transit project sponsors have increasingly issued debt instruments known as Grant Anticipation Notes (GANs), which are backed by anticipated grant money. Grant Anticipation Revenue Vehicles (GARVEEs) are a particular form of GAN being used for transportation projects. A GARVEE is a debt financing instrument that has a pledge of future Federal-aid for debt service and is authorized for Federal reimbursement of debt service and related financing costs. This generates up-front capital for major highway projects that the State may be unable to build in the near term using traditional pay-as-you-go funding approaches. The GARVEE bond technique enables a State to accelerate construction timelines and spread the cost of a transportation facility over its useful life rather than just the construction period.

The 1995 NHS Act was a significant enabler for GARVEEs, expanding the eligibility of debt financing costs for Federal-aid reimbursements. In addition to traditional debt service, expenses such as underwriting fees, bond insurance, and financial counsel are now eligible for reimbursement.

GARVEEs have helped facilitate PPPs. They expand access to capital markets, supplement general revenue bonds, and provide immediate and reliable sources of funding. This makes large projects possible and allows construction to begin more quickly—all of which attract greater private sector involvement because of GARVEEs' ability to yield immediate influxes of up-front capital. For all these reasons, GARVEEs have become a major element of transportation funding, as shown in *Exhibit 6-23*. As of December 2007, the amount of GARVEE debt issued nationally had reached over $7.3 billion.

Private Activity Bonds

SAFETEA-LU amended Section 142 of the Internal Revenue Code to add highway and freight transfer facilities to the types of privately developed and operated projects for which private activity bonds may be issued. This change allows private activity on these types of projects, while maintaining the tax-exempt status of the bonds. SAFETEA-LU limits the total amount of such bonds to $15 billion and directs the Secretary of Transportation to allocate this amount among qualified facilities. Three types of facilities are eligible: (1) any surface transportation project which receives Federal assistance under Title 23 of the United States Code, (2) certain international bridges and tunnels, and (3) certain freight transfer facilities, such as those that move cargo from rail to truck or from truck to rail.

Exhibit 6-23

GARVEE Transactions, as of December 2007

State	Issues	Total Issuance (Millions of Dollars)	Projects Financed	Insurance
Alabama	1	$200.0	County bridge program	Yes
Alaska	1	$102.8	Eight road and bridge projects	No
Arizona	5	$460.4	Maricopa freeway projects	No
Arkansas	3	$575.0	Interstate highways	No
California	1	$614.9	Eight road projects	Yes, except 2005 series
Colorado[1]	5	$1,665.6	Any project financed wholly or in part by Federal funds	No
Georgia	1	$360.0	Various transportation projects	Yes
Idaho	1	$194.3	Various expansion projects	Yes
Kentucky	2	$417.5	Three Interstate widening and rehabilitation projects	Yes
Maine	1	$48.4	Replacement of the Waldo-Hancock Bridge	Yes
Maryland	1	$325.0	InterCounty Connector	No
Montana	1	$122.8	44 miles of U.S. 93 improvements	Yes
New Mexico	2	$118.7	New Mexico SR 44	Yes
North Carolina	1	$287.6	38 projects around the State	Yes
North Dakota	1	$51.4	Highway and bridge projects	Yes
Ohio	8	$928.1	Various projects including Spring-Sandusky and Maumee River improvements	No
Oklahoma[2]	3	$192.2	Projects in 12 corridors	No
Puerto Rico	1	$139.8	Various transportation projects	Yes
Rhode Island	2	$401.4	Freeway, bridge, and freight rail improvement projects	Yes
Virgin Islands	1	$20.8	Enighed Pond Port Project and Red Hook Passenger Terminal Building	Yes
West Virginia	2	$109.2	Route 35 enhancements	Yes
Total	**44**	**$7,335.9**		

[1] Colorado DOT issued $400.2 million in June 2002 and $280.2 million in May 2004 to refund prior bonds.

[2] With premiums on net proceeds worth $50 million.

Source: Federal Highway Administration.

Passage of the private activity bond legislation reflects the Federal government's desire to increase private sector investment in U.S. transportation infrastructure. Providing private developers and operators with access to tax-exempt interest rates lowers the cost of capital significantly, enhancing investment prospects. Increasing the involvement of private investors in highway and freight projects generates new sources of money and ideas and improves efficiency.

As of January 15, 2008, the Department of Transportation had approved $3.3 billion in private activity bond allocations for five projects. These projects are the Port of Miami Tunnel; the Missouri Department of Transportation Safe and Sound Bridge Improvement Program; the Knik Arm Crossing in Alaska; Interstate-495 High-Occupancy Toll Lanes in Virginia; and the Lyndon Baines Johnson Expressway in Texas.

> **Q&A**
>
> **Can a transportation project utilize more than one innovative finance technique?**
>
> Yes. There are numerous projects that have been constructed or operated under more than one innovative finance technique.
>
> The Pocahontas Parkway, for example, is operated under a long-term PPP-model lease arrangement. Operators of the parkway are taking advantage of credit from the TIFIA program to extend the highway to Richmond International Airport. The parkway is also a participant in Special Experimental Project No. 15.
>
> Alaska's Anton Anderson Memorial Tunnel implemented two PPP models. Improvements to Alaska's Anton Anderson Memorial Tunnel were completed under the Design-Build model, but its operations have been carried out using the private contract-fee service model.
>
> The Central Texas Turnpike between Interstate 35 and U.S. 183 was built under a Design-Build model. About $916 million in credit from the TIFIA program assisted in its construction.

Innovations in Tolling

Tolling is a central element of many projects developed under innovative finance techniques, but it is also being used to pay for facilities constructed in more traditional ways. SAFETEA-LU included several innovations to expand the use of tolling.

The Interstate System Construction Toll Pilot Program authorizes the U.S. Secretary of Transportation to select up to three projects nationwide where a State may collect tolls on Interstate highways, bridges, or tunnels in order to construct new Interstate highways; for a project to be eligible, tolling must be judged to be the most efficient and economical finance method. In 2007, Federal officials selected the first such project, authorizing the South Carolina Department of Transportation to participate in order to construct a portion of the proposed Interstate 73.

The Express Lane Demonstration Program authorizes the U.S. Secretary of Transportation to select up to 15 projects nationwide where States, public authorities, and public or private entities may permit the automated collection of tolls on existing HOV facilities. The goal of the program is to demonstrate the impact that tolling can have on managing high levels of congestion, reducing emissions, and financing the addition of Interstate lanes. Tolls charged on high occupancy vehicle (HOV) facilities under this program must vary according to time of day or level of traffic; variable pricing on non-HOV facilities is optional.

SAFETEA-LU also continued several existing pilot programs. The Value Pricing Pilot Program, first established in ISTEA as the Congestion Pricing Pilot Program and renamed in TEA-21, examines the potential effects that different value pricing approaches would have on congestion reduction. The Interstate System Reconstruction and Rehabilitation Toll Pilot Program was established under TEA-21 as a construction revenue source. This program, continued through SAFETEA-LU, allows tolling on up to three existing Interstate facilities to fund needed reconstruction or rehabilitation on Interstate highway corridors that could not otherwise be adequately maintained or functionally improved.

Transit Finance

Transit Funding

In 2006, $43.4 billion was available from all sources to finance transit investment and operations, compared with $39.5 billion in 2004. Transit funding comes from two major sources: public funds allocated by Federal, State, and local governments, and system-generated revenues earned for the provision of transit services. Federal funding for transit includes fuel taxes dedicated to transit from the Mass Transit Account (MTA) of the Highway Trust Fund (HTF), as well as undedicated taxes allocated from Federal general fund appropriations; revenue sources are shown in *Exhibit 6-24*. State and local governments also provide funding for transit from their general fund appropriations, as well as from fuel, income, sales, property, and other unspecified taxes, specific percentages of which may be dedicated to transit. These percentages vary considerably among taxing jurisdictions and by type of tax. Other public funds from sources such as toll revenues and general transportation funds may also be used to fund transit. System-generated revenues are composed principally of passenger fares, although additional revenues are also earned by transit systems from advertising and concessions, park-and-ride lots, investment income, and rental of excess property and equipment.

Exhibit 6-24

Revenue Sources for Transit Financing, 2006

	(Millions of Dollars)				
	Federal	**State**	**Local**	**Total**	**Percent**
Public Funds	**$8,075.5**	**$8,570.8**	**$14,261.8**	**$30,908.1**	**71.3%**
General Fund	$1,615.1	$2,358.3	$3,014.6	$6,988.0	16.1%
Fuel Tax	$6,460.4	$549.5	$159.8	$7,169.7	16.5%
Income Tax		$195.1	$70.8	$265.9	0.6%
Sales Tax		$2,429.9	$4,797.6	$7,227.5	16.7%
Property Tax		$0.0	$547.3	$547.3	1.3%
Other Dedicated Taxes		$1,203.5	$1,163.6	$2,367.1	5.5%
Other Public Funds		$1,834.5	$4,508.1	$6,342.6	14.6%
System-Generated Revenue				**$12,452.4**	**28.7%**
Passenger Fares				$10,461.1	24.1%
Other Revenue				$1,991.3	4.6%
Total All Sources				**$43,360.5**	**100.0%**

Source: National Transit Database.

Level and Composition of Transit Funding

Exhibit 6-25 breaks down the sources of total transit funding. In 2006, public funds of $30.9 billion were available for transit and accounted for 71.3 percent of total transit funding. Of this amount, Federal funding was $8.1 billion, accounting for 26.1 percent of total public funding and for 18.6 percent of all funding from both public and nonpublic sources. State funding was $8.6 billion, accounting for 27.7 percent of total public funds and 19.8 percent of all funding. Local jurisdictions provided the bulk of transit funds, $14.3 billion in 2006, or 46.1 percent of total public funds and 32.9 percent of all funding. System-generated revenues were $12.5 billion, 28.7 percent of all funding.

What type of dedicated funding does mass transit receive from Federal highway-user fees? Q&A

Prior to FY 1983, all Federal funding for transit was from general revenue sources. In 1983 the Mass Transit Account (MTA) was established within the Highway Trust Fund, funded by 1.0 cent of the Federal motor-fuel tax. In 1990, the portion of the Federal fuel tax dedicated to the MTA was increased to 1.5 cents, in 1995 to 2.0 cents, in 1997 to 2.85 cents, and in 1998 to 2.86 cents (retroactive to October 1, 1997) with the passage of the Transportation Equity Act for the 21st Century. Since 1997, 2.86 cents of Federal highway-user fees on gasohol, diesel and kerosene fuel, and other special fuels, including benzol, benzene, and naphtha, have also been dedicated to the MTA. Also since 1997, the total Federal fuel tax for a gallon of gasoline has been 18.4 cents and the total tax for a gallon of diesel has been 24.4 cents.

The MTA has also received 2.13 cents of the user fee on liquefied petroleum gas (LPG) and 1.86 cents of the user fee on liquefied natural gas (LNG) since 1997. The MTA does not receive any of the nonfuel revenues (such as heavy vehicle use taxes) that accrue to the Highway Trust Fund.

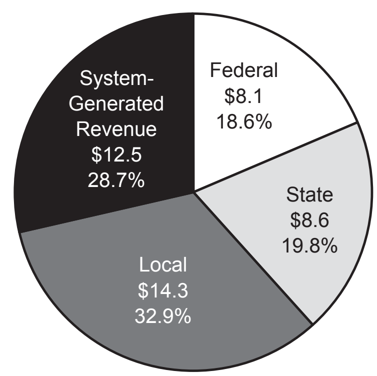
Since the passage of the Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) only the Formula and Bus Grants Program is funded from the MTA. Prior to SAFETEA-LU, MTA funded other FTA programs.

Federal Funding

Federal funding for transit comes from two sources: the general revenues of the U.S. government and revenues generated from fuel taxes credited to the HTF's MTA. The MTA, a trust fund for capital projects in transit, is the largest source of Federal funding for transit. Eighty-two percent of the transit funds authorized for transit by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) ($37.2 billion) will be derived from the MTA. Funding from the MTA in nominal dollars increased from $0.5 billion in 1983 to $6.5 billion in 2006.

Exhibit 6-25

2006 Public Transit Revenue Sources (Billions of Dollars)



Source: National Transit Database.

Since 1973, Federal surface transportation authorization statutes have contained flexible funding provisions that enable transfers from certain highway funds to transit programs and vice versa. In 1973, Congress began to allow local areas to exchange interstate highway trust funds for transit funding from general revenues; this allows Federal-aid highway dollars to be used for transit grant purposes, with a higher local share. Flexible funding was implemented under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and continued by the Transportation Equity Act for the 21st Century (TEA-21). Transfers are subject to State and regional/local discretion, and priorities are established through Statewide transportation planning processes. All States and territories within the United States participate in the flexible funding program, except Kansas, North Dakota, South Dakota, and Wyoming. The amount of flexible funding transferred from highways to transit fluctuates from year to year and is drawn from several different sources.

What makes up general revenue sources? Q&A

General revenue sources, or the general fund, comprise all appropriation, expenditure, and receipt transactions, except for those that are required to be accounted for in a separate fund, generally by statute. General revenue sources include income taxes, corporate taxes, tariffs, fees and other government income not committed by statute to a particular purpose.

Does the Federal Transit Administration have any security-specific grant programs?

Q&A

The Federal Transit Administration (FTA) does not have a security-specific grant program. However, Section 5307 grantees are required to either spend at least one percent of their Section 5307 formula funds on transit security or certify that they do not need to do so.

Section 5307 (d)(1)(J) specifically states that grantees will expend at least one percent of the funds received in a fiscal year for increased lighting in or adjacent to a public transportation system; increased camera surveillance of an area in or adjacent to that system; to provide an emergency telephone line to contact law enforcement or security personnel in an area in or adjacent to that system; or any other project intended to increase the security and safety of an existing or planned public transportation system.

Section 5307 grantees in urbanized zone areas (UZAs) with a population of less than 200,000 may use both capital and operating security-related expenses to meet or exceed the "1% for security" requirement. Section 5307 grantees in UZAs with a population greater than 200,000 can only use security-related capital projects to meet the 1% for security requirement. SAFETEA-LU expanded the definition of allowable security-related capital projects to include security planning, training and drills and exercises.

FTA tracks annual Section 5307 expenditures for security through its Triennial Review oversight program.

The Surface Transportation Program (STP) is the largest source of funds from the FHWA. Funding is at 80 percent Federal share and may be used for all projects eligible for funds under current FTA programs excluding operating assistance.

Congestion Mitigation and Air Quality (CMAQ) Improvement Program funds are used to support transportation projects in air quality nonattainment areas. A CMAQ project must contribute to the attainment of the national ambient air quality standards by reducing air pollutant emissions from transportation sources.

Several transit projects are also earmarked under TEA-21 and SAFETEA-LU as high-priority projects. FHWA asked that they be administered by FTA. FHWA earmarked funds through FY 1999 were transferred to FTA's formula programs only.

The Department of Homeland Security (DHS) also provides funding for projects aimed at improving transit security. In 2005, DHS provided $134.1 million to increase transit security across the Nation. In 2006, DHS increased the funds available for transit security, providing transit service providers with a total of $136.0 million.

In FY 2006, $1.8 billion in flexible funds/transfers were available to FTA for obligation. Of that total, $1.3 billion (68.0 percent) was transferred in FY 2006; the remaining available $430.5 million (32.0 percent) was the un-obligated carryover or recovery of prior year transfers. Thirty-eight states transferred flexible funds during FY 2006. Obligations in FY 2006 totaled $1.3 billion. Once transferred, these funds take on the characteristics of the program in which they are received and are included in the figures reported across various programs. Obligations in FY 2006 were: Urbanized Area Formula: $1.2 billion (91.9 percent); Capital: $18.0 million (1.4 percent); Elderly and Persons with Disabilities: $62.8 million (4.9 percent); and Non-urbanized Area Formula: $23.0 million (1.8 percent). Since the program's initiation in FY 1992, a total of $13.1 billion has been transferred from highways to transit, with obligations of approximately $12.6 billion.

No flexible funds may be transferred directly to the Section 5309 Program; however, flexible funds that have been transferred to the 5307 Program may be used with Section 5309 funds to finance capital investment projects.

State and Local Funding

General funds and other dedicated public funds are important sources of funding for transit at both the State and local levels; State and local transit funding sources are shown in *Exhibits 6-26 and 6-27*. In 2006, 27.5 percent of State funds and 21.0 percent of local funds came from general revenues. Allocations from other public funds accounted for 21.4 percent of total State and 32.1 percent of total local funding for transit. Dedicated sales taxes are a major source of funding for transit at both the State and local level. In 2006, they accounted for 28.4 percent of total State and 33.4 percent of total local funding for transit. Dedicated income and property taxes provide more modest levels of funding at both the State and local levels. Dedicated income taxes are a more important source of transit funds at the State level, whereas dedicated property taxes are more important at the local level.

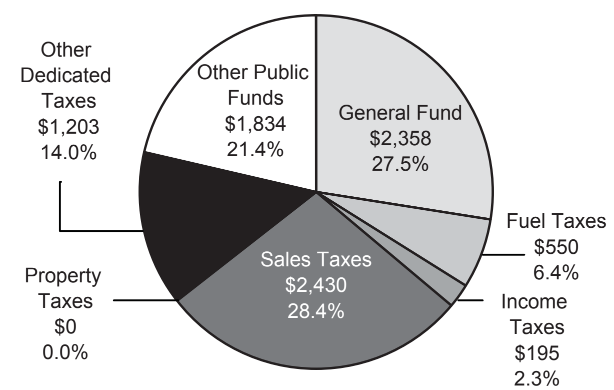
Q&A

What are other public funds?

Other public funds are those funds that are not dedicated to transit at their source or are not included in the budgeting process of general revenue funds. These funds include vehicle licensing and registration fees, communications access fees, surcharges and taxes, lottery and casino, and the proceeds from property and asset sales.

Exhibit 6-26

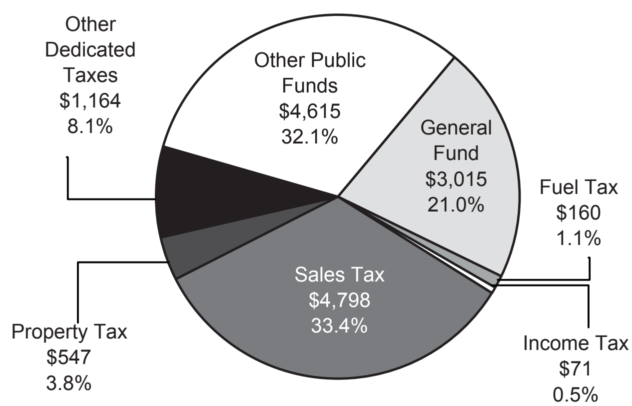
2006 State Sources of Transit Funding (Millions of Dollars)



Source: National Transit Database.

Exhibit 6-27

2006 Local Sources of Transit Funding (Millions of Dollars)



Source: National Transit Database.

Level and Composition of System-Generated Funds

In 2006, system-generated funds were $12.5 billion and provided 28.7 percent of total transit funding. Passenger fares contributed $10.5 billion, accounting for 84.0 percent of system-generated funds and 24.1 percent of total transit funds. These passenger fare figures do not include payments by State entities to transit systems that offset reduced transit fares for certain segments of the population, such as students and the elderly. These payments are included in the other revenue category.

Trends in Public Funding

Prior to 1962, there was no Federal funding for transit. State and local funding was limited, equal to approximately 15.0 percent of current total funding in 2006 real terms. Public funding for transit grew rapidly in the 1970s, and Federal funding increased at an average annual rate of 38.9 percent and State and local funding increased at an average annual rate of 11.9 percent. Federal funding grew much more slowly during the 1980s, increasing at an average annual rate of 0.4 percent, while funding at the State and local levels continued to grow steadily at an average annual rate of 7.8 percent. During the 1990s, Federal funding for transit grew more rapidly than in the 1980s, increasing at an average annual rate of 4.3 percent. However, State and local government funding grew more slowly than in the preceding decade, increasing at an average annual rate of 4.8 percent. Public funding for transit increased even more rapidly between 2000 and 2006 than in the 1980s and 1990s, growing at an average annual rate of 6.7 percent; Federal funding increased at an average annual rate of 7.4 percent, and State and local funding grew at an average annual rate of 6.4 percent. The average annual increase in Federal funding between 2004 and 2006 was 7.8 percent and the average annual increase in State and local funding over this period was 3.2 percent. These data are presented in *Exhibit 6-28*.

Federal funding for transit, as a percentage of total public funding for transit from Federal, State, and local sources combined, reached a peak of 42.9 percent in the early 1980s, as shown in *Exhibit 6-29*. However, by 1990, the Federal government share had fallen to 26.0 percent because the growth in State and local funding for transit greatly exceeded the growth of Federal funding during the 1980s. Since 1990, the Federal government has provided between 27.0 and 21.0 percent of total public funding for transit; in 2006, it provided 26.1 percent of these funds.

Exhibit 6-28

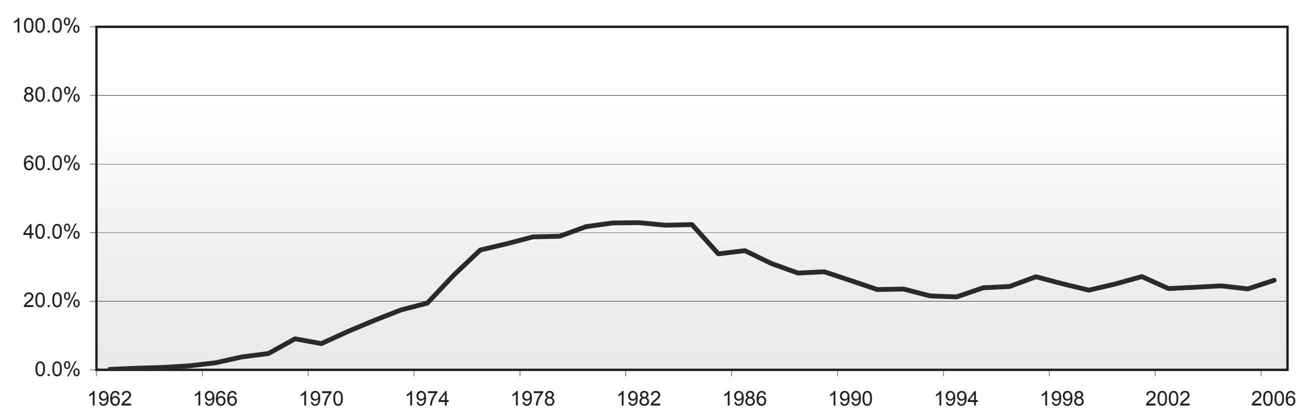
Public Funding for Transit by Government Jurisdiction, 1960–2006

	(Millions of Current Dollars)			
Year	Federal	State and Local	Total	Federal Share
1960	$0.0	$683.0	$683.0	0.0%
1970	$124.0	$1,499.0	$1,623.0	7.6%
1980	$3,307.0	$4,617.0	$7,924.0	41.7%
1990	$3,458.0	$9,823.0	$13,281.0	26.0%
1991	$3,395.0	$11,116.0	$14,511.0	23.4%
1992	$3,448.0	$11,195.0	$14,643.0	23.5%
1993	$3,296.5	$11,990.7	$15,287.2	21.6%
1994	$3,379.6	$12,522.4	$15,902.0	21.3%
1995	$4,081.5	$12,971.0	$17,052.5	23.9%
1996	$4,059.9	$12,642.7	$16,702.6	24.3%
1997	$4,742.0	$12,727.7	$17,469.7	27.1%
1998	$4,420.8	$13,199.5	$17,620.3	25.1%
1999	$4,586.2	$15,166.1	$19,752.3	23.2%
2000	$5,259.3	$15,739.4	$20,998.7	25.0%
2001	$6,585.7	$17,630.8	$24,216.5	27.2%
2002	$6,296.0	$20,294.0	$26,590.0	23.7%
2003	$6,688.1	$21,107.4	$27,795.5	24.1%
2004	$6,954.4	$21,451.6	$28,406.0	24.5%
2005	$6,854.9	$22,214.6	$29,069.5	23.6%
2006	$8,075.5	$22,832.6	$30,908.1	26.1%

Source: National Transit Database/Office of Management and Budget.

Exhibit 6-29

Federal Share of Public Funding for Transit, 1962–2006



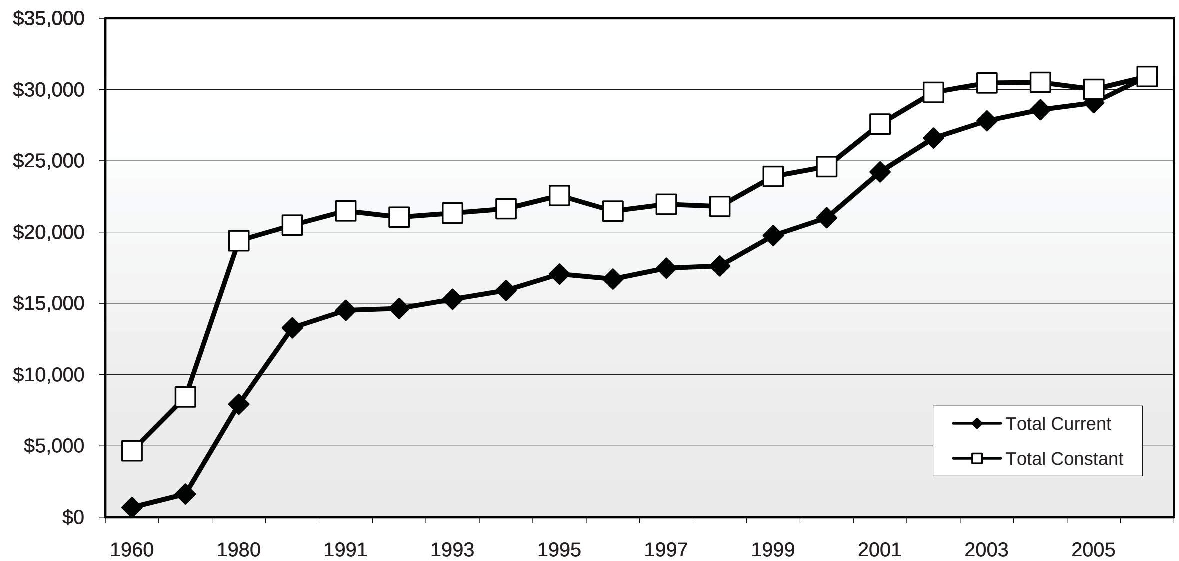
Source: National Transit Database.

Funding in Current and Constant Dollars

Total public funding for transit in current dollars reached its highest level of $30.9 billion in 2006, compared with $28.4 billion in 2004. Federal funding in current dollars was 16.1 percent higher in 2006 than in 2004, increasing from $7.0 billion in 2004 to $8.1 billion in 2006; and State and local funding in current dollars was 5.6 percent higher, increasing from $21.5 billion in 2004 to $22.8 billion in 2006. Total public funding for transit in constant dollars increased by an annual average rate of change of 0.7 percent from 2004 to 2006; funding in constant dollars from Federal sources increased by 8.8 percent over this period (updated per the Consumer Price Index). Funding from State and local sources decreased by 1.1 percent. These data are presented in summary in *Exhibit 6-30*.

Exhibit 6-30

Current and 2006 Constant Dollar Funding for Public Transportation, 1960–2006



Source: National Transit Database/Office of Management and Budget.

Capital Funding and Expenditures

Funding for capital investments by transit operators in the United States comes primarily from public sources. Capital investment funds for transit are also generated through innovative finance programs.

Capital investments include the design and construction of new transit systems, extensions of existing systems ("New Starts"), and the modernization of existing fixed assets. Fixed assets include fixed guideway systems (e.g., rail tracks), terminals, and stations, as well as maintenance and administrative facilities. Capital investment expenditures also include the acquisition, renovation, and repair of rolling stock (i.e., buses, railcars, locomotives, and service vehicles).

In 2006, total public transit agency expenditures for capital investment were $12.8 billion in current dollars and accounted for 29.4 percent of total available funds, a slight decline from total public transit agency expenditures in 2004, which allocated 32.0 percent of expenditures for capital investment. Federal funds were $5.6 billion in 2006 (43.5 percent of total transit agency capital expenditures), State funds were $1.7 billion (13.3 percent of total transit agency capital expenditures), and local funds were $5.5 billion (43.1 percent of total transit agency capital expenditures).

While the share of these funding sources shifted slightly in 2006, as shown in *Exhibit 6-31*, Federal funds increased to 43.5 percent after declining between 2002 and 2005, with the lowest point at 39.0 percent in 2004.

Exhibit 6-31

Sources of Funds for Transit Capital Expenditures, 1997–2006

	(Millions of Dollars)										Average Annual Growth	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006/ 1997	2006/ 2004
Federal	$4,137.5	$3,679.5	$3,725.9	$4,274.9	$5,468.4	$4,993.7	$5,091.8	$4,930.2	$4,611.8	$5,552.2	3.3%	6.1%
Share	54.2%	49.7%	44.1%	47.2%	50.5%	40.6%	39.9%	39.0%	39.2%	43.5%		
State	$1,006.7	$875.3	$857.5	$973.3	$1,011.1	$1,432.9	$1,622.7	$1,756.1	$1,494.2	$1,698.2	6.0%	-1.7%
Share	13.2%	11.8%	10.2%	10.7%	9.3%	11.6%	12.7%	13.9%	12.7%	13.3%		
Local	$2,492.0	$2,855.7	$3,859.9	$3,807.7	$4,345.1	$5,874.3	$6,060.5	$5,942.7	$5,653.6	$5,501.7	9.2%	-3.8%
Share	32.6%	38.5%	45.7%	42.0%	40.1%	47.8%	47.4%	47.1%	48.1%	43.1%		
Total	$7,636.2	$7,410.5	$8,443.3	$9,055.9	$10,824.6	$12,300.9	$12,775.0	$12,629.1	$11,759.6	$12,752.1	5.9%	0.5%

Source: National Transit Database.

As shown in *Exhibit 6-32,* rail modes require a higher percentage of total capital investment than bus modes because of the higher cost of building fixed guideways and rail stations. In 2006, $9.2 billion, or 72.3 percent of total transit capital expenditures, was invested in rail modes of transportation, compared with $3.5 billion, or 27.7 percent of the total, which was invested in nonrail modes. This investment distribution was consistent with 2002 and 2004 distributions.

Exhibit 6-32

Transit Capital Expenditures by Mode and by Type, 2006

Mode	Guideway	Rolling Stock	Systems	Maintenance Facilities	Stations	Fare Revenue Collection Equipment	Adminis-trative Buildings	Other Vehicles	Other Capital Expendi-tures[1]	Total	Percent of Total
	(Millions of Dollars)										
Rail	$4,170.5	$1,420.3	$581.2	$806.1	$1,738.0	$135.0	$47.9	$48.0	$274.4	$9,221.4	72.3%
Commuter Rail	$1,042.9	$712.3	$64.1	$188.4	$343.3	$5.1	$4.3	$7.6	$111.2	$2,479.2	19.4%
Heavy Rail	$1,095.1	$419.3	$444.4	$373.1	$1,083.5	$109.5	$15.0	$37.7	$114.8	$3,692.4	29.0%
Light Rail	$2,026.1	$250.7	$71.3	$243.8	$308.5	$20.3	$28.6	$2.6	$47.6	$2,999.6	23.5%
Other Rail [2]	$6.4	$37.9	$1.4	$0.8	$2.6	$0.1	$0.0	$0.1	$0.8	$50.2	0.4%
Nonrail	$328.9	$1,677.4	$214.4	$481.2	$455.2	$72.8	$113.5	$23.7	$163.6	$3,530.7	27.7%
Motor Bus	$318.0	$1,484.1	$198.2	$447.7	$375.0	$71.3	$105.7	$22.3	$144.8	$3,167.0	24.8%
Demand Response	$0.0	$105.8	$13.7	$17.1	$1.5	$0.9	$7.5	$0.8	$6.1	$153.5	1.2%
Ferryboat	$0.0	$50.0	$1.4	$10.9	$62.7	$0.0	$0.0	$0.0	$11.1	$136.2	1.1%
Trolley Bus	$10.9	$9.3	$0.8	$5.4	$15.3	$0.6	$0.1	$0.4	$0.9	$43.8	0.3%
Other Nonrail [3]	$0.0	$28.2	$0.3	$0.0	$0.7	$0.0	$0.1	$0.2	$0.6	$30.2	0.2%
Total	$4,499.4	$3,097.7	$795.6	$1,287.4	$2,193.2	$207.8	$161.4	$71.7	$438.0	$12,752.1	100%
Percent of Total	35.3%	24.3%	6.2%	10.1%	17.2%	1.6%	1.3%	0.6%	3.4%	100.0%	

[1] Capital expenditures not elsewhere included. These expenditures include furniture and equipment that are not an integral part of buildings and structures; they also include shelters, signs, and passenger amenities (e.g., benches) not in passenger stations.

[2] Automated rail, Alaska rail, cable car, inclined plane, monorail.

[3] Jitney, Público, and vanpool.

Source: National Transit Database.

Exhibit 6-32 shows the capital investment expenditures by asset type in 2006. Fluctuations in the levels of capital investment in different types of transit assets reflect normal rehabilitation and replacement cycles, as well as new investment. Capital investment expenditures have only been reported to the NTD at the level of detail in *Exhibit 6-32* since 2002.

Guideway investment was $4.5 billion in 2006; investment in systems in 2006 was $795.6 million. Guideway includes at-grade rail, elevated and subway structures, tunnels, bridges, track and power systems for all rail modes, and paved highway lanes dedicated to buses. Investment in systems by transit operators includes groups of devices or objects forming a network, especially for distributing something or serving a common purpose (e.g., telephone systems).

Investment in rolling stock in 2006 was $3.1 billion, investment in stations was $2.2 billion, and investment in maintenance facilities was $1.3 billion. Rolling stock includes the bodies and chassis of transit vehicles and their attached fixtures and appliances, but does not include fare collection equipment and revenue vehicle movement control equipment such as radios. Stations include station buildings, platforms, shelters, parking and other forms of access, and crime prevention and security equipment at stations. Facilities include the purchase, construction, and rehabilitation of administrative and all types of maintenance facilities. Facilities also include investment in building structures, climate control, parking, yard track, vehicle and facilities maintenance equipment, furniture, office equipment, and computer systems. (Note that facilities include guideway and rail systems reported separately in Chapters 3 and 7.) In 2006, $438.0 million was invested in other capital.

Other vehicles and revenue collection equipment, which were included in other capital in 2002, were reported separately in 2004 and 2006. Other capital, as defined in 2004, includes the construction of general administration facilities, furniture, equipment that is not an integral part of buildings and structures, data processing equipment (including computers and peripheral devices whose sole use is in data processing operations), revenue vehicle movement control equipment, and shelters located at on-street bus stops.

Q&A

What are "New Starts"?

Projects involving the construction of new fixed guideway systems are known as "New Starts." Title 49 USC Section 5309 provides for the allocation of funds for the design and construction of new transit systems and extensions to current systems ("New Starts") among other purposes. To receive FTA capital investment funds for a New Starts project, the proposed project must emerge from the metropolitan and/or Statewide planning process. A rigorous series of planning and project development requirements must be completed in order to qualify for this funding. Local officials are required to analyze the benefits, costs, and other impacts of alternative transportation strategies before deciding upon a locally preferred alternative. FTA evaluates proposed projects on the basis of financial criteria and project justification criteria as prescribed by statute. Initial planning efforts are not funded through the Section 5309 program, but may be funded through Section 5303 Metropolitan Planning, Section 5339 Alternatives Analysis, or Section 5307 Urbanized Area Formula Grants programs.

Under current law, Federal funding may account for up to 80 percent of a New Starts funding requirement. Generally, the Federal share of such projects now averages about 50 percent of the total project cost. SAFETEA-LU authorized $7.4 billion in Federal funding for New Starts from 2005 through 2009; TEA-21 authorized $6.1 billion in Federal funding for New Starts from 1998 to 2003. Authorization for New Starts from 2004 to 2006 has increased from $1.3 billion in 2004, to $1.44 billion in 2005, and $1.5 billion in 2006.

Operating Expenditures

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2006, $30.6 billion was available for operating expenses and accounted for 70.6 percent of total available funds. Of this amount, $2.5 billion was provided by the Federal government (8.2 percent of total transit agency operating expenditures), $6.9 billion was provided by State governments (22.5 percent of total transit agency operating expenditures), $8.9 billion by local governments (29.0 percent of total transit agency operating expenditures), and $12.3 billion by system-generated revenues (40.3 percent of total transit agency operating expenditures). These data are given in *Exhibit 6-33*. The Federal share of operating expenditures was higher in 2006, at 8.2 percent, than in any other year during the 1997 to 2006 period, up from a 7.5 percent share in 2004; the State share of operating expenditures of 22.5 percent in 2006 was consistent with 2004 expenditures. The share of operating expenditures provided by local governments and system-generated revenues decreased slightly from 29.4 percent to 29.0 percent from 2004 to 2006.

TEA-21 mandated that Federal funding to transit systems in urbanized areas with populations over 200,000 be used only for capital expenses and operating expenses for preventive maintenance, and not for other types of operating expenses. Formula grant funds to urbanized areas with populations of less than 200,000 were still allowed to be used for operating expenses. As a result of the 2000 census, 56 areas were reclassified as urbanized areas with populations of more than 200,000. (These reclassifications were announced by the Census Department in May 2002.) Transit agencies operating in these areas were slated to lose their eligibility to use Federal formula funding to finance transit operations starting in FY 2003. The Transit Operating Flexibility Act of 2002 amended Section 5307 of 49 USC to allow transit systems that were in these areas to continue to use their formula funds for operating expenses as well as for capital expenses in FY 2003, despite their change in status. This change was extended by the Surface Transportation Extension Act of 2003. Under SAFETEA-LU these transit agencies may continue to use formula funds for operating expenses in FY 2005 at 100 percent of their FY 2002 apportionment, in FY 2006 at 50 percent of their FY 2002 apportionment, and in FY 2007 at 25 percent of their FY 2002 apportionment.

Exhibit 6-33

Sources of Funds for Transit Operating Expenditures,* 1997–2006

	(Millions of Dollars)										Average Annual Growth	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006/ 1997	2006/ 2004
Federal	$604.5	$741.3	$860.3	$984.4	$1,117.3	$1,302.2	$1,596.1	$2,024.2	$2,243.1	$2,524.2	17.2%	11.7%
Share	3.3%	4.0%	3.9%	4.5%	4.8%	5.4%	6.3%	7.5%	7.8%	8.2%		
State	$3,661.4	$3,819.1	$3,819.1	$4,351.3	$5,127.3	$6,112.7	$6,042.8	$6,036.1	$6,703.0	$6,874.7	7.3%	6.7%
Share	20.0%	20.5%	17.4%	20.1%	21.8%	25.3%	23.8%	22.5%	23.3%	22.5%		
Local	$5,567.7	$5,649.4	$6,097.4	$6,513.2	$7,147.3	$6,873.8	$7,381.5	$7,887.0	$8,363.8	$8,867.2	5.3%	6.0%
Share	30.4%	30.3%	27.8%	30.0%	30.4%	28.4%	29.1%	29.4%	29.1%	29.0%		
System-Generated Revenues	$8,476.6	$8,437.6	$11,128.2	$9,831.6	$10,111.5	$9,890.2	$10,355.3	$10,922.3	$11,451.1	$12,345.8	4.3%	6.3%
Share	46.3%	45.2%	50.8%	45.3%	43.0%	40.9%	40.8%	40.6%	39.8%	40.3%		
Total	$18,310.2	$18,647.4	$21,904.9	$21,680.5	$23,503.4	$24,178.9	$25,375.7	$26,869.6	$28,761.0	$30,612.5	5.9%	13.9%

**These figures differ slightly from the amounts disbursed for operating expenditures provided in Exhibits 6-34 and 6-35.*

Source: National Transit Database.

Operating Expenditures by Transit Mode

As shown in *Exhibit 6-34*, transit operators' actual operating expenditures were $29.0 billion in 2006, compared with $25.4 billion in 2004. These expenditures increased at an average annual rate of 5.8 percent between 1997 and 2006. Light rail systems and demand response experienced the largest percentage increase in operating expenditures among the modes shown during the 1997 to 2006 period, rising at an average annual rate of 9.5 percent. This is due to investment in new light rail and demand response capacity increasing at a higher rate over the past ten years in comparison to the other modes. Operating expenditures for heavy rail increased at a lesser rate than light rail and demand response between 1997 and 2006 at an average annual rate of 4.8 percent. In contrast, the operating expenditures for commuter rail increased at an average annual rate of 5.7 percent over the 1997 to 2006 period. Operating expenditures for buses increased at an average annual rate of 5.5 percent between 1997 and 2006. Operating expenditures for the remaining modes combined as "Other" increased at an average annual rate of 6.8 percent between 1997 and 2006.

Buses accounted for the largest percentage of transit operating expenditures, with 54.4 percent of the operating expenditure total, at $15.8 billion, in 2006. Operating expenditures for heavy rail in 2006 were $5.3 billion, or 18.2 percent of the total; operating expenditures for commuter rail were $3.8 billion, or 13.0 percent of the total; and operating expenditures for demand response systems were $2.3 billion, or 7.9 percent of the total. Operating expenditures for light rail were $1.1 billion, and operating expenditures for the remaining modes were $0.8 billion, accounting for 3.7 percent and 2.8 percent of the total, respectively. These data are shown in *Exhibit 6-34*.

Exhibit 6-34

Transit Operating Expenditures by Mode, 1997–2006

			(Millions of Dollars)				
Year	Motor Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other	Total
1997	$9,776.8	$3,473.7	$2,278.0	$471.4	$1,009.0	$453.5	$17,462.4
1998	$10,119.9	$3,529.6	$2,360.0	$493.0	$1,134.2	$498.5	$18,135.2
1999	$10,840.6	$3,693.4	$2,574.3	$536.2	$1,274.7	$540.3	$19,459.6
2000	$11,026.4	$3,930.8	$2,679.0	$592.1	$1,225.4	$549.3	$20,003.1
2001	$11,814.0	$4,180.1	$2,853.7	$676.5	$1,409.9	$594.7	$21,528.8
2002	$12,585.7	$4,267.5	$2,994.7	$778.3	$1,635.7	$643.4	$22,905.1
2003	$13,315.8	$4,446.2	$3,172.7	$753.7	$1,778.7	$718.0	$24,185.2
2004	$13,789.5	$4,734.2	$3,436.4	$826.1	$1,902.0	$738.6	$25,426.8
2005	$14,665.8	$5,144.8	$3,657.1	$978.1	$2,071.2	$720.8	$27,237.8
2006	$15,796.5	$5,287.5	$3,764.9	$1,070.1	$2,285.9	$819.7	$29,024.6
Percent of Total							
1997	56.0%	19.9%	13.0%	2.7%	5.8%	2.6%	100.0%
2006	54.4%	18.2%	13.0%	3.7%	7.9%	2.8%	100.0%
Average Annual Growth Rate							
2006/1997	5.5%	4.8%	5.7%	9.5%	9.5%	6.8%	5.8%

Source: National Transit Database.

Operating Expenditures by Type of Cost

In 2006, $15.6 billion, or 53.7 percent of total transit operating expenditures, were for vehicle operations. Expenditures on vehicle maintenance were $5.7 billion, or 19.8 percent of the total; expenditures on nonvehicle maintenance were $3.0 billion, or 10.4 percent of the total; and expenditures on general administration were $4.7 billion, or 16.2 percent of the total. The distribution of these expenses across cost categories for 2006 is virtually the same as in 2004. These data are shown in *Exhibit 6-35*.

Bus and rail operations have inherently different cost structures. Although 66.6 percent of total operations expenditures for demand response transit (e.g., demand response operating expenses of $1.5 million as a percentage of demand response total operating expenses of $2.3 million) and 58.7 percent of total operations expenditures for buses were spent for actual operation of the vehicles, only 42.6 percent of rail operations expenditures were spent on the operation of rail vehicles. A significantly higher percentage of expenditures for rail modes of transportation is classified as nonvehicle maintenance for the repair and maintenance of fixed guideway systems.

Exhibit 6-35

Operating Expenditures by Mode and Type of Cost, 2006

	(Millions of Dollars)									
Mode	**Vehicle Operations**		**Vehicle Maintenance**		**Nonvehicle Maintenance**		**General Administration**		**Total**	
Motor Bus	$9,277.5	59.6%	$3,284.5	57.3%	$717.2	23.8%	$2,517.2	53.5%	$15,796.5	54.4%
Heavy Rail	$2,313.1	14.8%	$929.7	16.2%	$1,358.3	45.1%	$686.4	14.6%	$5,287.5	18.2%
Commuter Rail	$1,542.0	9.9%	$883.7	15.4%	$640.4	21.3%	$698.8	14.9%	$3,764.9	13.0%
Light Rail	$453.8	2.9%	$244.2	4.3%	$184.9	6.1%	$187.2	4.0%	$1,070.1	3.7%
Demand Response	$1,522.1	9.8%	$267.4	4.7%	$44.5	1.5%	$451.9	9.6%	$2,285.9	7.9%
Other	$469.5	3.0%	$123.6	2.2%	$63.4	2.1%	$163.2	3.5%	$819.7	2.8%
Total	**$15,578.0**	**100.0%**	**$5,733.1**	**100.0%**	**$3,008.8**	**100.0%**	**$4,704.6**	**100.0%**	**$29,024.6**	**100.0%**
Percent of All Modes	53.7%		19.8%		10.4%		16.2%		100.0%	

Source: National Transit Database.

Operating Expenditures per Vehicle Revenue Mile

Operating expenditures per vehicle revenue mile (VRM) is one measure of financial or cost efficiency. It shows the expense of operating a transit vehicle in revenue service. As shown in *Exhibit 6-36*, in 2006, operating expenditures per VRM for all transit modes combined was $7.31. The average annual increase in operating expenditures per VRM for all modes combined was 2.0 percent between 1997 and 2006.

Operating expenditures per capacity-equivalent VRM is a better measure of comparing cost efficiency among modes than operating expenditures per VRM because it adjusts for passenger-carrying capacities. As demonstrated by the data in *Exhibit 6-37,* rail systems are more cost efficient in providing service than nonrail systems, once investment in rail infrastructure has been completed. Based on operating costs alone, heavy rail is the most efficient at providing transit service, and demand response systems are the least efficient. (Note that annual changes in operating expense per capacity-equivalent VRM and unadjusted motor bus operating expenditures are consistent between *Exhibits 6-36* and *6-37* because they provide the basis for capacity-equivalent factors. Annual changes in operating expense per capacity-equivalent VRM and

Exhibit 6-36

Operating Expenditures per Vehicle Revenue Mile, 1997–2006

Year	Motor Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other*	Total
1997	$6.09	$6.44	$9.92	$11.84	$2.88	$5.13	$6.12
1998	$6.12	$6.43	$9.91	$11.65	$2.92	$5.00	$6.11
1999	$6.31	$6.58	$10.58	$11.37	$3.05	$4.42	$6.25
2000	$6.25	$6.80	$10.81	$11.51	$2.71	$5.05	$6.25
2001	$6.49	$7.07	$11.28	$12.72	$2.88	$5.41	$6.49
2002	$6.75	$7.07	$11.56	$12.98	$3.11	$5.59	$6.68
2003	$7.08	$7.27	$12.11	$12.25	$3.27	$6.37	$6.96
2004	$7.32	$7.58	$12.79	$12.40	$3.39	$5.21	$7.17
2005	$7.78	$8.20	$13.20	$14.40	$3.50	$4.66	$7.56
2006	$8.27	$8.34	$13.12	$14.66	$3.77	$5.13	$7.31
Average (1997–2006)	**$6.85**	**$7.18**	**$11.53**	**$12.58**	**$3.15**	**$5.20**	**$6.69**
Average Annual Rate of Change							
2006/1997	3.5%	2.9%	3.2%	2.4%	3.0%	0.0%	2.0%

** Automated guideway, Alaska railroad, cable car, ferryboat, inclined plane, jitney, monorail, Público, trolleybus, and vanpool.*

Source: National Transit Database.

Exhibit 6-37

Operating Expenditures per Capacity-Equivalent Vehicle Revenue Mile by Mode, 1997–2006

Year	Motor Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other *	Total
1997	$6.09	$2.94	$4.36	$5.14	$18.04	$7.26	$4.96
1998	$6.12	$2.93	$4.23	$4.98	$17.80	$7.61	$4.98
1999	$6.31	$2.92	$5.72	$4.54	$21.85	$7.43	$5.28
2000	$6.25	$2.94	$5.29	$4.55	$16.60	$7.71	$5.15
2001	$6.49	$3.03	$4.65	$5.01	$16.21	$8.53	$5.24
2002	$6.75	$2.91	$4.59	$5.20	$16.31	$8.43	$5.31
2003	$7.08	$2.94	$4.78	$4.44	$17.27	$9.57	$5.49
2004	$7.32	$3.06	$5.02	$4.61	$18.79	$9.10	$5.68
2005	$7.78	$3.27	$5.28	$5.32	$17.56	$8.66	$6.01
2006	$8.27	$3.34	$5.25	$5.43	$18.83	$9.91	$6.29
Average (1997–2006)	**$6.85**	**$3.03**	**$4.92**	**$4.92**	**$17.93**	**$8.42**	**$5.44**
Average Annual Rate of Change							
2006/1997	3.5%	1.4%	2.1%	0.6%	0.5%	3.5%	2.7%

** Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Público, tramway, trolleybus, and vanpool.*

Source: National Transit Database.

unadjusted VRM are not the same for the remaining modes because VRMs in each year have been adjusted by the vehicle carrying capacity in that year.)

Operating Expenditures per Passenger Mile

Operating expenditures per passenger mile is an indicator of the cost effectiveness of providing a transit service. It shows the relationship between service inputs as expressed by operating expenses and service consumption as expressed by passenger miles traveled. Operating expenditures per passenger mile for all transit modes combined increased at an average annual rate of 3.4 percent between 1997 and 2006 (from $0.43 to $0.59. Operating expenditures per passenger mile for buses increased at an average annual rate of 3.7 percent between 1997 and 2006. Operating expenditures per passenger mile for commuter rail increased at an average annual rate of 2.8 percent over this period. Operating expenditures per passenger mile for demand response systems, heavy rail, and light rail increased over the 1997 to 2006 period at average annual rates of 5.3 percent, 2.5 percent, and 2.5 percent, respectively. These data are shown in *Exhibit 6-38*.

Exhibit 6-38

Operating Expenditures per Passenger Mile Traveled by Mode, 1997–2006

Year	Motor Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other *	Total
1997	$0.56	$0.29	$0.28	$0.46	$1.90	$0.44	$0.43
1998	$0.57	$0.29	$0.27	$0.44	$2.21	$0.45	$0.44
1999	$0.58	$0.29	$0.29	$0.45	$2.28	$0.46	$0.45
2000	$0.59	$0.28	$0.29	$0.44	$2.09	$0.49	$0.44
2001	$0.60	$0.29	$0.30	$0.47	$2.25	$0.52	$0.46
2002	$0.64	$0.31	$0.32	$0.54	$2.51	$0.55	$0.50
2003	$0.69	$0.33	$0.33	$0.55	$2.58	$0.56	$0.53
2004	$0.73	$0.33	$0.35	$0.56	$2.70	$0.53	$0.55
2005	$0.76	$0.36	$0.39	$0.58	$2.80	$0.52	$0.58
2006	$0.77	$0.36	$0.36	$0.57	$3.03	$0.58	$0.59
Average (1997-2006)	**$0.65**	**$0.31**	**$0.32**	**$0.51**	**$2.44**	**$0.51**	**$0.50**
Average Annual Rate of Change							
2006/1997	3.7%	2.5%	2.8%	2.5%	5.3%	3.0%	3.4%

* *Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Público, trolleybus, aerial tramway, and vanpool.*

Source: National Transit Database.

Farebox Recovery Ratios

The farebox recovery ratio represents farebox revenues as a percentage of total transit operating costs. It measures users' contributions to the variable cost of providing transit services and is influenced by the number of riders, fare structure, and rider profile. Low regular fares, the high availability and use of discounted fares, and high transfer rates tend to result in lower farebox recovery ratios. Farebox recovery ratios for 2004 to 2006 are provided in *Exhibit 6-39*. The average farebox recovery ratio over this period for all transit modes combined was 36.1 percent; heavy rail had the highest average farebox recovery ratio (59.7 percent), followed by commuter rail (48.0 percent), bus (29.4 percent), light rail (27.1 percent), and demand response (10.0 percent). The farebox recovery ratios for the remaining "Other" modes averaged 33.7 percent. Farebox recovery ratios for total costs are not provided because capital investment costs are not spread evenly across years. Rail modes have farebox recovery ratios for total costs that are significantly lower than for operating costs alone because of these modes' high level of capital costs.

Exhibit 6-39

Farebox Recovery Ratio by Mode, 2002–2006

Year	Motor Bus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other *	Total
2002	27.9%	58.4%	48.3%	29.0%	11.3%	29.8%	34.9%
2003	26.5%	59.7%	48.9%	28.1%	9.1%	31.8%	34.6%
2004	26.7%	61.3%	47.0%	26.2%	9.4%	36.0%	34.9%
2005	28.0%	58.0%	47.0%	25.0%	10.0%	35.0%	35.0%
2006	38.0%	61.0%	49.0%	27.0%	10.0%	36.0%	41.0%
Average (2002–2006)	**29.4%**	**59.7%**	**48.0%**	**27.1%**	**10.0%**	**33.7%**	**36.1%**

* *Automated guideway, alaska railroad, cable car, ferryboat, inclined plane, jitney, monorail, Público, trolleybus, aerial tramway, and vanpool.*

Source: National Transit Database.

Rural Transit

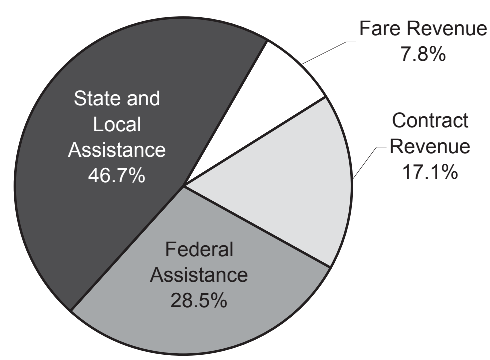
Since 1978, the Federal Government has contributed to the financing of transit in rural areas (i.e., areas with populations of less than 50,000). These rural areas are estimated to account for approximately 36 percent of the U.S. population and 38 percent of the transit-dependent population.

Funding for rural transit is currently provided through 49 USC Section 5311, which, in 1994, replaced Section 18 of the Urban Mass Transit Act. Rural transit funding was increased substantially with passage of TEA-21. Federal funding for rural transit was $224 million in FY 2002 and $240 million in FY 2003, the end of the TEA-21 authorization period. States may transfer additional funds to rural transit from highway projects, transit projects, or formula transit funds for small, urbanized areas.

As shown in *Exhibit 6-40*, 28.5 percent of rural transit authorities' operating budgets come from Federal Assistance funds. State and local governments cover 46.7 percent of their rural transit operating budgets through a combination of dedicated State and local taxes, appropriations from State general revenues, and allocations from other city and county funds. Contract revenue, defined as reimbursements from a private entity (profit or non-profit) for the provision of transit service, accounts for 17.1 percent of rural transit operating budgets. In 2006, total State and local contributions to rural transit operating budgets increased to a total of $496.9 million, up from $431 million in 2000 and $145 million in 1994.

Exhibit 6-40

Rural Transit Operators' Budget Sources for Operating Expenditures, 2006



Source: National Transit Database.

Comparison

Exhibit 6-41 compares the key highway and transit statistics discussed in this chapter with the values shown in the last version of the C&P report. The first data column contains the values reported in the 2006 C&P Report, which were based on 2004 data. Where the 2004 data have been revised, updated values are shown in the second column. The third column contains comparable values based on 2006 data.

Exhibit 6-41

Comparison of Highway and Transit Finance Statistics With Those in the 2006 C&P Report

	2004 Data		
Statistic	**2006 C&P Report**	**Revised**	**2006 Data**
Total Funding for Highways (all governments)	$145.3 billion		$166.0 billion
Total Funding for Transit	$39.5 billion		$43.4 billion
Total Public Funding for Transit	$28.4 billion		$30.9 billion
Percent of Public Funding for Transit Funded by Federal Government	24.3%	24.5%	26.0%
Total Highway-User Revenues (motor-fuel and vehicle taxes and tolls)	$106.8 billion	$105.8 billion	$117.1 billion
Highway-User Revenues Used for Roads	$83.0 billion		$93.4 billion
Total Transit Fares and Other System-Generated Revenue	$9.1 billion	$11.1 billion	$12.5 billion
Total Highway Expenditures (all govts.)	$147.5 billion		$161.1 billion
Percent of Total Highway Expenditures Funded by Federal Government	22.6%		22.4%
Total Highway Capital Outlay (all govts.)	$70.3 billion		$78.7 billion
Percent of Total Highway Capital Outlay Funded by Federal Government	43.8%		44.0%
Percent of Total Highway Capital Outlay Used for System Rehabilitation	51.8%	51.7%	51.3%
Total Transit Capital Outlay	$12.6 billion		$12.8 billion
Percent of Total Transit Capital Outlay Funded by Federal Government	39.0%		43.5%
Percent of Total Transit Capital Outlay Used for Rail	70%		72.3%

Highways and Bridges

All levels of government generated $166.0 billion in 2006 to be used for highways and bridges. Of this amount, $5.0 billion was placed in reserves, so cash outlays for highways and bridges in 2006 totaled about $161.1 billion, a 14.2-percent increase compared to 2004. The percentage of total highway funding provided by the Federal government dipped slightly from 22.6 to 22.4 percent, which means that State and local agencies provided a greater share of overall highway investment. This estimate includes funding not only for capital outlay, but also noncapital expenditures.

Highway user fees generated $117.1 billion in 2006, a 10.7 percent increase since 2004. About $93.4 billion of this revenue was used for roads and bridges.

In terms of capital outlay only, investment at all levels of government grew by 11.0 percent between 2004 and 2006, from $70.3 billion to $78.7 billion. The Federal share remained relatively constant, growing from 43.8 percent to 44.0 percent.

Inflation has greatly reduced the relative purchasing power of transportation dollars. Between 1997 and 2006, highway capital outlay expenditures declined by 4.0 percent in constant dollar terms, reflecting the increased cost of materials. Much of this increase is due to the rapid growth of Asian economies such as China and India, which have consumed higher levels of petroleum, steel, and other materials.

The portion of overall capital outlay used for rehabilitation in 2004 was re-estimated from the 51.8-percent figure cited in the 2006 C&P Report to 51.7 percent. This revision reflects data corrections, as well as the adoption of new procedures for estimating the distribution of capital expenditure types on roads functionally classified as rural local or urban local. In 2006, the share of capital investment used for system rehabilitation fell to 51.3 percent.

Transit

In 2006, $43.4 billion was available from all sources to finance transit investment and operations compared with $39.5 billion in 2004. Transit funding comes from two major sources: *public funds* allocated by Federal, State, and local governments; and *system-generated revenues* earned for the provision of transit services. In 2006 Federal funding was $8.1 billion (18.6 percent of total transit funds), State funding was $8.6 billion (19.8 percent of total transit funds), local funding was $14.3 billion (32.9 percent of total transit funds), and system-generated revenues were $12.5 billion (28.7 percent of total transit funds). Between 2004 and 2006, total Federal funding increased by 16.1 percent, total State and local funding increased by 5.6 percent, and total system-generated revenues increased by 12.6 percent.

While funding for transit increased from 2004 to 2006, it is important to note that the real value of money declined over that period, causing a loss of purchasing power among the Nation's transit agencies. In fact public funding for transit, measured in 2006 constant dollars, increased by 1.3% between 2004 and 2006.

Funding for capital investments by transit operators in the United States comes principally from public sources. Capital investments include the design and construction of new transit systems and extensions to current systems (also know as "New Starts") and the modernization of existing fixed assets. In 2006, total public transit agency expenditures for capital investment were $12.8 billion in current dollars (compared with $12.6 billion in current dollars in 2004) and accounted for 30 percent of total available funds. Federal funds were $5.6 billion (compared with $4.9 billion in 2004), State funds were $1.7 billion (compared with $1.8 billion in 2004), and local funds were $5.5 billion (compared with $5.9 billion in 2004). The share of capital funds from Federal sources rose from 39.0 percent in 2004 to 43.5 percent in 2006.

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2006, $30.6 billion was available for operating expenses (compared with $26.9 billion in 2004) and accounted for 70 percent of total available funds. Of this amount, $2.5 billion was provided by the Federal government (compared with $2.0 billion in 2004), $6.9 billion was provided by State governments (compared with $6.0 billion in 2004), $8.9 billion by local governments (compared with $7.9 billion in 2004), and $12.3 billion by system-generated revenues (compared with $10.9 billion in 2004). In 2006, transit operators' actual operating expenditures were $29.0 billion compared with $25.4 billion in 2004, a total increase of 14.1 percent.

The Federal share of funds for operating expenses increased from 7.5 percent in 2004 to 8.2 percent in 2006. Transit agencies in 56 urbanized areas that were slated to lose their eligibility to use Federal formula funding to finance transit operations starting in FY 2002 (as a result of being reclassified as urbanized areas with populations over 200,000) were allowed to continue as a result of the Transit Operating Flexibility Act passed in September 2002. Under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, these transit agencies may continue to use formula funds for operating expenses in FY 2005 at 100 percent of their FY 2002 apportionment, in FY 2006 at 50 percent of their FY 2002 apportionment, and in FY 2007 at 25 percent of their FY 2002 apportionment.

PART II

Investment/Performance Analysis

Introduction

Chapters 7 through 10 present and analyze future capital investment scenario estimates for highways, bridges, and transit. These chapters provide general investment benchmarks as a basis for the development and evaluation of transportation policy and program options. The 20-year investment scenario estimates shown in these chapters reflect the total capital investment from all sources that is projected to be required to achieve certain levels of performance. **They do not directly address specific public or private revenue sources that might be used to finance the investment under each scenario, nor do they identify how much might be contributed by each level of government.**

These four investment-related chapters include the following analyses:

Chapter 7, **Potential Capital Investment Impacts**, analyzes the projected impacts of different future levels of investment on measures of physical condition, operational performance, and other benefits to system users. These levels are based on alternative annual rates of increase or decrease in constant dollar investment over 20 years. The chapter also includes analyses of alternative highway funding mechanisms and their potential impacts on the performance of both highways and transit systems.

Chapter 8, **Selected Capital Investment Scenarios**, draws upon the information presented in Chapter 7, providing additional details on the mix of investment suggested by the models for different funding levels, and comparing this mix to the current distribution of capital spending by type of improvement (especially rehabilitation and expansion). Some of these scenarios are oriented around maintaining different aspects of system condition and performance, while others link to broader measures of system user benefits. The scenarios included in this chapter are intended to be illustrative and do not represent comprehensive alternative transportation policies; the Department does not endorse any of these scenarios as a target level of investment.

Chapter 9, **Scenario Implications**, provides supplemental analyses and discussion aimed at putting the scenarios presented in Chapter 8 into their proper context. It includes comparisons of historic capital funding levels to recent condition and performance trends, and of historic system use patterns to the State and MPO forecasts of future system use that underlie the scenarios. The chapter also discusses other implications of the material presented in Chapters 7 and 8.

Chapter 10, **Sensitivity Analysis**, explores the impact that changing some of the key assumptions underlying the analyses presented in Chapters 7 and 8 would have on the projected impacts of alternative levels of capital investment. The investment scenario projections in this report are developed using models that evaluate current system condition and operational performance and make 20-year projections based on certain assumptions about the life spans of system elements, future travel growth, and other model parameters. The accuracy of these projections depends, in large part, on the underlying assumptions used in the analysis. The uncertainty inherent in the estimates is further discussed below.

Unlike Chapters 1 through 6, which largely include highway and transit statistics drawn from other sources, the investment scenario projections presented in these chapters (and the models used to create the projections) were developed exclusively for the C&P report. The procedures for developing the investment scenario estimates have evolved over time to incorporate new research, new data sources, and improved estimation techniques relying on economic principles. The methodologies used to analyze investment for highways, bridges, and transit are discussed in greater detail in Appendices A, B, and C.

The combination of engineering and economic analysis in this part of the report is consistent with the movement of transportation agencies toward asset management, value engineering, and greater consideration of cost effectiveness in decision making. The economic approach to transportation investment is discussed in greater detail below.

The Economic Approach to Transportation Investment Analysis

Background

The methods and assumptions used to analyze future highway, bridge, and transit investment scenarios are continuously evolving. Since the beginning of the highway report series in 1968, innovations in analytical methods, new empirical evidence, and changes in transportation planning objectives have combined to encourage the development and application of improved data and analytical techniques. Estimates of future highway investment requirements, as reported in the 1968 National Highway Needs Report to Congress, began as a combined "wish list" of State highway "needs." As the focus of national highway investment changed from system expansion to management of the existing system during the 1970s, national engineering standards were defined and applied to identify system deficiencies, and the investments necessary to remedy these deficiencies were estimated. By the end of the decade, a comprehensive database, the Highway Performance Monitoring System (HPMS), had been developed to monitor highway system conditions and performance nationwide.

By the early 1980s, a sophisticated simulation model, the HPMS Analytical Process (HPMS-AP), was available to evaluate the impact of alternative investment strategies on system conditions and performance. The procedures used in the HPMS-AP were founded on engineering principles. Engineering standards were applied to determine which system attributes were considered deficient, and improvement option packages were developed using standard engineering practices to potentially correct given deficiencies, but without consideration of comparative economic benefits and costs.

In 1988, the Federal Highway Administration embarked on a long-term research and development effort to produce an alternative simulation procedure combining engineering principles with economic analysis, culminating with the development of the Highway Economic Requirements System (HERS). The HERS model was first utilized to develop one of the two highway investment scenarios presented in the 1995 C&P Report. In subsequent reports, HERS has been used to develop all of the highway investment scenarios.

Executive Order 12893, Principles for Federal Infrastructure Investments, issued on January 26, 1994, directs that Federal infrastructure investments be selected on the basis of a systematic analysis of expected benefits and costs. This order provided additional momentum for the shift toward developing analytical tools that incorporate economic analysis into the evaluation of investment requirements.

In the 1997 C&P Report, the Federal Transit Administration introduced the Transit Economic Requirements Model (TERM), which was used to develop both of the transit investment scenarios. TERM incorporates benefit-cost analysis into its determination of transit investment levels.

The 2002 C&P Report introduced the National Bridge Investment Analysis System (NBIAS), incorporating economic analysis into bridge investment modeling for the first time.

Economic Focus vs. Engineering Focus

The economic approach to transportation investment relies fundamentally upon an analysis and comparison of the economic benefits and costs of potential investments. By providing benefits whose economic value exceeds their costs, projects that offer "net benefits" have the potential to increase societal welfare and are thus considered to be "good" investments from a public perspective. The cost of an investment in transportation infrastructure is simply the straightforward cost of implementing an improvement project.

The benefits of transportation capital investments are generally characterized as the attendant reductions in costs faced by transportation agencies (such as for maintenance), users of the transportation system (such as savings in travel time and vehicle operating costs), and others who are affected by the operation of the transportation system (such as reductions in health or property damage costs).

Traditional engineering-based analytical tools focus mainly on estimating transportation agency costs and the value of resources required to maintain or improve the condition and performance of infrastructure. This type of analytical approach can provide valuable information about the cost effectiveness of transportation system investments from the public agency perspective, including the optimal pattern of investment to minimize life-cycle costs. However, this approach does not fully consider the potential benefits to users of transportation services from maintaining or improving the condition and performance of transportation infrastructure.

By incorporating the value of services that transportation infrastructure provides to its users, the HERS, TERM, and NBIAS models each have a broader focus than traditional engineering-based models. They also attempt to take into account some of the impacts that transportation activity has on non-users and recognize how investments in transportation infrastructure can alter the economic costs of these impacts. By expanding the scope of benefits considered in their analysis, these models are able to yield an improved understanding of existing and future investment needs for the Nation's surface transportation system.

Using this economics-based approach to analyze potential transportation investment is likely to result in different decisions about the catalog of desirable improvements than would be made using a purely engineering-based approach. For example, if a highway segment, bridge, or transit system is greatly underutilized, benefit-cost analysis might suggest that it would not be worthwhile to fully preserve its condition or to address its engineering deficiencies. Conversely, a model based on economic analysis might recommend additional investments to expand capacity or improve travel conditions above and beyond the levels dictated by an analysis that simply minimized engineering life-cycle costs, if doing so would provide substantial benefits to the users of the system.

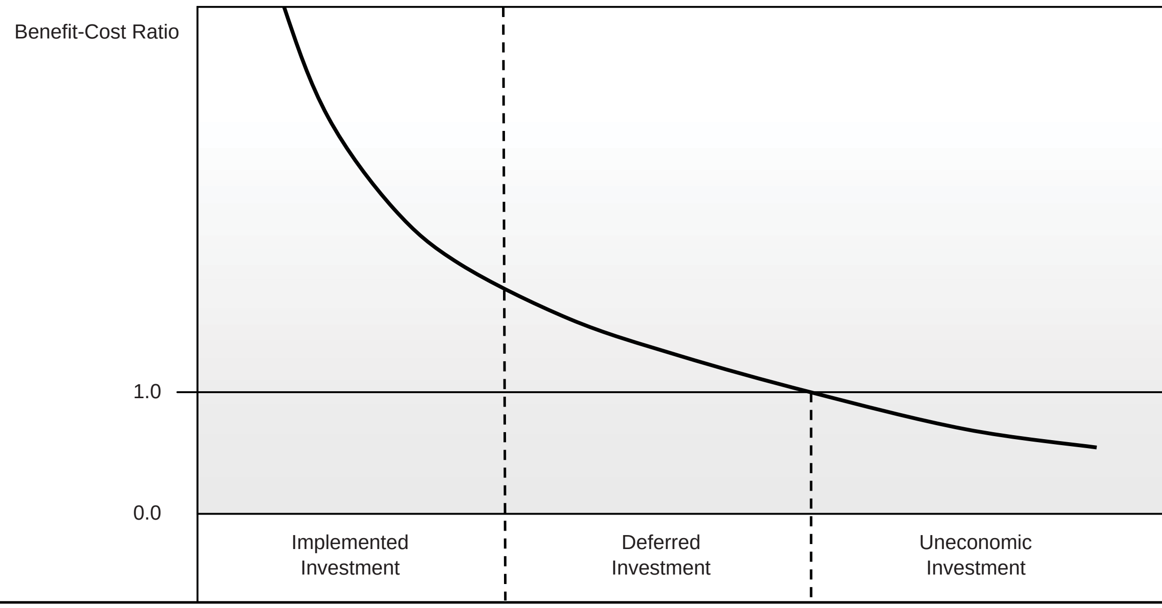
The economics-based approach also provides a more sophisticated method for prioritizing potential improvement options when funding is constrained. By identifying investment opportunities according to the net benefits they offer, economic analysis helps to provide guidance in directing limited transportation capital investment resources toward the types of system improvements that can together provide the largest benefits to transportation system users. Such an approach, which is applied in HERS, is illustrated in *Exhibit II-1*. Projects are ranked in order by their benefit-cost ratios, and are then successively implemented until the funding constraint is reached. Projects that would produce lesser net benefits would be deferred for reconsideration in the future.

One implication of prioritizing potential projects in this manner is that the marginal and average benefit-cost ratios associated with a program of improvements will decline as the overall level of investment rises. As the relative returns on potential highway, bridge, and transit investments decline, it becomes more likely that competing potential public or private sector investments will yield more net benefits to society.

Theoretically, if the level of available funding were great enough, it would be possible to implement all cost-beneficial projects. Projects that do not meet this threshold of economic viability (because they do not offer positive net benefits and thus cannot increase total net benefits provided by transportation system infrastructure) should not be selected or implemented, even if sufficient funding were available.

Exhibit II-1

Economically Efficient Investment



Financing Mechanisms and Investment Analysis

As discussed in Chapter 6, highway user revenues (including fuel taxes, motor-vehicle fees, and tolls) are one of the primary sources of funding for highway-related expenditures in the United States. This is particularly true for expenditures funded by the Federal government, which are predominantly drawn from user charges and are devoted primarily to capital outlay, but it is also a significant factor for State and local government expenditures. Private sector investment in highways is also dependent on revenue streams (primarily tolls) from users of the privately financed facilities. By raising the out-of-pocket costs of highway travel to users, highway user charges tend to reduce the demand for use of the system, and thereby reduce the amount of investment that would be required to achieve a given level of condition and performance, or to exhaust all cost-beneficial investments. While user charges levied on a fixed rate per-mile or per-gallon basis have an impact on traveler behavior, variable rate user charges with rates tied to the time of day or real-time congestion levels have the potential to have much larger impacts on peak-period travel.

The HERS model has been adapted to support analyses of the link between broad types of alternative financing mechanisms and projected future investment/performance relationships. The analyses presented in Chapter 7 of this report assume that any increases in highway and bridge capital investment above 2006 levels would be funded from non-user sources, user charges imposed on a fixed rate per-mile basis (such as a vehicle mile travelled [VMT] charge), or user charges imposed on variable rate basis (such as congestion pricing). Any excess revenues stemming from decreases in highway and bridge investment below 2006 levels were assumed to be rebated to users in the form of reductions to existing fixed rate user charges. For each of the selected highway capital investment scenarios described in Chapter 8, two versions are presented, one assuming fixed rate user financing and the other assuming variable rate user financing.

Recent editions of this report have used changes in average highway user costs as a proxy for changes in the underlying physical conditions and operational performance of highway systems. In this context, highway-user costs would not include existing or potential future fixed rate or variable rate user charges, as such charges have nothing to do with the actual state of the highway system.

The sources of funding for transit-related expenditures have traditionally been more diverse that those for highways because passenger fares, fuel taxes, sales taxes, and other public funding mechanisms all play a significant role in financing transit. Consequently, the linkages between financing mechanisms and future investment/performance relationships discussed above for highways are less critical from the transit perspective, and are not directly modeled in the transit investment analyses presented in this report. The analyses of potential bridge investment relationships also do not directly consider such linkages.

Congestion Pricing

When highway users make decisions about whether, when, and where to travel, they consider both the implicit costs (such as travel time and safety risk) and explicit, out-of-pocket costs (such as fuel costs and tolls) of the trip. Under normal operating conditions, their use of the road will not have an appreciable effect on the costs faced by other users. As traffic volumes begin to approach the carrying capacity of the road, however, traffic congestion and delays begin to set in and travel times for all users begin to rise, with each additional vehicle making the situation progressively worse. However, individual travelers do not take into account the delays and additional costs that their use of the facility imposes on other travelers, focusing instead only on the costs that they bear themselves. Economists refer to this divergence between the costs an individual user bears and the total added costs each additional user imposes as a congestion externality. Ignoring this externality is likely to result in an inefficiently high level of use of congested facilities, resulting in a loss of some of their potential benefits to users.

To maximize net societal benefits, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby "internalizing" the congestion externality, spreading peak traffic volumes more efficiently (but not necessarily eliminating all congestion delay), and increasing net benefits to users. In such a case, the economically efficient level of investment in highways would depend on the cost of building, preserving, and operating highways; valuations of travel time, vehicle operating costs, and safety; and interest rates. The price signals that such an arrangement would produce would also help guide the location of future investment in capacity expansion toward those areas where it would produce the greatest benefits.

The HERS model has been adapted to provide quantitative estimates of the impact that more efficient pricing could have on the future highway investment/performance relationships. These analytical procedures assume congestion pricing would be implemented universally on all congested roads, with variable rates set for individual facilities based on the marginal cost that each user of the facility imposes on all others during the peak travel period. While these charges would be applied for the principal purpose of congestion mitigation, they would be expected to generate significant amounts of revenue. The analyses in this report assume that such revenues would be available to support any additional investment assumed for a particular highway investment scenario, and would be supplemented by additional fixed rate user charges if necessary. To the extent that the revenues from variable rate user charges would exceed the amount needed to support a given highway investment scenario, the excess revenues were assumed to be rebated to users in the form of reductions to existing fixed rate user charges. It should be noted, however, that the actual disposition of such revenues would be at the discretion of the entity that imposes the charges, and that such revenues could instead be used to support additional investment in transit systems to accommodate travelers that might opt to change transportation modes in response to the adoption of congestion pricing, or for a variety of other transportation or nontransportation purposes.

For this report, the TERM model was utilized to predict the impact that the widespread adoption of highway congestion pricing might be expected to have on transit systems. These analyses assumed that a portion of the peak-period highway travel reductions predicted by HERS would translate into higher transit passenger growth, which would in turn affect projected future investment/performance relationships for transit systems. Chapter 8 includes some transit capital investment scenarios assuming higher passenger growth rates that are linked to specific highway congestion pricing scenarios.

While most transit routes have excess capacity (measured either in terms of passengers per vehicle or vehicles per route mile), some heavily used lines in major metropolitan areas do approach their passenger-carrying capacities during peak travel hours, with commensurate deterioration in the quality of service. As with highways, some of this overcrowding relates to the underpricing of transit service during rush hours. These overcrowded transit lines are often in corridors with heavily congested highway service, making a joint solution to the pricing problems on both highways and transit not only more important to impose, but also more complicated to analyze, devise, and implement.

The analyses of congestion pricing presented in this report focus mainly on their potential impacts on future investment/performance relationships, particularly in regards to the amount of combined public and private investment that might be needed to achieve particular outcomes in terms of future system performance. This report does not address social equity issues associated with congestion pricing, or the mechanics of how economically optimal rates would be computed or assessed on a real time basis. Some of these concerns could be addressed by directing a portion of the revenues generated by congestion pricing to compensate groups of individuals that would be negatively impacted, or to invest in technological improvements to improve the efficiency and operation of the tolling system. Significant advances in tolling technology have been made in recent years that have reduced both the operating costs of toll collection and the delays experienced by users from stopping or slowing down at collection points. Other advances have made it possible to charge different toll rates during different time periods, in some cases varying the price dynamically with real-time traffic conditions. While some of these technologies require extensive roadway infrastructure (and would thus likely be deployed only on high-volume, limited access roads), other in-vehicle technologies utilizing global positioning system devices are being developed that could make it possible to assess fees on virtually any roadway.

The HERS methodology for estimating the impacts of congestion pricing is presented in greater detail in Appendix A. The current approach has some technical limitations, and does not fully address the network effects associated with drivers diverting to other roads. Consequently, this report does not include any analyses of the potential impacts of partial implementation of congestion pricing on selected facilities. The baseline analyses of the impacts of variable rate user financing mechanisms presented in Chapters 7 and 8 assume the immediate universal implementation of efficient pricing. While this is not technically feasible, it would be consistent with an investment philosophy that if one believes that congestion pricing will ultimately be adopted on a widespread basis, then one's shorter term investment decisions should be made with that in mind, to avoid overbuilding today. Chapter 9 includes an analysis of the implications of delaying the implementation of pricing for 10 years. New analytical procedures are currently being developed for use in HERS that will improve its ability to analyze alternative congestion pricing strategies; these research efforts are discussed in the "Pricing Effects" section in Part IV of this report.

Fixed Rate User Financing and Non-User Financing

The highway investment analyses presented in Chapter 7 and 8 based on fixed rate user financing effectively assume a future in which variable-rate user charges will not be widely adopted. In the absence of efficient pricing, options for reducing congestion externalities and increasing societal benefits are limited. One possibility would be to invest in additional roadway capacity beyond the level that would be optimal under efficient pricing, thereby reducing congestion generally and the attendant costs that highway users impose on one another. This is sometimes referred to as a "second-best" solution to the problem of optimal highway investment. One implication of this is that the maximum efficient level of investment in highway capacity would likely be larger under the current system of highway user charges (primarily fees such as fuel taxes that do not vary with congestion levels) than would be the case with efficient, marginal cost pricing of highway use.

While the HERS model is equipped to analyze the impacts of imposing fixed rate user charges to cover any specified percentage of any assumed increase in highway investment levels, the analyses presented in this report consider only two alternatives. The non-user funding alternative assumes that 0 percent of increased investment would come from highway users, while the fixed user funding options assumes that 100 percent of increased investment would come from user charges imposed on a per-VMT basis. This approach differs from that used in the 2006 C&P Report, which assumed charges on a per-gallon basis, but is considered more appropriate for long term analysis, given current trends towards alternative fueled vehicles.

As noted above, TERM does not specifically model the linkage between future investment levels and financing mechanisms, which implicitly assumes non-user financing of future improvements, except to the extent that an increase in passenger miles travelled would translate into additional farebox revenues.

Multimodal Analysis

The HERS, TERM, and NBIAS all use a consistent approach for determining the value of travel time and the value of reducing transportation injuries and fatalities, which are key variables in any economic analysis of transportation investment. While HERS, TERM, and NBIAS all utilize benefit-cost analysis, their methods for implementing this analysis are very different. The highway, transit, and bridge models each rely on separate databases, making use of the specific data available for each mode of the transportation system and addressing issues unique to that mode.

These three models have not yet evolved to the point where direct multimodal analysis would be possible. For example, HERS assumes that, when lanes are added to a highway, this causes highway user costs to fall, resulting in additional highway travel. Some of the increased use of the expanded facility would result from newly generated travel, while some would be the result of travel shifting from transit to highways. However, HERS is unable to distinguish between these different sources of additional highway travel. At present, there is no direct way to analyze the impact that a given level of highway investment in a particular location would have on the transit investment in that vicinity (or vice versa). Opportunities for future development of HERS, TERM, and NBIAS, including efforts to allow feedback between the models, are discussed in Part IV.

This report does include some indirect multimodal analysis on a systemwide basis. As noted above, TERM was used to analyze the potential impacts of the diversion of highway travelers to transit alternatives in conjunction with the adoption of widespread highway congestion pricing.

Uncertainty in Transportation Investment Modeling

The three investment analysis models used in this report are deterministic rather than probabilistic, meaning that they provide a single projected value of total investment for a given scenario rather than a range of likely values. As a result, it is only possible to make general statements about the limitations of these projections, based on the characteristics of the process used to develop them, rather than giving specific information about confidence intervals.

As in any modeling process, simplifying assumptions have been made to make analysis practical and to meet the limitations of available data. While potential highway improvements are evaluated based on benefit-cost analysis, not all external costs (such as noise pollution) or external benefits (such as the net favorable impacts of highway improvements on productivity and competition in the economy) that may be considered in the actual selection process for individual projects are reflected in the investment models. Across a broad program of investment projects, such external effects may fully or partially cancel each other out, but to the extent that they do not, the "true" level of investment required to achieve a particular goal may be either higher or lower than those predicted by the model. Some projects that HERS, TERM, or NBIAS view as economically justifiable may not be after more careful scrutiny, while other projects that the models would reject might actually be justifiable if these other factors were considered.

While it is not possible to present precise confidence ranges for the estimates found in this report, it is possible to examine the sensitivity of the estimates to changes in some of the key parameters underlying the models. Such an analysis is presented in Chapter 10.

Capital Investment Scenarios

The 20-year capital investment scenario projections shown in this report reflect complex technical analyses that attempt to predict the impact that capital investment may have on the future conditions and performance of the transportation system. These scenarios are intended to be illustrative, and the U.S. Department of Transportation does not endorse any of them as a target level of investment. Where practical, supplemental information has been included to describe the impacts of other possible investment levels.

This report does not attempt to address issues of cost responsibility. The investment scenarios predict the impact that particular levels of combined Federal, State, local, and private investment might have on the overall conditions and performance of highways, bridges, and transit. While Chapter 6 provides information on what portion of highway investment has come from different revenue sources in the past, the report does not make specific recommendations about how much could or should be contributed by each level of government or the private sector in the future.

All of the capital investment scenarios are stated in constant 2006 dollars, and cover the period from 2007 through 2026.

Highway and Bridge Investment Scenarios

Future investments in highways and bridges are analyzed independently by separate models and techniques for a variety of alternative funding levels in Chapter 7, and the results are combined for the selected investment scenarios in Chapter 8. The NBIAS considers investments related to bridge repair, rehabilitation, and replacement. Investments for capacity expansion and the highway resurfacing and reconstruction component of system rehabilitation are modeled by HERS. While this model was primarily designed to analyze highway segments, HERS also factors in the costs of expanding bridges and other structures when deciding whether to add lanes to a highway segment. The costs reported for the investment scenarios also include adjustments made using external procedures, allowing elements of system rehabilitation, system expansion, and system enhancement that are not modeled in NBIAS or HERS to be reflected in the estimates. The investment scenario estimates shown should thus reflect the realistic size of the total highway capital investment program that is projected to be required in order to meet the performance goals specified in the scenarios.

Five selected scenarios are presented in Chapter 8 for the Interstate System, National Highway System, and the overall highway and bridge system; additional supplementary scenarios are shown for the systemwide analysis only. For each of these scenarios, two versions are presented, one assuming fixed rate user financing, and the other assuming variable rate user financing.

The **Sustain Current Spending scenario** projects the potential impacts of maintaining capital spending at base year 2006 levels in constant dollar terms over the 20-year period 2007 through 2026. The **Sustain Conditions and Performance scenario** assumes that combined public and private capital investment gradually changes in constant dollar terms over 20 years to the point at which two key performance indicators in 2026 are maintained at their base year 2006 levels. These indicators are adjusted average user costs (as computed by HERS) and the backlog of potential cost-beneficial bridge investments (as computed by NBIAS), which are intended to serve as summary measures of the overall conditions and performance of highways and bridges.

Three additional scenarios focus on the impacts of increasing combined public and private investment up to the point at which all potential capital improvements meeting a target benefit-cost ratio would be funded by 2026. These target benefit-cost ratios apply to the types of improvements modeled in HERS, and are set at 1.5, 1.2, and 1.0, respectively, in the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios**. The **MinBCR=1.0 scenario** represents an "investment ceiling" above which it would not be cost-beneficial to invest, even if available funding was unlimited. The version of this scenario assuming the widespread adoption of variable-rate user charges is also described as the "**Maximum Economic Investment**" level, as it reflects conditions under which users would be charged an economically rational price to travel on facilities that would be improved only to the extent that such investment was cost-beneficial. As the economic procedures in NBIAS are not as refined as those in HERS, comparable analyses are not currently feasible; consequently, the NBIAS component of each of these scenarios is identical, and is computed as the level of investment that would eliminate the total economic backlog of cost-beneficial investments to address bridge deficiencies by the end of the 20-year analysis period.

Two supplemental scenarios are presented at the systemwide level only. The **Sustain Conditions and Performance of System Components scenario** focuses on maintaining specific performance indicators for individual highway functional systems rather than more general indicators for the system as a whole. This scenario combines three elements: (1) the level of system expansion expenditures associated with maintaining average delay per VMT, (2) the level of system rehabilitation expenditures associated with maintaining average pavement roughness, and (3) the level of system rehabilitation expenditures associated with maintaining the economic investment backlog for bridges. The **Sustain Conditions and Improve Performance scenario** is a hybrid, combining the system rehabilitation expenditures from the **Sustain Conditions and Performance of System Components scenario** with the system expansion expenditures from the **MinBCR=1.0 scenario**.

In considering the future system performance impacts identified for each of these scenarios, it is important to note that they represent what **could** be achievable assuming a particular level of investment, rather than what **would** be achieved. While the models focus on engineering impacts and economic benefits and assume that projects would be carried out strictly in descending order of benefit-cost ratio, other factors do in fact influence project selection in actual practice. If some projects with lower benefit-cost ratios were carried out instead of projects with higher ratios, then the actual amount necessary to achieve any specific performance objective would be higher. Consequently, the level of investment identified as the amount sufficient to sustain a certain performance level should be viewed as the minimum amount that would be sufficient, if all other modeling assumptions prove to be accurate. This issue is discussed in more detail in Chapter 7, in a Q&A box titled "How closely does the HERS model simulate the actual project selection process of State and local highway agencies?"

Simply increasing the combined public and private spending to the **Maximum Economic Investment** level would not in itself guarantee that these funds would be expended in a cost-beneficial manner. Achieving the projected results for this scenario would require a combination of increasing spending and modifying Federal highway program requirements and State and local government practices to ensure that no project would be implemented unless its estimated benefits exceeded its estimated costs. There may also be some projects selected by the models, that, regardless of their economic merits or impact on conditions and performance, may simply be infeasible for political or other reasons. As a result, the supply of feasible cost-beneficial projects could possibly be exhausted at a lower level of investment than is indicated by this scenario. It is important to note that simple benefit-cost analysis is not a commonly utilized capital investment model in the private sector. Instead, firms utilize a rate of return approach and compare various investment options and their corresponding risk. In other words, a project that is barely cost-beneficial would almost certainly not be undertaken by the private sector when compared with an array of investment options that potentially produce higher return at equivalent or lower risk.

Transit Investment Scenarios

The transit section of Chapter 7 evaluates the impact of varying levels of capital investment on various measures of condition and performance, while the transit section of Chapter 8 provides a more in-depth analysis of specific investment scenarios. TERM uses separate modules to analyze different types of investments: those aimed at the physical condition of existing assets, those intended to maintain current operating performance, and those that would improve operating performance. TERM projects estimated capital investment to achieve the following benchmarks which are then combined to form the four primary investment scenarios:

<u>Maintain Asset Conditions</u>: Transit assets are replaced and rehabilitated over the 20-year period such that the average condition of the assets existing at the beginning of the period remains the same at the end of the period.

<u>Maintain Performance</u>: New transit vehicles and infrastructure investments are undertaken to accommodate increases in transit ridership so that the vehicle utilization rate existing at the beginning of the period remains the same at the end of the period.

<u>Improve Conditions</u>: Transit asset rehabilitation and replacement is accelerated to improve the average condition of all transit assets to a "good" level at the end of the 20-year period (2026). However, if an average condition of good can be reached only by replacing assets that are still in operationally acceptable condition, then the "Improve Conditions" scenario instead targets a slightly lower condition level.

<u>Improve Performance</u>: The performance of the Nation's transit system is improved as additional investments in bus rapid transit, light rail, or heavy rail are undertaken in urbanized areas with the most crowded vehicles and the systems with the slowest speeds to reduce vehicle utilization rates (and crowding) and increase average transit operating speeds.

The **Maintain Conditions and Performance scenario** identifies the level of investment needed to meet the Maintain Asset Conditions and Maintain Performance benchmarks. The **Improve Conditions and Maintain Performance scenario** reflects the investment needed to achieve the Improve Conditions and Maintain Performance benchmarks, while the **Maintain Conditions and Improve Performance scenario** reflects the Maintain Asset Conditions and Improve Performance benchmarks. The **Improve Conditions and Performance scenario** identifies the level of investment needed to meet the Improve Conditions and Improve Performance benchmarks. For each of these four primary scenarios, transit investments are disaggregated by type of improvement, type of asset, and urbanized area size. A fifth scenario, the **Maintain Current Funding scenario**, identifies the potential impacts on selected measures of conditions and performance of sustaining 2006 transit capital spending levels in constant dollar terms over the 2007 to 2026 period.

For Chapter 7 select analyses, a **Replace at Condition 2.5** threshold was incorporated as an additional scenario to assess the impact of this investment strategy. This condition rating is defined within the parameters of TERM's transit asset condition rating system of 1 to 5 (poor to excellent). The Rail Modernization Study, released by FTA in April 2009, considered an asset to be in a state of good repair when the physical condition of that asset is at or above a threshold condition rating value of 2.5 (the mid-point between adequate and marginal). Similarly, an entire transit system would be in a state of good repair if all of its assets all have a condition value of 2.5 or higher. The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than 2.5.

For each of the four primary scenarios, two versions are presented in Chapter 8, one reflecting a minimum benefit-cost ratio of 1.0, and one reflecting a minimum benefit-cost ratio of 1.2. TERM has two benefit-cost tests. One test is applied to all potential investments to maintain conditions, improve conditions, and maintain performance and compares the benefits to riders and society of continuing to maintain each agency-mode with the costs of maintaining each agency-mode over a 20-year period. A separate test is applied on an urbanized area basis to investments proposed to improve performance; this test assesses whether the benefits to an urbanized area from the speed improvements would exceed the costs of these investments. Raising the benefit-cost ratio threshold from 1.0 to 1.2 reduces the number of agency-modes in which TERM will invest; each version of the scenario represents the investment level associated with meeting the scenarios objectives based on the set of agency modes being considered.

For both versions of the four primary scenarios, Chapter 8 also covers an additional set of analyses that consider the level of transit investment that could be needed to serve individuals diverted from autos due to the influence of the widespread adoption of congestion pricing on highways. These analyses are linked to the variable-rate user financing versions of the highway **Sustain Current Spending** and **Maximum Economic Investment scenarios** described above.

Comparisons Between Report Editions

The investment scenario estimates presented in Part II are intended to be comparable with previous editions of the C&P report. However, it is important to consider the following factors when making such comparisons.

Different Base Years: The future investment scenario estimates are calculated in constant base year dollars. However, since the base year changes between reports, inflation alone will cause the dollar estimates to tend to rise over time. Given the sharp increases in construction costs experienced in recent years, stating the investment requirements in 2006 dollars rather than 2004 dollars makes a big difference in the apparent size of the investment scenario levels.

Changes in Condition or Performance: Changes in the physical condition or operational performance of the highway or transit systems may affect the investment scenario estimates between reports. It is important to recognize that the conditions of "today" (i.e., 2006) in this report differ from the conditions of "today" (i.e., 2004, 2002, etc.) as presented in previous editions of the report. Hence, as the level of current system conditions and performance varies over time, the investment scenarios that are based on maintaining the status quo are effectively targeting something different each time.

If performance for a particular indicator has been deteriorating over time, this effectively results in a "lowered bar" for scenarios aimed at maintaining that indicator at baseline levels, which would tend to exert downward pressure on the level of investment associated with such scenarios. Conversely, if an indicator is improving over time, then the "Maintain" scenarios tied to that indicator would represent an increasing standard that is being maintained, which would tend to drive up the price tag associated with the scenarios.

The situation is somewhat the opposite for scenarios aimed at improving performance over time. If the conditions and performance of the underlying system deteriorate over time, then the models are likely to find more potential improvement projects to be cost-beneficial, or to find more improvements necessary to improve the conditions or performance of the system, which would tend to drive up the costs associated with the "Improve" scenarios. Conversely, if the system conditions and performance were to improve over time, this could reduce the pool of potential cost-beneficial investments.

<u>Expansion of the Asset Base</u>: As the Nation's highway and transit systems expand over time, the cost of maintaining this larger asset base will also tend to increase. For assets with useful lifetimes of less than 20 years, expansions of the infrastructure will also generate additional rehabilitation and replacement investment under the scenarios.

<u>Changes in Technology</u>: Changes in transportation technology may cause the price of capital assets to increase or decrease over time and thus affect the capital investment scenario estimates.

<u>Changes in Scenario Definitions</u>: Although the C&P report series has consistently reported investment levels for "Maintain" and "Improve" scenarios over time, the exact definition of these scenarios may change from one report to another. Such changes are explicitly noted and discussed in the text of the report when this occurs.

<u>Changes in Analytical Techniques</u>: The models and procedures used to generate the investment scenario estimates are subject to ongoing refinements and improvements, resulting in better estimates over time. The underlying data series used as inputs in the models may also be subject to changes in reporting requirements over time.

Chapter 7

Potential Capital Investment Impacts

Potential Highway Capital Investment Impacts

This section projects the impacts that alternative levels of future investment in highways and bridges might be expected to have on various measures of system conditions and performance. The analyses presented here focus mainly on types of capital investment that can be directly modeled using the Highway Economic Requirements System (HERS) and the National Bridge Investment Analysis System (NBIAS). The capital investment scenarios presented in Chapter 8 draw upon these analyses, but also consider other types of capital investment that are not currently modeled in HERS or NBIAS.

This section also explores the implications of alternative funding mechanisms on the level of combined public and private investment that would potentially be required to achieve certain performance objectives. The options identified include funding from non-user based sources, funding from fixed rate user based sources, and funding from variable rate user based sources such as congestion pricing.

The accuracy of these projections depends on the validity of the technical assumptions underlying the analysis. Chapter 10 explores the impacts of altering some of these assumptions.

A subsequent section within this chapter explores comparable information for different types of potential future transit investments. This is followed by a section providing a crosswalk between the highway, bridge, and transit sections with the information presented in the previous edition of this report.

Highway Economic Requirements System

The investment scenario estimates shown in this report for highway resurfacing and reconstruction and highway and bridge capacity expansion are developed primarily from HERS, a simulation model that employs incremental benefit-cost analysis to evaluate highway improvements. The HERS analysis is based on data from the Highway Performance Monitoring System (HPMS), which provides information on current roadway characteristics, conditions, and performance and anticipated future travel growth for a nationwide sample of more than 119,000 highway sections. While HERS analyzes these sample sections individually, the model is designed to provide results valid at the national level. HERS does not provide definitive improvement recommendations for individual highway segments.

The HERS model analyzes highway investment by first evaluating the current state of the highway system using information on pavements, geometry, traffic volumes, vehicle mix, and other characteristics from the HPMS sample dataset. It then considers potential improvements on sections with one or more deficiencies, including resurfacing, reconstruction, alignment improvements, and widening or adding travel lanes. HERS then selects the improvement with the greatest net benefits, where benefits are defined as reductions in direct highway user costs, agency costs, and societal costs. In cases where none of the potential improvements produces benefits exceeding construction costs, the segment is not improved. Appendix A contains a more detailed description of the project selection and implementation process used by HERS.

Operations Strategies

The HERS model also takes into account the impact that new investments in certain types of intelligent transportation systems (ITSs) and the continued deployment of various operations strategies can have on highway system performance, as well as on the estimated level of capital investment that would be needed to

How closely does the HERS model simulate the actual project selection processes of State and local highway agencies?

Q&A

The HERS model is intended to approximate, rather than replicate, the decision processes used by State and local governments. HERS does not have access to the full array of information that local governments would use in making investment decisions. This means that the model results may include some highway and bridge improvements that simply are not feasible because of factors the model doesn't consider, such as political issues or other practical impediments. Excluding such projects would result in reducing the "true" level of investment that is economically justifiable. Conversely, the highway model assumes that State and local project selection will be economically optimal and doesn't consider external factors such as the distribution of projects among the States or within each State. In actual practice, projects are often not selected on the basis of their benefit-cost ratios; there are other important factors included in the project selection process aside from economic considerations. Thus, the "true" level of investment that would achieve the outcome desired under the scenarios could be higher than the estimates shown in this report.

Currently, approximately 20 States make some use of benefit-cost analysis in managing their transportation programs; only six States use the technique regularly. This means that the majority of transportation decisions in the United States today are being made with limited reference to the projected benefits and costs of a specific course of action relative to another course of action.

reach given performance benchmarks. This feature was introduced in the 2004 edition of the C&P report. The types of operations investments and strategies considered include freeway management (ramp metering, electronic roadway monitoring, variable message signs, integrated corridor management, and variable speed limits); incident management (incident detection, verification, and response); arterial management (upgraded signal control, electronic monitoring, and variable message signs); and traveler information (511 systems and advanced in-vehicle navigation systems with real-time traveler information).

Future operations investments are implemented in HERS through an assumed, exogenously specified scenario; they are not included directly in the benefit-cost calculations made within the model, and HERS does not directly consider any tradeoffs or complementarities between ITS and other types of highway improvements. The baseline scenario used for this report assumes the continuation of existing deployment trends. This scenario was used for all of the HERS-based analyses presented in Chapters 7, 8, and 9. Chapter 10 includes a sensitivity analysis considering the potential impacts of a more aggressive deployment of operations strategies and ITS. Appendix A includes a more complete description of the operations strategies and their impacts on performance.

Travel Demand Elasticity

One of the key economic analysis features of HERS involves its treatment of travel demand. Recognizing that drivers will respond to changes in the relative price of driving and adjust their behavior accordingly, HERS explicitly models the relationship between the amount of highway travel and the price of that travel. This concept, sometimes referred to as travel demand elasticity, is applied to the forecasts of future travel found in the HPMS sample data. The HERS model assumes that the forecasts for each sample highway segment represent a future in which average conditions and performance are maintained, thus holding highway user costs at current levels. Any change in user costs relative to the initial conditions calculated by HERS will thus have the effect of either inducing or suppressing future travel growth on each segment. Consequently, for any highway investment scenario that results in a decline in average user costs, the effective vehicle miles traveled (VMT) growth rate for the overall system will tend to be higher than the baseline rate derived from HPMS. For scenarios in which highway user costs increase, the effective VMT growth rate will tend to be lower than the baseline rate. A discussion of the impact that future investment levels could be expected to have on future travel growth is included in Chapter 9.

Linking Financing Mechanisms and Investment Impacts

The HERS model has recently been modified to allow the exploration of linkages between different types of financing mechanisms used to generate revenues for highway investment and the relationship between alternative investment levels and future system performance. If the revenues needed to support a higher level of future capital investment were generated from non-user sources (such as property taxes or general governmental revenues), then future travel demand would not be significantly affected by the cost of funding infrastructure improvements. However, if such revenues were generated from fixed-rate user charges (such as a VMT charge or fuel tax), the costs experienced by users would rise, resulting in some reduction to the effective VMT growth rate, which would in turn impact the operational performance of the system. To the extent that such revenues were generated directly from individual users by variable-rate user charges (such as congestion pricing, in which users pay according to the costs they impose on the system), the impact on peak period travel would be more dramatic, resulting in significant impacts on system performance for a given level of highway investment. Appendix A includes more details on how this feature was implemented in HERS.

National Bridge Investment Analysis System

The scenario estimates relating to bridge repair and replacement shown in this report are derived primarily from NBIAS. This model incorporates analytical methods from the Pontis bridge management system, which was first developed by the Federal Highway Administration in 1989 and is now owned and licensed by the American Association of State Highway and Transportation Officials. NBIAS, however, incorporates additional economic criteria into its analytical procedures. Pontis relies on detailed structural element-level data on bridges to support its analysis; NBIAS adds a capability to synthesize such data from general bridge condition ratings reported for all bridges in the National Bridge Inventory (NBI). While the analysis in this report is derived solely from NBI data, the current version of NBIAS is capable of processing element-level data directly.

The NBIAS model uses a probabilistic approach to model bridge deterioration for each synthesized bridge element. It relies on a set of transition probabilities to project the likelihood that an element will deteriorate from one condition state to another over a given period of time. The model then determines an optimal set of repair and rehabilitation actions to take for each bridge element, based on the condition of the element. NBIAS can also apply preservation policies at the individual bridge level and directly compare the costs and benefits of performing rehabilitation or repair work relative to completely replacing the bridge.

To estimate functional improvement needs, NBIAS applies a set of improvement standards and costs to each bridge in the NBI. The model then identifies potential improvements—such as widening existing bridge lanes, raising bridges to increase vertical clearances, and strengthening bridges to increase load-carrying capacity—and evaluates their potential benefits and costs. The NBIAS model is discussed in more detail in Appendix B.

Types of Capital Spending Projected by HERS and NBIAS

Chapter 6 identifies three major groups of capital improvement types: System Rehabilitation, System Expansion, and System Enhancement. The types of bridge improvements modeled in NBIAS roughly correspond to the types of bridge improvements classified as System Rehabilitation in Chapter 6. Because NBI data are available for bridges on all functional systems, NBIAS can be used directly to compute the bridge components of future investment scenarios that address the highway system as a whole.

For those functional systems for which data are available, the HERS evaluates types of improvements that roughly correspond to the types of highway resurfacing and reconstruction improvements classified as System Rehabilitation in Chapter 6. HERS also evaluates potential widening improvements, consistent with the types of improvements classified as System Expansion in Chapter 6. As the widening costs considered in HERS reflect both the typical costs of adding lanes per mile of roadway under different circumstances and the costs of modifying a typical number of structures per mile in conjunction with a widening project, the HERS estimates are considered to represent system expansion costs for both highways and bridges. In summary, HERS measures system rehabilitation costs for highways, and system expansion costs for highways and bridges combined; NBIAS measures system rehabilitation costs for bridges.

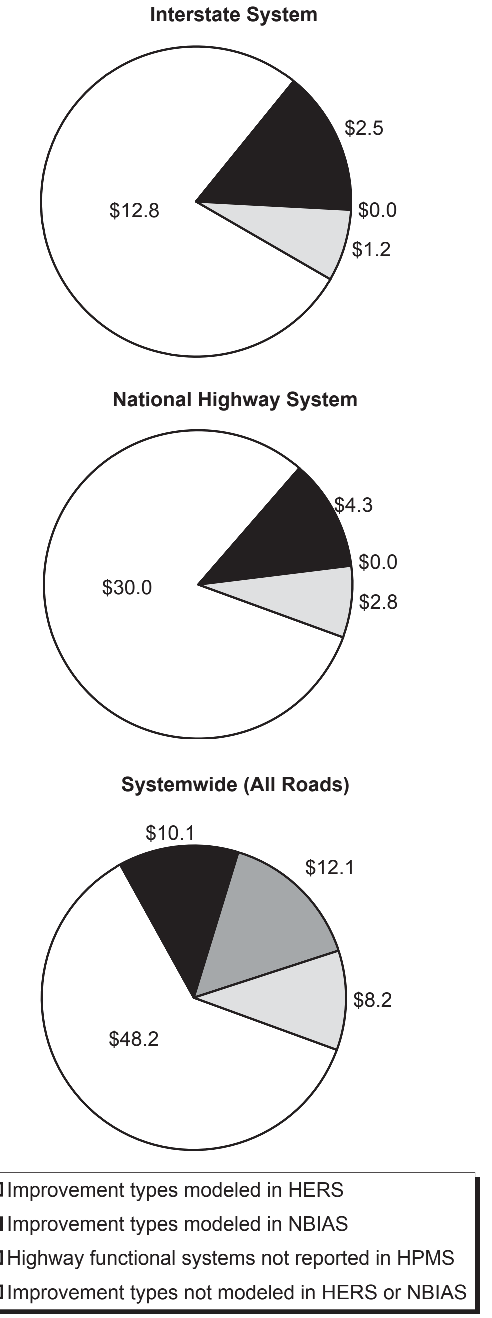
The HPMS sample segment database used by HERS is limited to Federal-aid highways, and thus excludes roads classified as rural minor collector, rural local, or urban local. Consequently, in order to develop future investment scenarios that address the highway system as a whole, it is necessary to account for these functional systems outside of the modeling process. HERS and NBIAS do not directly evaluate the types of improvements that correspond to the types of improvements classified as System Enhancement in Chapter 6. Thus, developing future investment scenarios that account for these types of improvements also requires external adjustments to be made to the directly modeled improvements generated by HERS and NBIAS. The term **"non-modeled spending"** is used throughout this chapter and subsequent chapters to refer to spending on capital improvements that is not captured in the HERS or NBIAS analyses.

Exhibit 7-1 identifies the portion of total public and private capital investment on highways and bridges in 2006 that corresponds to the types of improvements modeled in HERS and NBIAS. Of the $16.5 billion of capital investment on the Interstate System in 2006, approximately $12.8 billion (77.5 percent) was used for types of improvements modeled in HERS. Approximately $2.5 billion (15.1 percent) was used for types of improvements modeled in NBIAS, while $1.2 billion (7.4 percent) went for types of improvements not addressed by either HERS or NBIAS.

Of the $37.1 billion of capital investment on the National Highway System (NHS) as a whole in 2006, including the Interstate System,

Exhibit 7-1

Portion of 2006 Capital Expenditures Equivalent to Investment Types Modeled in HERS and NBIAS (Billions of Dollars)



Sources: Highway Statistics 2006, Table SF-12A and unpublished FHWA data.

How closely do the capital improvement types presented in Chapter 6 line up with the types of improvements modeled in HERS and NBIAS?

Q&A

The reconstruction without added capacity, restoration and rehabilitation, and resurfacing capital improvement types included within System Rehabilitation expenditures in Chapter 6 correspond well to the types of capital improvements modeled in HERS. Reconstruction with added capacity is split between System Rehabilitation and System Expansion in Chapter 6, and must also be split between these categories in the HERS output.

Among the improvement types classified as System Expansion for existing roads, the major widening category from Chapter 6 lines up best with types of improvements modeled in HERS, because such improvements are generally motivated by a desire to address congestion on a facility. The relocation improvement type is also a relatively good fit, although some relocation improvements are motivated primarily by safety concerns more than congestion concerns, and might not be picked up in the HERS analysis.

While HERS does not directly model the construction of new roads and bridges, many such investments are motivated by a desire to alleviate congestion on existing facilities in a corridor, and thus would be captured indirectly by the HERS analysis in the form of additional normal-cost or high-cost lanes. As described in Appendix A, the costs per mile assumed in HERS for high-cost lanes are based on typical costs of tunneling, double-decking, or building parallel routes, depending on the functional class and area population size for the section being analyzed. To the extent that investments in new construction and new bridge categories identified in Chapter 6 are motivated by desires to encourage economic development or accomplish other goals aside from the reduction of congestion on the existing highway network, such investments would not be picked up in the HERS analysis. A study conducted by FHWA's National Systems & Economic Development Team suggests that an estimated $0.5 billion to $2.0 billion per year is spent on highways for economic development purposes. This study is available at: http://www.fhwa.dot.gov/planning/econdev/taskabjan30_1.htm

The bridge replacement, major bridge rehabilitation, and minor bridge work categories included as part of System Rehabilitation expenditures in Chapter 6 generally correspond to the types of capital improvements for bridges modeled in NBIAS. However, the expenditure data may include work on bridge approaches and ancillary improvements that would not be picked up in the modeling.

The safety, traffic management/engineering, and environmental and other capital improvement categories identified as part of System Enhancement expenditures in Chapter 6 are treated as if they are not captured in the HERS or NBIAS analyses. However, some safety deficiencies may be addressed as part of broader pavement and capacity improvements modeled in HERS. Also, the HERS Operations preprocessor described in Appendix A includes capital investments in operations equipment and technology that would fall under the traffic management/engineering category in Chapter 6.

approximately $30.0 billion (80.8 percent) was used for types of improvements modeled in HERS. Approximately $4.3 billion (11.6 percent) was used for types of improvements modeled in NBIAS, while $2.8 billion (7.4 percent) went for types of improvements not addressed by either HERS or NBIAS.

On a systemwide basis, the portion of capital spending modeled in HERS is only 61.3 percent, or $48.2 billion out of a total $78.7 billion. This percentage is lower than the comparable values for the Interstate or NHS due to the highway functional systems for which sample section data are not collected through HPMS, which make up $12.1 billion (15.9 percent) of total 2006 capital spending. Approximately $10.1 billion (12.9 percent) of total capital spending was used for types of improvements modeled in NBIAS, while $8.2 billion (10.5 percent) went for system enhancement expenditures which are not addressed by either HERS or NBIAS.

Alternative Levels of Future Capital Investment Analyzed

The specific investment levels reflected in the exhibits in this section were selected from a much larger series of analyses. **Each level corresponds to a particular point of interest, such as the amount of investment that is projected to be sufficient to maintain a particular highway or bridge performance indicator at**

its base year level, or the amount that would finance all potential capital improvements up to a particular benefit-cost ratio cutoff. For each of these analyses, it was assumed that any increase or decrease in combined public and private investment would be phased in gradually, at a constant rate relative to 2006.

Exhibit 7-2 shows alternative annual rates of increase or decrease in combined future systemwide public and private capital investment and how these would translate into investment levels for individual years, cumulative investment over 20 years, and average annual investment. The average annual investment levels at an annual growth rate of 0.00 percent correspond to the 2006 investment levels identified above, including $48.2 billion for improvement types modeled in HERS, $10.1 billion for improvement types modeled in NBIAS, and $20.3 billion for nonmodeled spending. Maintaining capital investment in constant dollar terms at 2006 levels would translate to a combined investment of $1.574 trillion over 20 years. As all of the values identified are stated in constant 2006 dollars, it is important to note that additional increases would be needed each year to offset the impact of inflation for the period of 2007 to 2026.

Q&A

How do the assumptions in this report about the pace of changes in alternative investment levels differ from prior C&P reports?

For this report, the annual growth rates relative to 2006 levels shown in the exhibits in this section were applied directly in HERS and NBIAS so that the level of investment for each of the years studied rose over time. This approach is considered more realistic than that utilized in the 2006 C&P Report, which assumed that combined public and private capital investment would immediately jump to the average annual level being analyzed, and remain fixed at that level for 20 years.

The 2006 C&P Report was, in turn, an improvement from the 2004 C&P Report with regard to changing investment levels. The 2004 C&P Report assumed that there would be significant front-loading of capital investment in the early years of the analysis as the existing backlog of potential cost-beneficial investments was addressed followed by a sharp decline in later years.

The progression toward a gradual ramping up of spending in the C&P reports reflects an awareness that abrupt increases in spending levels could initially overburden the construction industry and contribute to significant inflation in infrastructure construction costs.

Chapter 9 includes some analysis regarding the timing of investments.

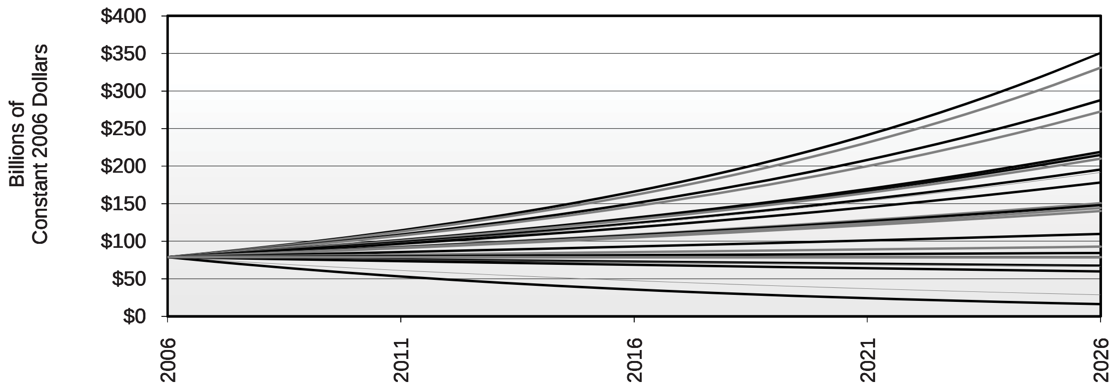
The feasibility of achieving the increases or decreases in constant investment presented in *Exhibit 7-2* was not evaluated as part of this analysis. In addition, the upper end of the range of investment levels evaluated exceeds the amount of spending that would be cost-beneficial for some system components and for some forms of highway financing mechanisms. While each of the particular rates of change selected has some specific analytical significance, the analyses presented in this chapter are not intended to constitute complete investment scenarios, but instead provide the building blocks for the selected scenarios presented in Chapter 8.

Impacts of Systemwide Investments Modeled by HERS

Exhibit 7-1 shows that of total public and private capital spending of $78.7 billion on all roads in 2006, $48.2 billion was utilized for the types of improvements modeled in HERS. This section projects the potential impacts on system performance of raising or lowering this $48.2 billion in constant dollar terms by various annual rates over 20 years. These percentage increases are also applied to the $78.7 billion in the findings presented in this section; this acknowledges that the improvements reflected in HERS represent only one piece of total capital investment, and that the types of improvements reflected in NBIAS or those that are not reflected in either model should also be considered when projecting the impacts of different overall levels of combined public and private investment.

Exhibit 7-2

Alternative Levels of Combined Systemwide Public and Private Capital Investment Analyzed for 2007 to 2026



Annual Percent Change Relative to 2006	Cumulative 2007-2026 Investment (Billions of 2006 Dollars)	Average Annual Investment (Billions of 2006 Dollars) [1]			
		Total Capital Outlay	Spending Modeled in HERS [2]	Spending Modeled in NBIAS [3]	Non-Modeled Spending [4]
7.76%	$3,778	$188.9	$115.7	$24.3	$48.8
7.45%	$3,641	$182.0	$111.5	$23.4	$47.1
6.70%	$3,331	$166.5	$102.0	$21.4	$43.1
6.41%	$3,219	$160.9	$98.6	$20.7	$41.6
5.25%	$2,812	$140.6	$86.1	$18.1	$36.3
5.15%	$2,779	$139.0	$85.1	$17.9	$35.9
5.03%	$2,741	$137.1	$84.0	$17.6	$35.4
4.65%	$2,624	$131.2	$80.4	$16.9	$33.9
4.55%	$2,594	$129.7	$79.5	$16.7	$33.5
4.17%	$2,484	$124.2	$76.1	$16.0	$32.1
3.30%	$2,252	$112.6	$69.0	$14.5	$29.1
3.21%	$2,229	$111.5	$68.3	$14.4	$28.8
3.07%	$2,195	$109.7	$67.2	$14.1	$28.4
2.96%	$2,168	$108.4	$66.4	$14.0	$28.0
2.93%	$2,161	$108.0	$66.2	$13.9	$27.9
1.67%	$1,881	$94.0	$57.6	$12.1	$24.3
0.83%	$1,718	$85.9	$52.6	$11.1	$22.2
0.34%	$1,631	$81.5	$50.0	$10.5	$21.1
0.00%	$1,574	$78.7	$48.2	$10.1	$20.3
-0.78%	$1,451	$72.5	$44.4	$9.3	$18.8
-0.86%	$1,439	$71.9	$44.1	$9.3	$18.6
-1.37%	$1,366	$68.3	$41.8	$8.8	$17.7
-4.95%	$963	$48.2	$29.5	$6.2	$12.5
-7.64%	$757	$37.9	$23.2	$4.9	$9.8

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment for each of the categories shown grows by the percentage shown in each row in constant dollar terms relative to base year levels.

[2] Includes highway resurfacing and reconstruction improvements classified as System Rehabilitation in Chapter 6 as well as highway and bridge widening improvements classified as System Expansion in Chapter 6; excludes improvements to roadways functionally classified as rural minor collector, rural local, or urban local.

[3] Includes all bridge improvements classified as System Rehabilitation in Chapter 6.

[4] Includes improvements classified as System Enhancement in Chapter 6, as well as improvements to roadways classified as rural minor collector, rural local, or urban local that are not caputred in the HERS analysis.

Source: FHWA Staff Analysis.

Alternative Financing Mechanisms

Several of the exhibits in this section compare the potential impacts of alternative financing mechanisms, estimating their relative impact on system performance at a series of alternative funding levels. For funding levels that exceed the current 2006 level of combined public and private highway capital investment, the analyses assume that the additional revenues needed to support such investment would be generated from one of three broad categories: non-user sources, fixed-rate user based sources, or variable-rate user based sources. The selected future highway capital investment scenarios presented in Chapter 8 draw upon some of the analyses presented in this section assuming fixed-rate user based financing or variable-rate user based financing. The non-user sources financing option is not carried forward into Chapter 8.

> **Q&A**
>
> **How do the types of funding mechanisms considered in the HERS analysis relate to private sector investment?**
>
> The HERS analysis does not distinguish among Federal, State, local, or private sector highway spending. Generally, private sector investment in highways is dependent on revenue streams (primarily tolls) from users of the privately owned facilities. If a private entity were to impose variable rate tolls on a time-of-day basis, HERS would evaluate the potential impacts on peak period VMT to be identical to those that would occur if a public sector entity had imposed congestion charges at the same rates.
>
> In theory, a private sector investment could take on the characteristics of a non-user based financing mechanism. For example, if a government were to pay a private entity to manage a facility on the basis of a "shadow toll" based on usage, but did not impose a fee on highway users to cover these costs, the impact on VMT on that facility would be the same as if the local government had managed the facility itself using general revenues as a funding source.

The analyses incorporating funding from non-user based sources assume no linkage between increased spending, increased revenue generation, and highway VMT. The analyses incorporating funding from fixed-rate user based sources assume the application of an inflation indexed charge on a per-VMT basis to generate any funding needed to support a higher level of capital investment. The potential size of this charge was initially determined by computing the difference between the investment level being studied and the current 2006 level of combined public and

> **Q&A**
>
> **Why do the analyses of funding from fixed rate user sources assume a charge imposed on a per-VMT basis, rather than a per-gallon basis?**
>
> This report does not attempt to differentiate among the relative impacts of alternative fixed rate funding mechanisms such as flat tolls, VMT charges, or the motor-fuel tax; the fixed rate financing analyses are intended to be generic and to provide a contrast with the analyses assuming non-user financing or variable rate user financing (i.e., congestion pricing).
>
> HERS has the capability to model fixed rate user charges on either a per-gallon or per-VMT basis. The per-VMT option was selected for this report, recognizing that such charges may well play an important role in highway financing by 2026. Utilizing the per-VMT option also has the advantage of reducing computational complexity, as it does not need to factor in the effects of changing fleet mileage (and the change in differential between passenger vehicles and commercial trucks) as would have been the case had the per-gallon option been utilized. Another motivation for applying the per-VMT option for the fixed rate user financing analyses is to facilitate comparisons with the congestion pricing analyses that assume a variable rate charge imposed on a per-VMT basis.
>
> The reaction of individual drivers to a per-gallon charge would differ in some ways from their response to a per-VMT charge; in particular, a per-gallon charge would provide a more direct incentive to shift to driving a more fuel-efficient vehicle. However, the cumulative impacts of raising a specific amount of revenue from users on a fixed rate basis via a per-gallon charge versus a per-VMT charge are likely to be less significant, particularly in terms of the types of issues discussed in this report. Some limited HERS analyses conducted assuming fixed rate charges imposed on a per-gallon basis suggest that the total estimated amount of cost-beneficial investment would not differ significantly from analyses assuming per-VMT charges. The level of investment required to achieve other performance benchmarks would vary somewhat, but would not be uniformly biased either upward or downward.

private highway capital investment, and dividing that amount by total projected VMT. This initial value was then recomputed iteratively to account for the impact that the imposition of such a charge would have on the overall cost of driving, which would lead to some reduction in VMT growth. As the same fixed VMT charge would be levied throughout the day, such charges would not affect peak period travel differently than off-peak travel, and as such would be similar in effect to a fuel tax—another form of fixed rate user charge. In cases in which the investment level being analyzed was less than the current 2006 capital spending level, a negative fixed VMT charge was applied, simulating the effects of a reduction in highway user charges. **It is important to note that this report does not directly address the issue of the sustainability of current highway financing structures and does not attempt to identify changes in revenue mechanisms or tax rates that might be required to sustain highway capital spending at 2006 levels in constant dollar terms.**

Exhibit 7-3 identifies the difference between the alternative levels of combined public and private capital investment that were analyzed, and actual capital spending in 2006. If capital investment were to grow by 7.76 percent per year in constant dollar terms over the 2006 level of $78.7 billion, this would result in an average annual investment level of $188.9 billion for the period from 2007 to 2026 in constant dollar terms, a difference of $110.2 billion. In contrast, if highway capital investment were to shrink by 7.64 per year in constant dollar terms, this would free up an average annual amount of $40.8 billion for other purposes.

Exhibit 7-3 also translates these constant dollar differences between alternative annual investment levels and actual 2006 capital outlay into dollars-per-VMT figures. The values identified as "Per VMT Modeled in HERS" represent the actual fixed rate-user charges that were assumed for each of the investment levels analyzed based on the particular VMT estimate computed for that investment level. For example, to cover the $103.4 billion average annual revenue that would be required to support an annual increase of capital investment of 7.45 percent per year, the model imposed a surcharge of $0.033 per VMT. In contrast, for the analysis of a 4.95 percent annual decrease in capital investment, the model imposed a negative surcharge of $0.010 per VMT, simulating a reduction in existing user charges. To put these values into perspective, the $171.1 billion identified in Chapter 6 as the total amount generated in 2006 via motor-fuel taxes, motor-vehicle fees, and tolls equates to $0.039 on a per VMT basis, based on total VMT in 2006.

It is important to note that these differences are based on total capital outlay, rather than simply spending modeled in HERS. Because the NBIAS model has no revenue-linkage features and there is no direct way to simulate the relationship between revenue sources and investment levels for non-modeled items, the HERS analyses reflected in this report assume that the VMT surcharge would have to cover increases in these types of spending proportional to any increases in the level of capital investment directly modeled in HERS.

Exhibit 7-3 also identifies values per total VMT and per total gallons of fuel consumption, which are included for informational purposes only. The actual VMT charges modeled in HERS excluded VMT on functional classes for which HPMS sample data are not available (rural minor collector, rural local, and urban local). Hypothetically, if a fixed-rate VMT charge were imposed on all travel based on odometer readings, it would be more realistic to set the rate based on total VMT. Alternatively, if a fixed-rate user charge were implemented via a mechanism that imposed a toll on selected routes based on transponders, it would be more realistic to set the rate based on a subset of total VMT. The smaller the portion of travel included in a VMT-based financing mechanism, the higher the per-VMT charge would have to be to generate the same level of revenue (assuming that no other additional charges would be used to generate revenue from portions of the system not subject to the VMT charge). Note that the shaded cells in *Exhibit 7-3* represent investment levels that were found to exceed the level of potential cost-beneficial investment assuming funding by fixed rate user charges only.

Exhibit 7-3

Additional Revenue Needed to Achieve Alternative Levels of Combined Systemwide Public and Private Capital Investment for 2007 to 2026

Annual Percent Change Relative to 2006	Average Annual Investment (Billions of 2006 Dollars)		Difference Between Annual Investment Levels and 2006 Total Capital Outlay			
	Spending Modeled in HERS [1]	Total Capital Outlay	In Billions of 2006 Dollars [2]	Per VMT [3]: VMT Modeled in HERS	Per VMT [3]: Total VMT	Per Gallon [4]: Total Fuel Consumption
7.76%	$115.7	$188.9	$110.2			
7.45%	$111.5	$182.0	$103.4	$0.033	*$0.028*	*$0.582*
6.70%	$102.0	$166.5	$87.9	$0.028	*$0.024*	*$0.451*
6.41%	$98.6	$160.9	$82.3	$0.026	*$0.022*	*$0.406*
5.25%	$86.1	$140.6	$61.9	$0.020	*$0.017*	*$0.348*
5.15%	$85.1	$139.0	$60.3	$0.019	*$0.016*	*$0.343*
5.03%	$84.0	$137.1	$58.4	$0.019	*$0.016*	*$0.338*
4.65%	$80.4	$131.2	$52.5	$0.017	*$0.014*	*$0.258*
4.55%	$79.5	$129.7	$51.0	$0.016	*$0.014*	*$0.238*
4.17%	$76.1	$124.2	$45.5	$0.015	*$0.012*	*$0.262*
3.30%	$69.0	$112.6	$33.9	$0.011	*$0.009*	*$0.174*
3.21%	$68.3	$111.5	$32.8	$0.010	*$0.009*	*$0.172*
3.07%	$67.2	$109.7	$31.1	$0.010	*$0.008*	*$0.168*
2.96%	$66.4	$108.4	$29.7	$0.010	*$0.008*	*$0.160*
2.93%	$66.2	$108.0	$29.4	$0.009	*$0.008*	*$0.157*
1.67%	$57.6	$94.0	$15.4	$0.005	*$0.004*	*$0.079*
0.83%	$52.6	$85.9	$7.2	$0.002	*$0.002*	*$0.038*
0.34%	$50.0	$81.5	$2.9	$0.001	*$0.001*	*$0.013*
0.00%	$48.2	$78.7	**$0.0**	**$0.000**	***$0.000***	***$0.000***
-0.78%	$44.4	$72.5	-$6.1	-$0.002	*-$0.002*	*-$0.035*
-0.86%	$44.1	$71.9	-$6.7	-$0.002	*-$0.002*	*-$0.038*
-1.37%	$41.8	$68.3	-$10.4	-$0.003	*-$0.003*	*-$0.059*
-4.95%	$29.5	$48.2	-$30.5	-$0.010	*-$0.008*	*-$0.181*
-7.64%	$23.2	$37.9	-$40.8	-$0.013	*-$0.011*	*-$0.204*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

[2] The amounts shown represent the additional revenue that would be required to support an increase in total capital outlay from the 2006 level of $78.7 billion to the alternative level being analyzed.

[3] The values shown represent the annual dollar differences divided by projected annual VMT for the 2007 to 2026 period, based on the set of HERS analyses assuming fixed rate user charges. The "Modeled in HERS" values exclude VMT on rural minor collector, rural local, and urban local functional classes, which were not modeled in HERS.

[4] The values shown represent the annual dollar differences divided by projected fuel consumption for the 2007 to 2026 period, based on the set of HERS analyses assuming fixed rate user charges.

Source: Highway Economic Requirements System.

Variable Rate User Based Sources

The analyses incorporating funding from variable user based sources assumed that such charges would be set at a level at which users of congested facilities would pay a cost equivalent to the negative impact that their use has on other drivers. The projected revenue that would be generated from such congestion charges was then applied to cover the difference between the investment level being studied and the current 2006 level of combined public and private highway capital investment; if the revenue from this congestion charge was not projected to be sufficient for this purpose, the analysis assumed the imposition of an additional fixed rate VMT charge to cover the rest of the difference. In cases where congestion pricing revenue exceeded the level needed to support the level of investment being studied, a negative fixed rate VMT charge was applied, simulating the effects of lowering existing fuel taxes, fixed-rate tolls or other fees imposed on highway users. In the absence of such reductions of existing user charges, this surplus revenue could be applied to support increased investment in highways, transit alternatives, or other initiatives.

Exhibit 7-4 identifies the variable and fixed rate charges computed by HERS for each of the alternative levels of combined systemwide public and private capital investment analyzed. If highway capital investment were to grow by 4.55 percent per year in constant dollar terms over the 2006 level of $78.7 billion, this would result in an average annual investment level of $129.7 billion for the period from 2007 to 2026 in constant dollar terms, a difference of $51.0 billion. At this level of investment, HERS estimates that a congestion charge set in the manner outlined above would generate an average of $38.1 billion annually, leaving $12.9 billion to be covered by a fixed rate VMT charge. The variable congestion charge would

Exhibit 7-4

Estimated Variable and Fixed Rate VMT Charges to Achieve Alternative Levels of Combined Systemwide Public and Private Capital Investment for 2007 to 2026

Annual Percent Change Relative to 2006	Average Annual Investment (Billions of 2006 Dollars)			Additional Revenues Per Year From VMT Charges [2] (Billions of 2006 Dollars)		Charges per VMT Modeled in HERS [3]		
	Spending Modeled in HERS [1]	Total Capital Outlay				Variable Rate		Fixed Rate
		All Types	Difference From 2006	Variable Rate	Fixed Rate	Average Rate Where Imposed	Weighted Average Rate [4]	
4.55%	$79.5	$129.7	$51.0	$38.1	$12.9	$0.339	$0.012	$0.004
4.17%	$76.1	$124.2	$45.5	$38.9	$6.6	$0.341	$0.013	$0.002
3.30%	$69.0	$112.6	$33.9	$40.7	-$6.8	$0.347	$0.013	-$0.002
3.21%	$68.3	$111.5	$32.8	$40.9	-$8.2	$0.348	$0.013	-$0.003
3.07%	$67.2	$109.7	$31.1	$41.2	-$10.2	$0.349	$0.013	-$0.003
2.96%	$66.4	$108.4	$29.7	$41.5	-$11.8	$0.350	$0.014	-$0.004
2.93%	$66.2	$108.0	$29.4	$41.6	-$12.2	$0.350	$0.014	-$0.004
1.67%	$57.6	$94.0	$15.4	$44.1	-$28.7	$0.359	$0.014	-$0.009
0.83%	$52.6	$85.9	$7.2	$45.5	-$38.2	$0.364	$0.015	-$0.012
0.34%	$50.0	$81.5	$2.9	$46.3	-$43.5	$0.367	$0.015	-$0.014
0.00%	$48.2	$78.7	**$0.0**	$47.0	-$47.0	$0.370	$0.015	-$0.015
-0.78%	$44.4	$72.5	-$6.1	$48.2	-$54.3	$0.375	$0.016	-$0.018
-0.86%	$44.1	$71.9	-$6.7	$48.3	-$55.0	$0.375	$0.016	-$0.018
-1.37%	$41.8	$68.3	-$10.4	$49.1	-$59.5	$0.378	$0.016	-$0.019
-4.95%	$29.5	$48.2	-$30.5	$53.5	-$84.0	$0.396	$0.017	-$0.027
-7.64%	$23.2	$37.9	-$40.8	$55.5	-$96.3	$0.404	$0.018	-$0.031
3.75%	$72.6	$118.4	$39.8	$39.8	**$0.0**	$0.344	$0.013	**$0.000**

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

[2] The variable rate values shown represent the estimated dollar amounts generated by variable user charges, based on the set of HERS analyses assuming variable rate user charges. The difference between these revenues and the total amount needed to achieve each target funding level was assumed to come from fixed rate user charges. Negative fixed rate user charges indicate that the variable user charges would generate more revenue than would be needed to support the level of investment being analyzed.

[3] The rates shown were computed using the projected annual VMT for the 2007 to 2026 period based on the set of HERS analyses assuming variable rate user charges, and exclude VMT on rural minor collector, rural local, and urban local functional classes. The "Average Rate Where Imposed" values represent the average toll imposed on congested sections. The "Weighted Average Rate" factors in the many sections for which no congestion charge is applied.

[4] The weighted averages shown represent the revenues generated from variable rate user charges divided by total VMT, factoring in the many locations and times of day where no charge would be imposed.

Source: Highway Economic Requirements System.

vary widely by location; in 2026, the amounts imposed on individual highway sections would range from $0.00 to approximately $3.79 per VMT. In those locations in which a congestion charge would be imposed, the average rate applied would be $0.339 per VMT; factoring in the many locations and times of day where no charge would be imposed brings the systemwide weighted average down to $0.012 per VMT. In order to generate sufficient revenues to support this level of investment, an additional fixed rate VMT charge of $0.004 per mile would need to be imposed. It should be noted that the combination of the weighted average variable rate VMT charge and the additional fixed rate charge is roughly consistent with the flat $0.016 cents per VMT charge identified in *Exhibit 7-3* based on revenues from fixed rate user charges only for the same level of investment. *Exhibit 7-4* does not reflect any potential increases in highway capital investment of more than 4.55 percent per year because such levels were found to exceed the level of potential cost-beneficial investment assuming funding by variable rate user charges.

Q&A

How do the estimates of potential revenues from congestion pricing charges identified in this report compare to other estimates?

The particular approach to modeling variable rate user charges in this report—setting the rates at a level equal to the marginal cost that each new driver on a congested facility imposes on other drivers—is only one of many approaches that could be used. Analyses in which charges are set at levels designed to achieve specific speed or throughput targets or analyses assuming mixed use facilities including both tolled and non-tolled lanes, would naturally tend to produce different results. Alternative assumptions regarding driver responses to a given price change and future traffic volumes would also influence the results, as would the time period covered by the analyses.

Other studies have estimated the revenue potential of congestion pricing to exceed $100 billion per year, which is more than double the level reflected in this report.

Exhibit 7-4 also shows that the average rates and revenues from variable congestion charges are projected to decline as the level of capital investment rises. This occurs because a portion of the increased capital investment would be directed towards capacity expansion projects that would alleviate some congestion, so that the impact that each additional driver on a congested roadway would have on all other drivers on that section would be smaller. In many cases, the revenues generated from variable congestion charges would exceed the amount of additional revenue needed to support this investment. If highway capital investment were to be held steady at $78.7 billion in constant dollar terms, all of the $47.0 billion projected to be generated from the variable rate congestion charges (averaging $0.370 per VMT where such a charge is imposed) would be available for other purposes, such as reductions to existing fixed rate user charges. This amount is more than sufficient to fully offset all existing motor fuel and motor vehicle taxes imposed at the Federal and local government levels, while allowing some reductions in State-level taxes as well. [See *Exhibit 6-1* and *Exhibit 6-2* in Chapter 6]. Alternatively, such surplus revenue could be utilized to reduce all existing fixed rate highway user charges at the Federal, State, and local levels by approximately 40 percent in constant dollar terms.

The last data row in *Exhibit 7-4* identifies the level of highway capital investment at which HERS predicts that the revenue generated by variable rate congestion charges would be exactly equal to difference between that level of investment and base year 2006 spending. The model estimates that if highway capital investment were to grow by 3.75 percent per year in constant dollar terms over the 2006 level of $78.7 billion, this would result in an average annual investment level of $118.4 billion for the period from 2007 to 2026 in constant dollar terms, a difference of $39.8 billion. This difference matches the amount of revenue that HERS projects would be generated by a congestion charge set in the manner outlined above, so that no additional revenue from fixed rate user charges would be needed to support this level of investment.

Impact of Future Investment on Overall Highway Conditions and Performance

The HERS model defines benefits as reductions in highway user costs, agency costs, and societal costs. Highway user costs include those related to travel time, vehicle operation, and crashes. Recent editions of the C&P report have used changes in highway user costs as a proxy for changes in overall highway conditions and performance. **It is important to note that in this context, highway user costs are being used to quantify the impacts that the conditions and performance of the system have on highway users; therefore, they do not include taxes imposed on highway users.** Thus, the fixed rate and variable rate VMT charges identified in the preceding section are not included as a component of highway user costs affected by the conditions and performance of the system.

While the user costs in this report are based primarily on 2006 values, the projections of future user costs have been modified to reflect the Energy Information Administration's (EIA) forecast of future fuel efficiency for the vehicle fleet from its *Annual Energy Outlook 2008* publication. EIA's forecast incorporates the effect of changes in Corporate Average Fuel Economy (CAFE) standards required by the Energy Independence and Security Act of 2007 (Public Law 110-140). **While these fuel efficiency improvements will result in real changes in the costs experienced by highway users, they do not represent impacts that system conditions and performance have on highway users**. Applying EIA's projected fuel economy values through 2026 to the base year 2006 data would reduce the HERS baseline estimate of highway user costs by 2.5 percent, from $1.0980 per mile to $1.0703 per mile. For this report, this reduced value is used as the basis for describing changes in **"Adjusted User Costs"** in order to provide a statistic that better reflects overall system conditions and performance. The analyses presented in this chapter are based on EIA's reference case forecast of future fuel prices; Chapter 10 includes an analysis of the potential impacts of replacing these estimates with values from EIA's high price forecast.

Q&A

What changes have been proposed in CAFE standards, and what impacts are these changes expected to have?

The Energy Independence and Security Act of 2007 (Public Law 110-140) included several provisions to increase the fuel efficiency of the American motor vehicle fleet, including a requirement to raise CAFE standards. On April 22, 2008, the U.S. Department of Transportation proposed a 25 percent increase in fuel efficiency standards over 5 years for new passenger vehicles and light trucks. For passenger cars, the proposal would increase fuel economy from the current 27.5 miles per gallon to 35.7 miles per gallon by 2015. For light trucks, the proposal would increase fuel economy from 23.5 miles per gallon in 2010 to 28.6 miles per gallon in 2015. The impacts of these standards on the fuel economy of the overall vehicle fleet will be felt gradually as new vehicles replace older, less fuel-efficient vehicles.

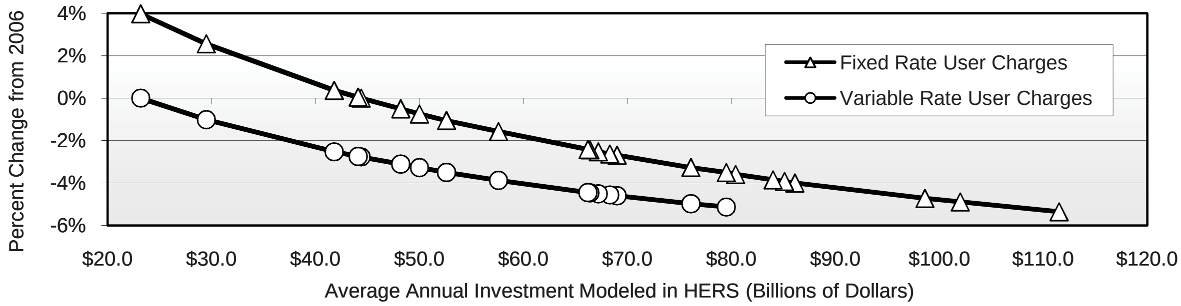
In announcing the rule, the U.S. Department of Transportation estimated the proposal would save nearly 55 billion gallons of fuel and reduce carbon dioxide emissions by 521 million metric tons annually. The Department also estimated that the plan would save the Nation's drivers at least $100 billion in fuel costs over the lifetime of the vehicles covered by the rule.

The 2008 rulemaking builds on two earlier changes that increased the mileage requirements for light trucks.

Exhibit 7-5 describes how average total user costs and average adjusted user costs are influenced by the total amount invested in highways, and the financing mechanisms employed to support such investment. While the percentage reductions in highway user costs appear relatively small, it is important to recognize that they include the costs associated with all travel time, not just the additional travel time that results from congestion. A significant portion of travel time is not directly related to delay, but rather is simply a function of the physical separation between trip origins and destinations. There is, therefore, a limit on the ability of highway investment to cause dramatic reductions in this key component of user costs. Similarly, a large portion of vehicle operating costs are independent of the conditions and performance of the highway

Exhibit 7-5

Projected Changes in 2026 Highway User Costs Compared With 2006 Levels for Different Possible Funding Levels and Financing Mechanisms



Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]		Percent Change in User Costs on Roads Modeled in HERS					
			Average User Costs			Adjusted Average User Costs[2]		
			Funding Mechanism[3]			Funding Mechanism[3]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	-5.2%			-2.8%		
7.45%	*$182.0*	$111.5	-5.0%	-5.4%		-2.6%	-2.9%	
6.70%	*$166.5*	$102.0	-4.6%	-4.9%		-2.2%	-2.4%	
6.41%	*$160.9*	$98.6	-4.4%	-4.7%		-2.0%	-2.3%	
5.25%	*$140.6*	$86.1	-3.8%	-4.0%		-1.3%	-1.5%	
5.15%	*$139.0*	$85.1	-3.7%	-3.9%		-1.2%	-1.4%	
5.03%	*$137.1*	$84.0	-3.6%	-3.9%		-1.1%	-1.4%	
4.65%	*$131.2*	$80.4	-3.4%	-3.6%		-0.9%	-1.1%	
4.55%	*$129.7*	$79.5	-3.3%	-3.5%	-5.1%	-0.8%	-1.0%	-2.7%
4.17%	*$124.2*	$76.1	-3.1%	-3.3%	-5.0%	-0.6%	-0.8%	-2.5%
3.30%	*$112.6*	$69.0	-2.6%	-2.7%	-4.6%	-0.1%	-0.2%	-2.1%
3.21%	*$111.5*	$68.3	**-2.5%**	-2.6%	-4.6%	**0.0%**	-0.1%	-2.1%
3.07%	*$109.7*	$67.2	-2.4%	**-2.5%**	-4.5%	0.1%	**0.0%**	-2.0%
2.96%	*$108.4*	$66.4	-2.3%	-2.4%	-4.5%	0.2%	0.1%	-2.0%
2.93%	*$108.0*	$66.2	-2.3%	-2.4%	-4.4%	0.2%	0.1%	-2.0%
1.67%	*$94.0*	$57.6	-1.5%	-1.6%	-3.9%	1.0%	1.0%	-1.4%
0.83%	*$85.9*	$52.6	-1.0%	-1.1%	-3.5%	1.5%	1.5%	-1.0%
0.34%	*$81.5*	$50.0	-0.8%	-0.7%	-3.3%	1.8%	1.8%	-0.8%
0.00%	*$78.7*	$48.2	-0.5%	-0.5%	-3.1%	2.0%	2.1%	-0.6%
-0.78%	*$72.5*	$44.4	-0.1%	**0.0%**	-2.8%	2.5%	2.6%	-0.3%
-0.86%	*$71.9*	$44.1	**0.0%**	0.0%	-2.7%	2.6%	2.6%	-0.2%
-1.37%	*$68.3*	$41.8	0.3%	0.4%	**-2.5%**	2.9%	3.0%	**0.0%**
-4.95%	*$48.2*	$29.5	2.4%	2.6%	-1.0%	5.0%	5.2%	1.6%
-7.64%	*$37.9*	$23.2	3.8%	4.0%	**0.0%**	6.4%	6.7%	2.6%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for total capital outlay are included to reflect other spending not modeled in HERS.

[2] The "Adjusted Average User Costs" statistic estimates changes in user costs attributable to changes in overall system conditions and performance. This statistic excludes projected reductions in user costs attributable to improved fuel economy resulting from changes to the CAFE standards.

[3] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT, which will impact the level of performance that would be achieved.

Source: Highway Economic Requirements System.

system, and a significant portion of crash costs are the result of behavioral factors that would be difficult to address solely through highway infrastructure investment.

The percent changes in user costs shown in *Exhibit 7-5* are also tempered by the operation of the elasticity features in HERS. The model assumes that, if user costs are reduced on a section, additional travel will shift to that section. This additional traffic volume tends to offset some of the initial reduction in user costs. Conversely, if user costs increase on a highway segment, drivers will be diverted away to other routes or other modes, or will eliminate some trips entirely. When some vehicles abandon a given highway segment, the remaining drivers benefit in terms of reduced congestion delay, which offsets part of the initial increase in user costs. The impact of different investment levels on highway travel is discussed in the next section.

Exhibit 7-5 shows that current spending levels would be more than adequate to maintain average user costs in 2026 at 2006 levels, due to projected improvements in vehicle fuel economy. If capital spending on the types of improvements modeled in HERS were increased at an annual rate of approximately 3.21 percent in constant dollar terms, and this increased investment were financed by non-user sources, then it would be possible to reduce average user costs by 2.5 percent (therefore maintaining adjusted user costs at their base year level). If a fixed rate user charge financing mechanism were used instead, then in order to maintain adjusted user costs (equivalent to a 2.5 percent reduction in highway user costs), combined public and private highway capital investment would need to increase at an annual rate of 3.07 percent in constant dollar terms.

If variable rate user charges were instituted on all congested highway sections, then 2006 spending levels are projected to be more than adequate to maintain either average user costs or adjusted average user costs at their 2006 levels. A decrease in spending at an annual rate of approximately 1.37 percent in constant dollar terms would still allow adjusted average user costs to be maintained (equivalent to a 2.5 percent reduction in highway user costs), while an annual decrease of 7.64 percent would still be adequate to maintain average user costs.

Exhibit 7-5 also shows that for any given funding level, average highway user costs (excluding taxes) will be lower when a variable rate user charge is imposed than when fixed rate user charges or non-user sources serve as the funding mechanism. Charging highway users to finance highway investments in general, and charging peak period users to pay for the societal costs associated with peak period highway use in particular, allows the highway system to operate in a more efficient and rational manner from an economic perspective. For example, if combined public and private investment levels were sustained at 2006 levels, HERS projects that average user costs would decrease by 3.1 percent over 20 years if variable rate user charges were employed as a financial mechanism. In contrast, average user costs would decline by only 0.5 percent over 20 years if either fixed rate user charges or non-user sources were employed.

Assuming variable rate user charges were imposed, an annual increase of 4.55 percent over 2006 levels could result in a 5.1 percent decrease in average highway user costs in 2026 relative to 2006. This would translate into annual user costs savings of approximately $202 billion, based on projected future VMT at that level of investment. HERS projects that this is the greatest amount of user costs savings that can be achieved; additional investments beyond this point would not be cost-beneficial. In other words, this level of investment would be adequate to support all potential investments whose discounted stream of future benefits were equal to or exceeded their construction costs, which is mathematically represented by a benefit-cost ratio of 1.0 or higher. The benefit-cost ratios associated with each of the alternative levels of investment presented in *Exhibit 7-5* for each funding mechanism are identified later in this chapter.

To a certain extent, additional investment in highway capacity expansion can serve as a partial substitute for the economically efficient pricing of highway facilities, and achieve some reduction in highway user costs. Constant dollar spending could grow at an average rate of 7.45 percent assuming a fixed rate user charge mechanism, or 7.76 percent assuming a non-user based financing mechanism, while still being invested in a cost-beneficial manner. However, as shown in *Exhibit 7-5*, despite these sharply higher levels of capital investment, neither of these financing mechanisms could reduce average user costs appreciably more than the reduction cited above as achievable at a much lower cost in conjunction with the application of congestion pricing (i.e., variable rate user charges).

Exhibit 7-5 also demonstrates that the performance impacts of financing through non-user sources are not significantly different than those projected for fixed-rate user based financing. These differences become larger as the level of highway investment increases beyond the current spending level because the imposition of fixed rate surcharges to support higher investment levels would offset a portion of the increased VMT that might otherwise occur. Conversely, if spending were to fall below current levels in constant dollar terms, the relative increase in user costs would be higher assuming that the savings were refunded to highway users in the form of lower highway user charges, which would tend to offset some of the reduction in VMT that might otherwise occur.

Projected VMT in 2026

Exhibit 7-6 identifies the projected VMT in 2026 for alternative investment levels and funding mechanisms. The values shown for HERS-modeled roads excludes VMT on functional classes for which HPMS sample

Exhibit 7-6

Projected VMT in 2026 for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]		Projected VMT in 2026 (Trillions of VMT)					
			On HERS-Modeled Roads			Estimated on All Roads		
			Funding Mechanism[2]			Funding Mechanism[2]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	3.762			*4.456*		
7.45%	*$182.0*	$111.5	3.758	3.662		*4.452*	*4.338*	
6.70%	*$166.5*	$102.0	3.749	3.669		*4.442*	*4.347*	
6.41%	*$160.9*	$98.6	3.746	3.671		*4.437*	*4.349*	
5.25%	*$140.6*	$86.1	3.733	3.678		*4.422*	*4.357*	
5.15%	*$139.0*	$85.1	3.732	3.678		*4.421*	*4.357*	
5.03%	*$137.1*	$84.0	3.731	3.679		*4.419*	*4.358*	
4.65%	*$131.2*	$80.4	3.726	3.679		*4.414*	*4.359*	
4.55%	*$129.7*	$79.5	3.725	3.680	3.596	*4.413*	*4.359*	*4.260*
4.17%	*$124.2*	$76.1	3.721	3.680	3.596	*4.407*	*4.360*	*4.260*
3.30%	*$112.6*	$69.0	3.710	3.681	3.594	*4.396*	*4.360*	*4.258*
3.21%	*$111.5*	$68.3	3.709	3.681	3.594	*4.394*	*4.360*	*4.257*
3.07%	*$109.7*	$67.2	3.708	3.681	3.594	*4.392*	*4.360*	*4.257*
2.96%	*$108.4*	$66.4	3.706	3.680	3.593	*4.391*	*4.360*	*4.257*
2.93%	*$108.0*	$66.2	3.706	3.680	3.593	*4.390*	*4.360*	*4.257*
1.67%	*$94.0*	$57.6	3.692	3.679	3.588	*4.374*	*4.358*	*4.251*
0.83%	*$85.9*	$52.6	3.683	3.677	3.584	*4.363*	*4.356*	*4.246*
0.34%	*$81.5*	$50.0	3.678	3.675	3.582	*4.357*	*4.354*	*4.243*
0.00%	*$78.7*	$48.2	3.674	3.674	3.579	*4.352*	*4.352*	*4.240*
-0.78%	*$72.5*	$44.4	3.666	3.671	3.575	*4.343*	*4.349*	*4.235*
-0.86%	*$71.9*	$44.1	3.665	3.671	3.574	*4.342*	*4.349*	*4.234*
-1.37%	*$68.3*	$41.8	3.660	3.669	3.572	*4.335*	*4.346*	*4.231*
-4.95%	*$48.2*	$29.5	3.624	3.648	3.550	*4.293*	*4.322*	*4.205*
-7.64%	*$37.9*	$23.2	3.602	3.633	3.534	*4.267*	*4.304*	*4.187*

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT.

Source: Highway Economic Requirements System.

data are not available (rural minor collector, rural local, and urban local). The estimated values for all roads were computed by applying the 20-year growth in VMT for HERS-modeled roads to total VMT on all roads in 2006. The projected VMT for all funding mechanisms identified in *Exhibit 7-6* are influenced by the changes in user costs identified in *Exhibit 7-5*. The projected VMT assuming fixed rate user financing are also affected by the fixed charges identified in *Exhibit 7-3*, while the projected VMT assuming variable rate user financing are affected by both the variable and fixed charges identified in *Exhibit 7-4*.

Exhibit 7-6 shows that if current spending levels were sustained in constant dollar terms, then projected VMT for HERS-modeled roads would rise from 2.561 trillion in 2006 to 3.674 trillion by 2026 assuming financing by either non-user sources or by fixed rate user charges, since the fixed rate charge in this instance would be zero. Assuming that the imposition of variable rate user charges offset by reductions to existing fixed rate user charges would slow the growth in VMT, the projected level in 2026 would be only 3.579 trillion. Similarly, if spending were to grow by 4.55 percent per year in constant dollar terms, projected VMT would be 3.680 trillion assuming fixed rate user financing compared to 3.596 assuming variable rate user financing. These differences occur because traveling at off-peak is not a perfect substitute for peak period travel, and more individuals would be likely to eliminate trips or seek out alternative modes of travel in response to a targeted peak period variable highway user charge than would be the case for a more broadly imposed fixed user charge. The transit section of Chapter 8 includes some analysis of the potential impacts that variable rate highway user charges could have on future transit travel growth and on the operational performance of transit systems. The implications of projected future growth rates are discussed in more detail in Chapter 9.

Q&A

Why do the projected VMT values assuming financing through fixed rate user charges start to decline after investment levels reach a certain point?

The decline in projected VMT for investment assuming fixed rate user financing begins to decline after projected investment rises past an annual growth rate of approximately 3.3 percent. This occurs because, as noted above, the VMT charge assumed by HERS is applied to only the VMT on HERS modeled roads, but was set at a level adequate to support higher funding for all types of capital investment, not just spending modeled in HERS. At a certain point, this charge has a deterrent effect on VMT growth that is stronger than the positive effect on such growth caused by declines in average highway user costs associated with improved conditions and performance.

Had the VMT charge been applied more broadly in this analysis, this decline would be smaller, or would not occur.

User Cost Components

Travel time costs constitute approximately 48.7 percent of the HERS baseline estimate of highway user costs in 2006 of $1.0980 per mile. Vehicle operating costs constitute approximately 35.0 percent of total user costs, while crash-related costs (which are reflected in vehicle insurance costs and other social costs) make up the remaining 16.3 percent. *Exhibit 7-7* describes how travel time costs and vehicle operating costs are influenced by the total amount invested in highways, and the financing mechanisms employed to support such investment.

Exhibit 7-7 indicates that vehicle operating costs are expected to decline at all levels of investment, regardless of which financing mechanism is used. As described earlier, the HERS analyses for this report incorporated EIA's forecasts of sharp increases in future fuel efficiency for the vehicle fleet as a result of changes in CAFE standard and other factors.

Exhibit 7-7 shows that the imposition of variable rate user charges to combat congestion would facilitate greater reductions in average user costs than could be achieved if other funding mechanisms were employed, even at much higher levels of investment. For example, if investment were to increase at an annual rate of 4.55 percent in constant dollar terms, and variable rate user charges were imposed, HERS projects that

Exhibit 7-7

Projected Changes in 2026 Travel Time Costs and Vehicle Operating Costs Compared With 2006 Levels for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]		Percent Change in Average User Costs on Roads Modeled in HERS					
			Travel Time Costs			Vehicle Operating Costs[2]		
			Funding Mechanism[3]			Funding Mechanism[3]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	-3.4%			-10.3%		
7.45%	*$182.0*	$111.5	-3.2%	-3.8%		-10.1%	-10.0%	
6.70%	*$166.5*	$102.0	-2.6%	-3.2%		-9.8%	-9.6%	
6.41%	*$160.9*	$98.6	-2.4%	-2.9%		-9.6%	-9.5%	
5.25%	*$140.6*	$86.1	-1.4%	-1.9%		-9.0%	-8.9%	
5.15%	*$139.0*	$85.1	-1.4%	-1.8%		-8.9%	-8.9%	
5.03%	*$137.1*	$84.0	-1.3%	-1.7%		-8.9%	-8.8%	
4.65%	*$131.2*	$80.4	-1.0%	-1.4%		-8.7%	-8.6%	
4.55%	*$129.7*	$79.5	-0.9%	-1.3%	-3.9%	-8.6%	-8.5%	-9.5%
4.17%	*$124.2*	$76.1	-0.6%	-0.9%	-3.7%	-8.4%	-8.3%	-9.3%
3.30%	*$112.6*	$69.0	0.1%	-0.1%	-3.3%	-7.9%	-7.8%	-8.9%
3.21%	*$111.5*	$68.3	0.2%	-0.1%	-3.3%	-7.8%	-7.8%	-8.9%
3.07%	*$109.7*	$67.2	0.3%	0.1%	-3.2%	-7.8%	-7.7%	-8.8%
2.96%	*$108.4*	$66.4	0.4%	0.2%	-3.2%	-7.7%	-7.6%	-8.8%
2.93%	*$108.0*	$66.2	0.5%	0.2%	-3.1%	-7.7%	-7.6%	-8.7%
1.67%	*$94.0*	$57.6	1.4%	1.3%	-2.5%	-6.8%	-6.8%	-8.1%
0.83%	*$85.9*	$52.6	2.1%	2.0%	-2.1%	-6.3%	-6.3%	-7.7%
0.34%	*$81.5*	$50.0	2.4%	2.4%	-1.8%	-6.0%	-6.0%	-7.4%
0.00%	*$78.7*	$48.2	2.7%	2.7%	-1.7%	-5.8%	-5.8%	-7.2%
-0.78%	*$72.5*	$44.4	3.4%	3.5%	-1.3%	-5.5%	-5.4%	-6.8%
-0.86%	*$71.9*	$44.1	3.5%	3.6%	-1.3%	-5.4%	-5.4%	-6.8%
-1.37%	*$68.3*	$41.8	3.9%	4.0%	-1.0%	-5.1%	-5.1%	-6.5%
-4.95%	*$48.2*	$29.5	6.7%	7.0%	0.6%	-3.3%	-3.2%	-4.7%
-7.64%	*$37.9*	$23.2	8.6%	9.0%	1.7%	-2.2%	-2.2%	-3.4%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The "Vehicle Operating Costs" shown represent a subset of the "Average User Costs" presented in Exhibit 7-5, rather than the "Adjusted Average User Costs." These figures reflect the projected effects of improved fuel economy standards.

[3] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT, which will impact the level of performance that would be achieved.

Source: Highway Economic Requirements System.

a 3.9 percent reduction in average travel time costs could be achieved. This reduction is more significant than it appears, since a significant portion of travel time costs include the fixed amount of time required to move from one point to another at free-flow speeds, and thus would not be affected by actions that reduce congestion. HERS projects that the best that could be achieved in terms of travel time savings assuming funding by fixed rate user charges would be a 3.8 percent reduction if investment were to increase at an average annual rate of 7.45 percent.

Exhibit 7-7 also shows that variable rate user charges have the potential to partially mitigate the potential impacts of reductions in highway investment on travel time costs. For example, if combined public and private capital investment in highways were to decline by 7.64 percent annually in constant dollar terms, HERS projects a 1.7 percent increase in average travel time costs assuming a variable rate user charge financing mechanism, compared to an 9.0 percent increase assuming fixed rate user financing.

The HPMS database does not contain location-specific information on crashes, or the presence or absence of safety devices such as guard rails or rumble strips. Consequently, the HERS analysis does not identify specific safety-oriented investment opportunities, but instead considers the ancillary safety impacts of capital investments that are directed primarily toward system rehabilitation or capacity expansion. As a result, the overall crash costs calculated by HERS do not vary as significantly at different investment levels as do travel time costs and vehicle operating costs. The HERS analysis projects small increases in crash costs in constant dollars over time, ranging from 0.1 percent at higher levels of investment to 2.4 percent if capital investment is significantly reduced. The analysis suggests that the imposition of variable rate congestion charges may have some minor safety implications as it facilitates higher speeds, which tends to increase crash severity.

Impact of Future Investment on Highway Operational Performance

Exhibit 7-8 shows how average delay per VMT is influenced by the total amount invested in highways, and the financing mechanisms employed to support such investment. HERS estimates that if combined public and private highway capital investment were to increase by 4.65 percent annually in constant dollar terms and this increase were funded from non-user sources, then average delay per VMT in 2026 could be maintained at 2006 levels. If fixed rate user charges were employed instead, average delay per VMT could be maintained if capital investment grew by 4.17 percent annually in constant dollar terms; the difference is caused by the impact that the imposition of the fixed rate user charges would have on travel behavior. If current funding levels were sustained in constant dollar terms, it is projected that average delay per VMT would increase by 11.0 percent assuming funding from non-user sources.

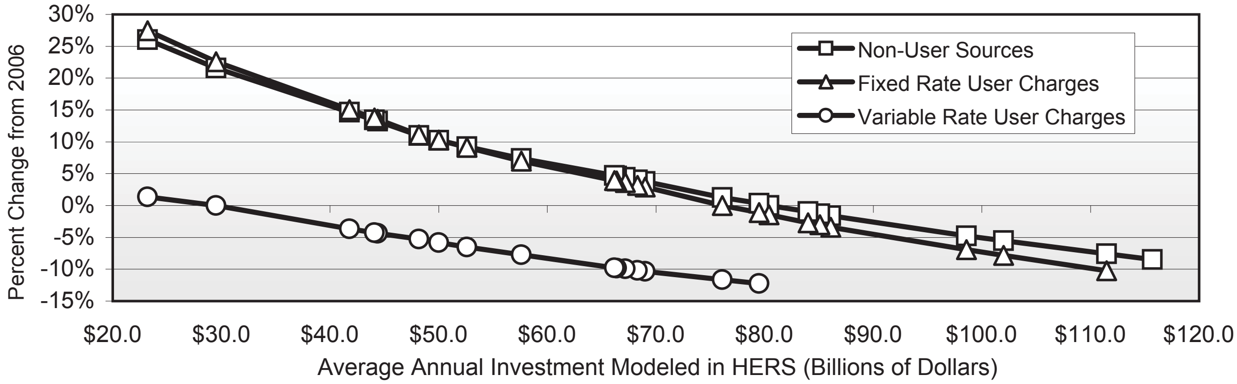
Assuming variable rate congestion charges were imposed broadly, HERS projects that current levels of highway capital investment would be adequate to reduce average delay per VMT, and that maintaining average delay at 2006 levels might still be achievable even if capital investment were to drop by 4.95 percent annually in constant dollar terms. If combined public and private highway capital investment were to rise by 4.55 percent annually in constant dollar terms, a 12.3 percent reduction in average delay per VMT could be achieved. HERS projects that such a reduction could not be achieved in the absence of such variable rate charges, even at much higher investment levels.

Exhibit 7-8 also identifies the portion of the spending modeled in HERS that was directed towards system expansion for each of the alternative investment levels that were analyzed. This is significant because investments in system expansion, such as the widening of existing highways or building new routes in existing corridors, would have a greater impact on delay than would investments in system rehabilitation such as the reconstruction or resurfacing of lanes on existing facilities.

If variable rate user charges were broadly imposed, this would significantly reduce congestion, thus reducing the potential benefits that could be achieved by widening existing highway sections. Consequently, the benefit-cost ratios associated with widening projects would tend to be lower, making it more likely that pavement reconstruction or resurfacing projects would be selected in a constrained funding environment. For example, if combined public and private highway capital investment were to rise by 4.55 percent annually in constant dollar terms, HERS would recommend that an average annual level of $41.8 billion be directed to system expansion assuming the additional funding comes from non-user sources, $41.6 billion assuming funding from fixed rate user charges, and $33.3 billion assuming variable rate user charges are imposed broadly. All of these amounts exceed current investment in system expansion by all levels of

Exhibit 7-8

Projected Changes in 2026 Highway Travel Delay Compared with 2006 Levels for Different Possible Funding Levels and Financing Mechanisms



Annual Percent Change Relative to 2006	Average Annual Investment (Billions of $2006)					Percent Change in Average Delay Per VMT on Roads Modeled in HERS		
			HERS System Expansion [2]					
			Funding Mechanism			Funding Mechanism		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	$64.3			-8.5%		
7.45%	*$182.0*	$111.5	$61.6	$61.3		-7.6%	-10.2%	
6.70%	*$166.5*	$102.0	$55.8	$55.5		-5.5%	-7.8%	
6.41%	*$160.9*	$98.6	$53.6	$53.2		-4.7%	-6.9%	
5.25%	*$140.6*	$86.1	$45.9	$45.5		-1.6%	-3.4%	
5.15%	*$139.0*	$85.1	$45.3	$44.8		-1.3%	-3.0%	
5.03%	*$137.1*	$84.0	$44.6	$44.2		-0.9%	-2.7%	
4.65%	*$131.2*	$80.4	$42.4	$42.2		**0.0%**	-1.5%	
4.55%	*$129.7*	$79.5	$41.8	$41.6	$33.3	0.4%	-1.1%	-12.3%
4.17%	*$124.2*	$76.1	$39.7	$39.5	$31.4	1.3%	**0.0%**	-11.6%
3.30%	*$112.6*	$69.0	$35.3	$35.2	$27.8	3.8%	2.9%	-10.3%
3.21%	*$111.5*	$68.3	$34.9	$34.8	$27.4	4.0%	3.2%	-10.2%
3.07%	*$109.7*	$67.2	$34.2	$34.0	$26.8	4.4%	3.6%	-9.9%
2.96%	*$108.4*	$66.4	$33.7	$33.5	$26.3	4.6%	3.8%	-9.8%
2.93%	*$108.0*	$66.2	$33.6	$33.4	$26.2	4.7%	3.9%	-9.8%
1.67%	*$94.0*	$57.6	$28.9	$28.9	$21.9	7.4%	7.0%	-7.7%
0.83%	*$85.9*	$52.6	$26.3	$26.2	$19.7	9.2%	9.1%	-6.5%
0.34%	*$81.5*	$50.0	$24.7	$24.6	$18.4	10.2%	10.3%	-5.8%
0.00%	*$78.7*	$48.2	$23.8	$23.7	$17.6	11.0%	11.1%	-5.3%
-0.78%	*$72.5*	$44.4	$21.5	$21.5	$16.0	13.2%	13.5%	-4.4%
-0.86%	*$71.9*	$44.1	$21.3	$21.3	$15.8	13.4%	13.7%	-4.3%
-1.37%	*$68.3*	$41.8	$20.0	$20.0	$14.8	14.6%	15.1%	-3.7%
-4.95%	*$48.2*	$29.5	$13.8	$13.9	$9.6	21.6%	22.6%	**0.0%**
-7.64%	*$37.9*	$23.2	$10.5	$10.5	$7.1	26.0%	27.5%	1.4%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The amounts shown represent the portion of spending that HERS directed towards system expansion rather than system rehabilitation, which varies depending on the funding mechanism employed.

Source: Highway Economic Requirements System.

government combined, indicating that there are significant opportunities for cost-beneficial investment to add capacity to the highway system, regardless of which funding mechanism is employed.

Congestion Delay and Incident Delay

Exhibit 7-9 identifies the potential impacts of alternative investment levels and financing mechanisms on the congestion delay and incident delay components of the average delay per VMT figures presented in *Exhibit 7-8*. As noted above, the HERS model assumes the continuation of existing trends in the deployment of certain types of ITS and various operations strategies, which are expected to have a greater impact on reducing delay associated with isolated incidents than with delay associated with recurring congestion. *Exhibit 7-9* shows that such deployments would be particularly effective in conjunction with the application of variable rate user charges, allowing reductions in average incident delay per VMT even at significantly reduced levels of highway capital investment. At current funding levels, HERS projects that incident delay would rise, but projects that an annual increase in combined public and private highway capital investment of between 0.83 percent to 1.67 percent in constant dollar terms may be sufficient to

Exhibit 7-9

Projected Changes in 2026 Congestion Delay and Incident Delay Compared With 2006 Levels for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars) [1]		Percent Change in Delay on Roads Modeled in HERS					
			Congestion Delay per VMT			Incident Delay per VMT		
			Funding Mechanism [2]			Funding Mechanism [2]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	-1.8%			-29.7%		
7.45%	*$182.0*	$111.5	**-0.3%**	-4.6%		-28.3%	-33.1%	
6.70%	*$166.5*	$102.0	**3.0%**	**-0.7%**		-24.9%	-29.2%	
6.41%	*$160.9*	$98.6	4.3%	**0.6%**		-23.7%	-27.5%	
5.25%	*$140.6*	$86.1	8.8%	5.8%		-17.5%	-20.8%	
5.15%	*$139.0*	$85.1	9.3%	6.5%		-17.0%	-20.0%	
5.03%	*$137.1*	$84.0	9.8%	6.9%		-16.4%	-19.4%	
4.65%	*$131.2*	$80.4	11.2%	8.8%		-14.6%	-17.1%	
4.55%	*$129.7*	$79.5	11.8%	9.4%	-8.3%	-14.1%	-16.7%	-36.6%
4.17%	*$124.2*	$76.1	13.3%	11.1%	-7.3%	-12.7%	-14.9%	-35.4%
3.30%	*$112.6*	$69.0	17.1%	15.5%	-5.4%	-8.2%	-9.4%	-32.7%
3.21%	*$111.5*	$68.3	17.5%	15.9%	-5.2%	-8.0%	-9.1%	-32.5%
3.07%	*$109.7*	$67.2	18.1%	16.7%	-4.8%	-7.4%	-8.6%	-32.2%
2.96%	*$108.4*	$66.4	18.4%	17.0%	-4.6%	-6.9%	-8.1%	-31.9%
2.93%	*$108.0*	$66.2	18.5%	17.1%	-4.5%	-6.8%	-8.0%	-31.8%
1.67%	*$94.0*	$57.6	22.8%	22.1%	-1.6%	**-2.3%**	**-2.9%**	-27.8%
0.83%	*$85.9*	$52.6	25.6%	25.4%	**0.0%**	**1.1%**	**1.0%**	-25.4%
0.34%	*$81.5*	$50.0	27.2%	27.3%	1.1%	2.8%	2.8%	-23.8%
0.00%	*$78.7*	$48.2	28.4%	28.6%	1.8%	4.0%	4.2%	-22.6%
-0.78%	*$72.5*	$44.4	31.7%	32.2%	3.0%	8.2%	8.7%	-20.5%
-0.86%	*$71.9*	$44.1	32.0%	32.5%	3.2%	8.6%	9.1%	-20.3%
-1.37%	*$68.3*	$41.8	33.9%	34.6%	4.0%	10.6%	11.4%	-19.0%
-4.95%	*$48.2*	$29.5	44.1%	45.9%	8.9%	23.3%	24.9%	-10.7%
-7.64%	*$37.9*	$23.2	50.4%	53.0%	10.7%	32.0%	34.1%	-7.7%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future travel behavior, which will impact the level of performance that would be achieved.

Source: Highway Economic Requirements System.

maintain incident delay at base year levels. At higher levels of investment, HERS projects that reductions in incident delay of 29.7 to 36.6 percent could be achieved, depending on the funding mechanism used to support this increased investment. Appendix A provides more details on the operations strategies and ITS considered in HERS, and Chapter 10 includes some analysis of the potential impacts of more aggressive deployment patterns than were assumed in the baseline analyses reflected in this chapter.

Exhibit 7-9 also indicates that average delay per VMT due to recurring congestion is projected to rise by 1.8 percent if current spending is sustained over time in constant dollar terms and assuming that variable rate user charges are imposed, or by 28.6 percent assuming funding from fixed rate user charges. HERS projects that a 0.83 percent annual increase in combined public and private highway capital investment in constant dollar terms could be sufficient to maintain average congestion delay per VMT if variable rate congestion charges are imposed. If financing from non-user sources is employed, an annual constant dollar increase of 6.70 percent to 7.45 percent could be sufficient to maintain congestion delay. If fixed rate user charges are utilized, an annual increase of 6.41 percent to 6.70 percent in constant dollar terms might achieve this target.

Volume/Service Flow

Exhibit 7-10 shows how the estimated percentage of VMT occurring on roads with peak ratios of volume to service flow (V/SF) above 0.80 and 0.95 could be affected by alternative investment levels and funding mechanisms. As indicated in Chapter 4, these levels are generally used to describe congested and severely congested operating conditions on highways, respectively. If 2006 highway spending levels were maintained in constant dollar terms through 2026 in constant dollar terms, HERS projects that the percentage of VMT occurring on severely congested roads would increase from 13.0 percent in 2006 to 15.7 percent by 2026 if variable rate user charges are applied or to 21.2 percent by 2026 if other financing mechanisms are utilized.

HERS projects that an increase in combined public and private highway capital investment of 1.67 percent to 2.93 percent annually in constant dollar terms may be sufficient to maintain the percentage of VMT on severely congested roads at the 2006 levels if variable rate user charges are applied. If funding from fixed user charges is employed, an annual constant dollar increase of 6.41 percent to 6.70 percent could be sufficient to achieve this target; if funding from non-user sources is utilized, an annual increase of 6.70 percent to 7.45 percent in constant dollar terms might be needed to achieve the same level of performance.

Exhibit 7-10 also indicates that if combined public and private highway capital investment were sustained at 2006 levels, the percentage of VMT on congested roads would be projected to increase from 23.6 percent to somewhere between 34.8 percent and 37.5 percent in 2026, depending on the funding mechanism utilized to support this investment. It should be noted that the relative impacts of imposing variable rate user charges projected by HERS are greater for severely congested roads than for moderately congested roads, indicating that the widespread adoption of variable congestion charges would grow more effective as the degree of congestion on a facility increases in severity.

For a potential capacity improvement to be implemented as part of a HERS scenario, the improvement must meet the minimum benefit-cost ratio cutoff associated with the level of investment being analyzed. As a result, there may be some road segments in a given time period that meet or exceed the threshold for being considered congested, but that do not merit capacity expansion in HERS. *Exhibit 7-10* suggests that it would not be cost-beneficial to maintain the percentage of VMT occurring on roads with V/SF ratios greater than 0.80 at the base year 2006 level, regardless of which funding mechanism is employed. This suggests that the existence of some limited degree of congestion may be desirable from an economic point of view in terms of regulating travel demand, and that significant capital expenditures to address congestion may only be warranted when congestion worsens in severity to a level beyond the 0.80 V/SF threshold.

Exhibit 7-10

Projected Volume/Service Flow Indicators for 2026, for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars) [1]		Percent of VMT on Roads Modeled in HERS with					
			V/SF > 0.80			V/SF > 0.95		
			Funding Mechanism [2]			Funding Mechanism [2]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	29.1%			12.3%		
7.45%	*$182.0*	$111.5	29.6%	28.0%		**12.8%**	11.5%	
6.70%	*$166.5*	$102.0	30.8%	29.4%		**14.1%**	**12.8%**	
6.41%	*$160.9*	$98.6	31.2%	29.9%		14.4%	**13.2%**	
5.25%	*$140.6*	$86.1	32.8%	31.8%		16.1%	15.2%	
5.15%	*$139.0*	$85.1	33.0%	32.0%		16.2%	15.4%	
5.03%	*$137.1*	$84.0	33.1%	32.2%		16.4%	15.6%	
4.65%	*$131.2*	$80.4	33.5%	32.8%		17.0%	16.3%	
4.55%	*$129.7*	$79.5	33.6%	32.9%	29.0%	17.1%	16.5%	10.9%
4.17%	*$124.2*	$76.1	34.0%	33.4%	29.5%	17.5%	16.9%	11.3%
3.30%	*$112.6*	$69.0	34.9%	34.4%	30.9%	18.4%	18.0%	12.3%
3.21%	*$111.5*	$68.3	35.0%	34.5%	31.0%	18.5%	18.1%	12.4%
3.07%	*$109.7*	$67.2	35.1%	34.6%	31.2%	18.7%	18.2%	12.6%
2.96%	*$108.4*	$66.4	35.2%	34.8%	31.4%	18.8%	18.4%	12.7%
2.93%	*$108.0*	$66.2	35.2%	34.8%	31.4%	18.8%	18.4%	**12.8%**
1.67%	*$94.0*	$57.6	36.2%	36.0%	33.0%	19.7%	19.6%	**14.3%**
0.83%	*$85.9*	$52.6	37.0%	36.8%	34.1%	20.5%	20.5%	15.0%
0.34%	*$81.5*	$50.0	37.3%	37.2%	34.5%	20.9%	20.9%	15.4%
0.00%	*$78.7*	$48.2	37.5%	37.4%	34.8%	21.2%	21.2%	15.7%
-0.78%	*$72.5*	$44.4	38.1%	38.1%	35.4%	22.0%	22.0%	16.3%
-0.86%	*$71.9*	$44.1	38.1%	38.2%	35.5%	22.0%	22.1%	16.3%
-1.37%	*$68.3*	$41.8	38.4%	38.6%	35.9%	22.5%	22.6%	16.8%
-4.95%	*$48.2*	$29.5	39.9%	40.2%	37.9%	24.5%	24.9%	18.8%
-7.64%	*$37.9*	$23.2	40.5%	41.0%	38.8%	25.5%	26.1%	19.6%
		2006 Baseline Values:	**23.6%**	**23.6%**	**23.6%**	**13.0%**	**13.0%**	**13.0%**

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT, which will impact the level of performance that would be achieved.

Source: Highway Economic Requirements System.

Q&A

Why do the average speeds presented in *Exhibit 7-11* appear relatively low?

The average speed of 42.7 miles per hour in 2006 represents a composite value for all of the roads modeled in HERS, which include a large number of urban collectors with speed limits of 25 miles per hour. HERS estimates the average speed on Interstate highways as 59.7 miles per hour.

Assuming variable rate user charges were imposed, and combined public and private highway capital investment were to increase by 4.55 percent per year through 2026 in constant dollar terms, HERS projects average Interstate speeds would rise to 66.1 miles per hour. Assuming fixed rate user financing, HERS projects that if spending were to increase by 7.45 percent per year through 2026, average Interstate speeds would rise to 65.1 miles per hour.

Speed

Exhibit 7-11 shows how average vehicle speeds could be affected by alternative investment levels and funding mechanisms. This measure corresponds to one of the main transit performance measures used in the Transit Economic Requirements Model, which is discussed later in this chapter.

HERS projects that sustaining combined public and private highway capital level at 2006 levels in constant dollar terms would be sufficient to allow average speeds to increase above the baseline 2006 level of 42.7 miles per hour on roads modeled in HERS, if variable rate user charges were imposed. If funding

Exhibit 7-11

Projected Average Speed for 2026, for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars) [1]		Average Speed on Roads Modeled in HERS: Funding Mechanism [2]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	43.9		
7.45%	*$182.0*	$111.5	43.8	44.1	
6.70%	*$166.5*	$102.0	43.6	43.8	
6.41%	*$160.9*	$98.6	43.5	43.7	
5.25%	*$140.6*	$86.1	43.2	43.4	
5.15%	*$139.0*	$85.1	43.2	43.3	
5.03%	*$137.1*	$84.0	43.1	43.3	
4.65%	*$131.2*	$80.4	43.0	43.2	
4.55%	*$129.7*	$79.5	43.0	43.1	44.1
4.17%	*$124.2*	$76.1	**42.9**	43.0	44.0
3.30%	*$112.6*	$69.0	**42.6**	**42.7**	43.8
3.21%	*$111.5*	$68.3	42.6	**42.7**	43.8
3.07%	*$109.7*	$67.2	42.6	42.6	43.8
2.96%	*$108.4*	$66.4	42.5	42.6	43.8
2.93%	*$108.0*	$66.2	42.5	42.6	43.8
1.67%	*$94.0*	$57.6	42.2	42.2	43.6
0.83%	*$85.9*	$52.6	41.9	42.0	43.4
0.34%	*$81.5*	$50.0	41.8	41.8	43.3
0.00%	*$78.7*	$48.2	41.7	41.7	43.3
-0.78%	*$72.5*	$44.4	41.5	41.5	43.1
-0.86%	*$71.9*	$44.1	41.5	41.4	43.1
-1.37%	*$68.3*	$41.8	41.3	41.3	**43.0**
-4.95%	*$48.2*	$29.5	40.4	40.3	**42.5**
-7.64%	*$37.9*	$23.2	39.7	39.6	42.0
		2006 Baseline Values:	**42.7**	**42.7**	**42.7**

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT, which will impact the level of performance that would be achieved.

Source: Highway Economic Requirements System.

from fixed user charges were employed, an annual constant dollar increase of 3.21 percent to 3.30 percent could be sufficient to achieve this target; if funding from non-user sources were utilized, an annual increase of 3.30 percent to 4.17 percent in constant dollar terms might be needed to achieve the same level of performance.

Impact of Future Investment on Highway Physical Conditions

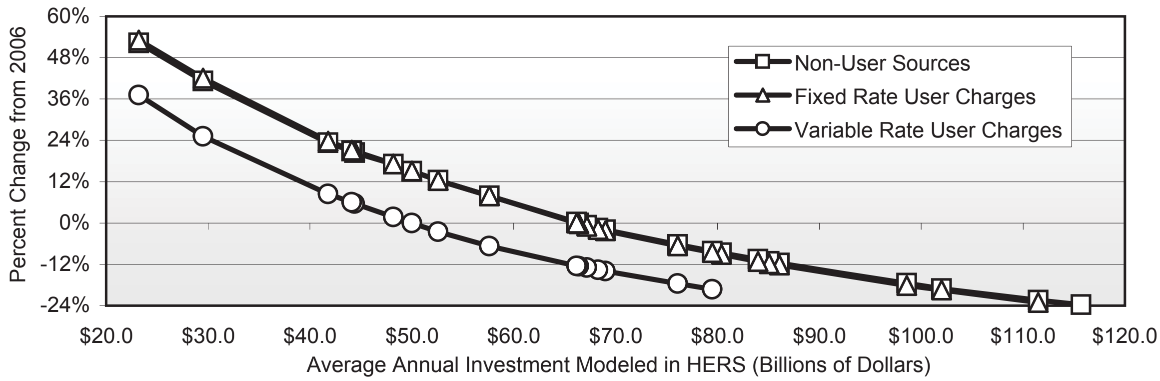
Exhibit 7-12 shows how pavement ride quality (based on the International Roughness Index [IRI] defined in Chapter 3) is influenced by the total amount invested in highways, and the financing mechanisms employed to support such investment. HERS estimates that if combined public and private highway capital investment were to increase by 0.34 percent annually in constant dollar terms and this increase were funded from variable rate user charges, then average IRI in 2026 for roads modeled in HERS could be maintained at 2006 levels. If fixed rate user charges were employed instead, average ride quality could be maintained if capital investment grew by 2.93 percent annually in constant dollar terms; assuming funding from non-user sources, an annual growth rate of 2.96 percent annually would be required to achieve these targets. In comparing these figures, it is important to note that HERS directs a higher percentage of investment towards system rehabilitation for the analyses assuming variable rate user charges, as the broad imposition of such charges would significantly reduce congestion, thus reducing the potential benefits that could be achieved by widening existing highway sections. Consequently, the benefit-cost ratios associated with system expansion projects would tend to be lower, making it more likely that pavement reconstruction or resurfacing projects would be selected in a constrained funding environment, as shown in *Exhibit 7-12*. Although the addition of new, smooth lanes to the existing system would bring up average ride quality a little bit, investments in system rehabilitation would have a larger, more direct impact on this measure of pavement condition.

If current investment levels were sustained for 20 years in constant dollar terms, HERS projects that average pavement roughness would increase by 17.1 percent relative to base year levels assuming funding from fixed rate user sources, compared to an increase of 1.8 percent if variable rate user charges were imposed. This difference is mainly the result of the larger relative investment in system rehabilitation recommended by HERS for all funding levels for analyses assuming the broad adoption of variable rate congestion charges. However, the lower levels of VMT associated with the variable rate user charges would have a minor impact on improving average IRI as well.

Exhibit 7-12 suggests that while more can be achieved at any given funding level in terms of improving pavement ride quality assuming the broad imposition of variable rate user charges, additional reductions in average pavement roughness could be achieved at significantly higher spending levels assuming funding from non-user sources or fixed rate user charges. If combined public and private highway capital investment were to increase by 7.76 percent assuming non-user financing, HERS projects a 23.8 percent reduction in average pavement roughness; this exceeds the 19.3 percent reduction that could be economically accommodated assuming a 4.55 percent annual increase in spending and the widespread adoption of variable rate user charges. This difference is attributable to the reduced number of widening actions taken by HERS for the analyses assuming the adoption of variable rate user charges. When HERS adds new lanes to an existing facility, as it is more likely to do if variable rate pricing is not in place, it also resurfaces or reconstructs all of the existing lanes. In some cases, these pavement improvements occur earlier in the life of the pavement than would normally be the case in the absence of the widening action, and would not have been cost-beneficial on their own. Consequently, the reduced number of widening actions taken by HERS under the variable rate funding analyses causes some of these pavement actions to be deferred beyond the 20-year period considered as part of this analysis, until such time as their relative benefits exceed their costs.

Exhibit 7-12

Projected Changes in 2026 Pavement Ride Quality Compared with 2006 Levels for Different Possible Funding Levels and Financing Mechanisms



Annual Percent Change Relative to 2006	Average Annual Investment (Billions of $2006)					Percent Change in Average IRI on Roads Modeled in HERS		
	Total Capital Outlay	Spending Modeled in HERS	HERS System Rehabilitation [2] Funding Mechanism			Funding Mechanism		
			Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	$51.4			-23.8%		
7.45%	*$182.0*	$111.5	$50.0	$50.2		-22.4%	-23.1%	
6.70%	*$166.5*	$102.0	$46.2	$46.5		-19.1%	-19.4%	
6.41%	*$160.9*	$98.6	$45.0	$45.4		-17.5%	-18.1%	
5.25%	*$140.6*	$86.1	$40.2	$40.6		-11.7%	-12.2%	
5.15%	*$139.0*	$85.1	$39.8	$40.3		-11.1%	-11.8%	
5.03%	*$137.1*	$84.0	$39.4	$39.7		-10.5%	-11.2%	
4.65%	*$131.2*	$80.4	$38.0	$38.2		-8.7%	-9.1%	
4.55%	*$129.7*	$79.5	$37.7	$37.9	$46.2	-8.2%	-8.6%	-19.3%
4.17%	*$124.2*	$76.1	$36.4	$36.6	$44.7	-6.3%	-6.6%	-17.6%
3.30%	*$112.6*	$69.0	$33.6	$33.7	$41.2	-1.9%	-2.3%	-14.0%
3.21%	*$111.5*	$68.3	$33.4	$33.5	$40.9	-1.5%	-1.9%	-13.6%
3.07%	*$109.7*	$67.2	$33.1	$33.2	$40.5	-0.7%	-1.0%	-13.0%
2.96%	*$108.4*	$66.4	$32.7	$32.9	$40.1	**0.0%**	-0.2%	-12.5%
2.93%	*$108.0*	$66.2	$32.6	$32.8	$40.0	0.3%	**0.0%**	-12.5%
1.67%	*$94.0*	$57.6	$28.7	$28.8	$35.7	7.9%	7.9%	-6.7%
0.83%	*$85.9*	$52.6	$26.4	$26.5	$33.0	12.5%	12.4%	-2.6%
0.34%	*$81.5*	$50.0	$25.2	$25.3	$31.5	15.0%	15.1%	**0.0%**
0.00%	*$78.7*	$48.2	$24.5	$24.5	$30.6	17.0%	17.1%	1.8%
-0.78%	*$72.5*	$44.4	$23.0	$23.0	$28.5	20.4%	20.8%	5.7%
-0.86%	*$71.9*	$44.1	$22.8	$22.8	$28.3	20.8%	21.2%	6.0%
-1.37%	*$68.3*	$41.8	$21.8	$21.8	$27.1	23.3%	23.8%	8.4%
-4.95%	*$48.2*	$29.5	$15.7	$15.6	$19.9	41.3%	42.0%	25.2%
-7.64%	*$37.9*	$23.2	$12.7	$12.7	$16.0	52.3%	53.1%	37.1%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] The amounts shown represent the portion of spending that HERS directed towards system rehabilitation rather than system expansion, which varies depending on the funding mechanism employed.

Source: Highway Economic Requirements System.

Exhibit 7-13 shows how the projected percentage of VMT on pavement with IRI values below 95 and 170 could be affected by alternative levels of investment and financing mechanisms. The pavement condition

Exhibit 7-13

Projected Pavement Ride Quality Indicators for 2026, for Different Possible Funding Levels and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]		Percent of VMT on Roads Modeled in HERS With IRI<95: Funding Mechanism[2]			IRI<170 Funding Mechanism[2]		
	Total Capital Outlay	Spending Modeled in HERS	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$188.9*	$115.7	74.6%			91.2%		
7.45%	*$182.0*	$111.5	73.6%	74.0%		90.7%	90.9%	
6.70%	*$166.5*	$102.0	71.1%	71.4%		89.6%	89.7%	
6.41%	*$160.9*	$98.6	70.1%	70.6%		89.1%	89.3%	
5.25%	*$140.6*	$86.1	66.1%	66.4%		87.2%	87.3%	
5.15%	*$139.0*	$85.1	65.7%	66.2%		87.0%	87.1%	
5.03%	*$137.1*	$84.0	65.3%	65.6%		86.8%	86.9%	
4.65%	*$131.2*	$80.4	64.0%	64.2%		86.2%	86.2%	
4.55%	*$129.7*	$79.5	63.6%	63.9%	70.7%	**86.0%**	**86.1%**	90.4%
4.17%	*$124.2*	$76.1	62.4%	62.6%	69.6%	**85.4%**	**85.5%**	89.8%
3.30%	*$112.6*	$69.0	59.5%	59.5%	66.7%	84.0%	84.0%	88.6%
3.21%	*$111.5*	$68.3	59.3%	59.1%	66.4%	83.9%	83.9%	88.5%
3.07%	*$109.7*	$67.2	58.8%	58.8%	66.1%	83.7%	83.7%	88.3%
2.96%	*$108.4*	$66.4	58.4%	58.5%	65.7%	83.5%	83.5%	88.1%
2.93%	*$108.0*	$66.2	58.3%	58.4%	65.7%	83.4%	83.5%	88.1%
1.67%	*$94.0*	$57.6	54.0%	53.9%	61.3%	81.2%	81.1%	**86.2%**
0.83%	*$85.9*	$52.6	51.3%	51.3%	58.2%	79.7%	79.7%	**84.7%**
0.34%	*$81.5*	$50.0	49.8%	49.9%	56.3%	79.0%	79.0%	83.9%
0.00%	*$78.7*	$48.2	**48.7%**	**48.8%**	55.1%	78.4%	78.5%	83.2%
-0.78%	*$72.5*	$44.4	**46.5%**	**46.4%**	52.4%	77.4%	77.3%	82.0%
-0.86%	*$71.9*	$44.1	46.2%	46.2%	52.2%	77.3%	77.2%	81.9%
-1.37%	*$68.3*	$41.8	44.7%	44.7%	**50.6%**	76.4%	76.3%	81.1%
-4.95%	*$48.2*	$29.5	36.6%	36.5%	**40.2%**	71.9%	71.7%	75.9%
-7.64%	*$37.9*	$23.2	32.5%	32.4%	34.6%	69.4%	69.2%	72.7%
	2006 Baseline Values:		**48.1%**	**48.1%**	**48.1%**	**85.8%**	**85.8%**	**85.8%**

[1] *The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.*

[2] *The funding mechanism used to cover the gap between a particular funding level and current spending will have different impacts on future VMT, which will impact the level of performance that would be achieved.*

Source: Highway Economic Requirements System.

criteria presented in Chapter 3 defined these levels as the thresholds for rating pavement ride quality as good and acceptable, respectively.

If 2006 highway spending levels were maintained through 2026 in constant dollar terms, HERS projects that the percentage of VMT occurring on pavements with good ride quality would increase from 48.1 percent in 2006 to 55.1 percent by 2026 if variable rate user charges are applied or to between 48.7 percent to 48.8 percent by 2026 if such charges are not applied. The difference is attributable primarily to the higher portion investment directed by HERS to system rehabilitation (i.e., pavement resurfacing or reconstruction) identified in *Exhibit 7-12.* HERS projects that the highest percentage of VMT on pavements with good ride quality that could be achieved through cost-beneficial investment would range from 70.7 percent to 74.6 percent, depending on the financing mechanism utilized. Traffic volumes on some of the roads modeled in HERS would not justify meeting this standard because the relative benefits to users resulting from this level of ride quality would be outweighed by the capital costs and work zone delays associated with the pavement actions that could achieve it.

Exhibit 7-13 also shows that if combined public and private highway capital investment were sustained at 2006 levels, the percentage of VMT occurring on roads with acceptable ride quality would be projected to decrease from 85.8 percent to between 78.4 percent and 83.2 percent in 2026, depending on the funding mechanism utilized to support this investment. HERS projects that an annual constant dollar increase in combined public and private highway capital investment of 0.83 percent to 1.67 percent could be sufficient to maintain the percentage of VMT on pavements with acceptable ride quality if congestion charges are imposed; if financing from non-user sources or fixed rate user charges is employed, an annual constant dollar increase of 4.17 percent to 4.55 percent might achieve this target. HERS projects that the highest percentage of VMT on pavements with acceptable ride quality that could be achieved through cost-beneficial investment would range from 90.4 percent to 91.2 percent, depending on the financing mechanism utilized. As noted in Chapter 3, the IRI threshold of 170 used to identify acceptable ride quality was originally set to measure performance on the NHS and may not fully reflect an acceptable standard for non-NHS routes, which tend to have lower travel volumes and speeds.

Benefit-Cost Ratios

As noted earlier, the benefits considered in HERS include reductions in highway user costs, agency costs and societal costs. The costs considered in HERS are the capital costs associated with a particular potential highway improvement. The HERS analysis presented in this report was performed by imposing a funding constraint on the model for investment in four consecutive 5-year analysis periods (for a total analysis period of 20 years). Under this type of analysis, HERS ranks potential improvements in order by their benefit-cost ratios and then implements them until the funding constraint is reached. Higher funding levels will thus include projects with lower benefit-cost ratios, both at the margin and on average. Appendix A contains a more detailed description of the project selection and implementation process used by HERS.

Exhibit 7-14 identifies benefit-cost ratio cutoff points associated with the alternative investment levels and funding levels analyzed. These values represent the benefit-cost ratio of the least attractive project that would be implemented at that level of investment. For example, if investment were to grow by 3.30 percent annually in constant dollar terms, and invested in order of potential projects' benefit-cost ratios as assumed by HERS, the lowest benefit-cost ratio for any project implemented is estimated to be 1.95 assuming funding from non-user sources, 1.93 assuming funding from fixed user sources, and 1.20 assuming funding from variable user sources. The lower benefit-cost ratio cutoffs associated with funding from fixed user or variable user sources are partially a function of the lower projected VMT levels identified in *Exhibit 7-6*; there would be fewer users to benefit from highway investments (in that some users would chose not to make low-value trips if they had to pay the real costs of such trips), and thus the level of potential highway user costs savings is lower for any given project. In addition, because the imposition of variable rate user charges on a highway section would tend to reduce peak period congestion levels and lead to significant travel time savings, the relative benefits that could be achieved by widening that highway section would be reduced.

It is important to note that the benefit-cost ratio cutoffs shown in *Exhibit 7-14* represent the lowest value estimated by HERS at any point during the 20-year analysis period. At higher levels of investment, the cutoff points tend to fall over this period. For example, if investment were to grow by 4.55 percent annually in constant dollar terms, and assuming funding from variable rate user sources, HERS estimates that the benefit-cost ratio cutoff would be 1.99 in the first 5-year period, falling gradually to 1.00 in the fourth

Exhibit 7-14

Benefit-Cost Ratio Cutoff Points Associated With Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual Investment (Billions of 2006 Dollars)		Minimum Benefit-Cost Ratio [2] Funding Mechanism			Funding Level Description [3]
	Total Capital Outlay	Spending Modeled in HERS[1]	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	
7.76%	*$188.9*	$115.7	**1.00**			Minimum BCR=1.0 (Non-User)
7.45%	*$182.0*	$111.5	1.06	**1.00**		Minimum BCR=1.0 (Fixed User)
6.70%	*$166.5*	$102.0	**1.20**	1.15		Minimum BCR=1.2 (Non-User)
6.41%	*$160.9*	$98.6	1.26	**1.20**		Minimum BCR=1.2 (Fixed User)
5.25%	*$140.6*	$86.1	**1.50**	1.45		Minimum BCR=1.5 (Non-User)
5.15%	*$139.0*	$85.1	1.53	1.46		See NBIAS discussion
5.03%	*$137.1*	$84.0	1.55	**1.50**		Minimum BCR=1.5 (Fixed User)
4.65%	*$131.2*	$80.4	1.63	1.59		Maintain Average Delay (Non-User)
4.55%	*$129.7*	$79.5	1.65	1.62	**1.00**	Minimum BCR=1.0 (Variable User)
4.17%	*$124.2*	$76.1	1.74	1.71	1.06	Maintain Average Delay (Fixed User)
3.30%	*$112.6*	$69.0	1.95	1.93	**1.20**	Minimum BCR=1.2 (Variable User)
3.21%	*$111.5*	$68.3	1.97	1.96	1.21	Maintain Adjusted User Cost (Non-User)
3.07%	*$109.7*	$67.2	2.01	1.98	1.24	Maintain Adjusted User Cost (Fixed User)
2.96%	*$108.4*	$66.4	2.04	2.01	1.25	Maintain Average IRI (Non-User)
2.93%	*$108.0*	$66.2	2.05	2.02	1.26	Maintain Average IRI (Fixed User)
1.67%	*$94.0*	$57.6	2.42	2.42	**1.50**	Minimum BCR=1.5 (Variable User)
0.83%	*$85.9*	$52.6	2.71	2.70	1.71	See NBIAS discussion
0.34%	*$81.5*	$50.0	2.87	2.86	1.82	Maintain Average IRI (Variable User)
0.00%	*$78.7*	$48.2	2.88	2.89	1.90	Actual 2006 Capital Outlay
-0.78%	*$72.5*	$44.4	2.94	2.94	2.12	Maintain Average User Cost (Fixed User)
-0.86%	*$71.9*	$44.1	2.94	2.95	2.14	Maintain Average User Cost (Non-User)
-1.37%	*$68.3*	$41.8	2.98	2.99	2.25	Maintain Adjusted User Cost (Variable User)
-4.95%	*$48.2*	$29.5	3.22	3.24	2.42	Maintain Average Delay (Variable User)
-7.64%	*$37.9*	$23.2	3.42	3.43	2.55	Maintain Average User Cost (Variable User)

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The benefit-cost ratios identified in this table pertain to spending modeled in HERS; the figures for "Total Capital Outlay" are included to reflect other spending not modeled in HERS.

[2] Values represent the lowest benefit-cost ratio for any project implemented at the level of funding and funding mechanism shown.

[3] The funding level description is provided to link back to previous exhibits that identified the level of funding required to maintain certain performance indicators at base year levels, assuming different funding mechanisms.

Source: Highway Economic Requirements System.

5-year period. In contrast, at lower levels of investment, the opposite tendency would be true. For instance, if investment were to decrease from the 2006 level by 7.64 percent annually and assuming funding from non-user sources, HERS estimates that the benefit-cost ratio cutoff would be 3.42 in the first 5-year period, rising gradually to 6.16 in the fourth 5-year period.

The benefit-cost ratios identified in *Exhibit 7-14* represent minimum values, and many projects implemented at each investment level would have much higher benefit-cost ratios. Consequently, the average benefit-cost ratio for each level of investment would be significantly higher. Assuming funding by non-user sources, the marginal benefit-cost ratios of 1.00 to 3.42 identified in *Exhibit 7-14* would be associated with average benefit-cost ratios ranging from 2.84 to 7.56; if fixed rate user charges were utilized, the marginal benefit-cost ratios of 1.00 to 3.43 would correspond to average benefit-cost ratios ranging from 2.85 to 7.62,

What are some considerations that should be taken into account when interpreting the benefit-cost ratios presented in *Exhibit 7-14*? Q&A

The reader should use caution when considering the attractiveness of different funding mechanism and investment levels based only on the benefit-cost ratios. An attempt to select among funding mechanisms and investment levels by using the "highest" benefit-cost ratio in *Exhibit 7-14* would almost certainly result in a misallocation of resources from an economic standpoint. In particular, although the incremental benefit-cost ratios for project investments under fixed rate user charges are higher than for project investments under variable rate user charges for any given funding level, the key parameter of interest for selecting the "best" economic package of investments and funding mechanisms would be the overall benefit to society attributable to the combined effects of both project investments and funding mechanisms. As shown in *Exhibit 7-5* (see percent changes in "adjusted average user costs"), the greatest social benefit (as measured by the monetary value of total reductions in user costs) for any given funding level occurs when cost-beneficial investments are pursued in coordination with a variable rate funding mechanism.

Similarly, due to the multi-period analysis used in HERS to evaluate investments over a 20-year period, the reader should not attempt to multiply the benefit-cost ratios in *Exhibit 7-14* by the associated total capital outlays to calculate the social benefits of that investment level. To do so would yield the false impression in some instances that higher investment levels yield lower total benefits. There are several reasons why this is so. First, the "Total Capital Outlay" figures in *Exhibit 7-14* represent an average annual amount over 20 years whereas the benefit-cost ratio values reported in the exhibit represent the lowest such value among the four 5-year investment periods that constitute the 20-year analysis period. Unless benefit-cost ratio values are constant over the four investment periods, the application of the lowest benefit-cost ratio to the average annual funding would be misleading. More importantly, however, is the failure of this method to account for deferred (unrealized) benefits over the full 20-year analysis period. In the case of scenarios with declining annual funding levels, HERS will tend to defer all investments except those with very high benefit-cost ratios until later in the 20-year analysis period (if it captures them at all). Society would not enjoy the benefits of many strong investments until much later in the 20-year overall analysis period—benefits that society would realize more quickly in higher funding scenarios. In short, the cumulative value of the 20-year loss of benefits associated with deferring strong investments at low funding levels is not captured by the simple multiplication of a benefit-cost ratio by a 1-year average total capital outlay. Only a multi-year summary of benefits stretching over 20 years would yield a true picture of society's total benefits from a given investment level. This impact is best captured in changes to the "Average User Cost" values and other statistics reported in *Exhibit 7-5* and *Exhibits 7-7* through *7-13*. Chapter 9 includes some additional discussion regarding the timing of investments. Finally, as noted above, the benefit-cost ratios for investments do not capture the benefits associated with the funding mechanism itself (e.g., fixed versus variable user charges).

weighted by project cost. Assuming variable rate user charges were broadly adopted, the marginal benefit-cost ratios of 1.00 to 2.55 identified in *Exhibit 7-14* would be associated with average benefit-cost ratios ranging from 2.75 to 6.19. In interpreting these figures, it should be noted that average benefit-cost ratios do not constitute a good indicator of the relative merits of one investment level versus another because they only capture the benefits associated with projects that are implemented, and do not reflect the disbenefits associated with projects that were not implemented. Hence, multiplying these average benefit-cost ratios by average spending would not yield an accurate measure of the net benefits associated with a particular investment level.

The funding level descriptions shown in *Exhibit 7-14* are included to identify the analytical significance of each of the alternative funding growth rates that are analyzed in this section. Some of these investment levels are associated with a particular minimum benefit-cost ratio; others are associated with maintaining particular indicators of conditions and performance as presented in previous exhibits. Two of these investment levels were selected due to their analytical significance in the NBIAS model, as will be discussed later in this section.

Due to the large number of potential highway investments analyzed in HERS, the minimum benefit-cost ratios identified in *Exhibit 7-14* for alternative highway investment levels should be largely consistent with those for major system components. For example, if combined public and private investment in the types of capital improvements modeled in HERS were to increase by 1.67 percent annually and variable rate user charges were applied, the minimum BCR of 1.5 would generally apply to the portion of that investment directed to the NHS, and that portion directed to individual functional systems.

Impacts of NHS Investments Modeled by HERS

As described in Chapter 2, the NHS constitutes a critical subset of the total highway system, including the Interstate System as well as other routes most critical to national defense, mobility, and commerce. This section examines the total spending modeled in HERS, identifying the portion of this investment that is directed by the model to the NHS, and the impacts that such investment could have on future NHS conditions and performance.

Impact of Future Investment on NHS User Costs

Exhibit 7-15 describes how average total user costs and average adjusted user costs on the NHS are influenced by the total amount invested on the system, and the financing mechanisms utilized to support such investment. As discussed earlier in this chapter, the "Adjusted Average User Cost" figures offset the impacts of the improvements in future fuel efficiency assumed as part of the analysis, in order to provide a better measure of the impact that changes in system conditions and performance have on highway user costs. The first 24 investment levels described in *Exhibit 7-15* correspond to the systemwide spending levels explored earlier in this chapter that are analytically significant in terms of systemwide investment impacts; the next row has been included to specifically identify the costs associated with maintaining adjusted average user costs for each of the three types of funding mechanisms, while the last row shows the impacts of sustaining investment on the NHS at 2006 levels in constant dollar terms for each funding mechanism.

Exhibit 7-15 shows that if combined public and private highway capital investment on the types of improvements modeled in HERS were sustained in constant dollar terms at their current level of $48.2 billion and funded by either non-user sources or fixed rate user charges, the model would recommend that $29.2 billion be directed to the NHS. This is slightly below the $30.0 billion identified in *Exhibit 7-1* as having been spent on the NHS for HERS-modeled improvement types in 2006. It is projected that this level of investment would result in an increase in adjusted average user costs in 2026 relative to 2006 levels of at least 0.5 percent. HERS predicts that adjusted average user costs could be maintained at base year levels if average annual investment on the NHS were to rise to $31.1 billion, assuming non-user or fixed rate user financing. Alternatively, if variable rate user charges were adopted, HERS projects that combined public and private highway capital investment on the NHS could be significantly reduced, while still maintaining adjusted average user costs at base year levels.

Exhibit 7-15 also shows that for any given funding level, HERS would direct a lower percentage of total investment towards the NHS if variable rate user charges were applied than if they were not. Such charges would generally be easier to apply and more effective in reducing congestion on the types of high-volume facilities that constitute the bulk of the NHS, which would reduce the potential benefits that could be achieved by widening such facilities. Consequently, the benefit-cost ratios associated with NHS investments would tend to be lower, making it more likely that investments on other routes would be selected in a constrained funding environment.

Impact of Future Investment on NHS Speeds and Delays

Exhibit 7-16 describes how average speed and average delay per VMT on the NHS is influenced by alternative financing mechanisms and the amount expended for types of improvements modeled in HERS, particularly investments in NHS system expansion. Widening existing NHS routes or building new routes in existing corridors would have a greater impact on speeds and delay than would investments in system rehabilitation such as the reconstruction or resurfacing of lanes on existing NHS routes.

Exhibit 7-15

Projected Changes in 2026 Highway User Costs on the NHS Compared With 2006 Levels for Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]				Percent Change in User Costs on the NHS					
		Spending on NHS			Average User Costs			Adjusted Average User Costs		
		Funding Mechanism [2]			Funding Mechanism [2]			Funding Mechanism [2]		
	Total HERS Capital Outlay	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$115.7*	$65.0			-8.1%			-5.2%		
7.45%	*$111.5*	$63.0	$62.6		-7.9%	-8.3%		-5.1%	-5.4%	
6.70%	*$102.0*	$58.0	$58.0		-7.4%	-7.8%		-4.5%	-4.9%	
6.41%	*$98.6*	$56.3	$56.2		-7.2%	-7.6%		-4.3%	-4.7%	
5.25%	*$86.1*	$49.7	$49.6		-6.4%	-6.7%		-3.5%	-3.8%	
5.15%	*$85.1*	$49.3	$49.0		-6.4%	-6.7%		-3.4%	-3.7%	
5.03%	*$84.0*	$48.6	$48.4		-6.3%	-6.6%		-3.3%	-3.6%	
4.65%	*$80.4*	$46.6	$46.4		-6.0%	-6.2%		-3.1%	-3.3%	
4.55%	*$79.5*	$46.1	$45.9	$38.6	-5.9%	-6.1%	-8.0%	-3.0%	-3.2%	-5.2%
4.17%	*$76.1*	$44.1	$44.0	$37.0	-5.6%	-5.8%	-7.9%	-2.7%	-2.9%	-5.0%
3.30%	*$69.0*	$40.4	$40.1	$33.8	-5.0%	-5.1%	-7.5%	-2.0%	-2.1%	-4.6%
3.21%	*$68.3*	$40.1	$39.7	$33.5	-5.0%	-5.1%	-7.4%	-2.0%	-2.1%	-4.5%
3.07%	*$67.2*	$39.5	$39.3	$33.1	-4.8%	-5.0%	-7.4%	-1.8%	-2.0%	-4.5%
2.96%	*$66.4*	$38.9	$38.7	$32.6	-4.7%	-4.8%	-7.3%	-1.7%	-1.8%	-4.4%
2.93%	*$66.2*	$38.8	$38.6	**$32.5**	-4.7%	-4.8%	-7.3%	-1.7%	-1.8%	-4.4%
1.67%	*$57.6*	$34.3	$34.2	**$28.3**	-3.7%	-3.8%	-6.7%	-0.7%	-0.8%	-3.8%
0.83%	*$52.6*	$31.8	$31.7	$25.9	-3.2%	-3.2%	-6.3%	**-0.2%**	**-0.2%**	-3.3%
0.34%	*$50.0*	**$30.2**	**$30.2**	$24.6	-2.8%	-2.8%	-6.0%	**0.2%**	**0.2%**	-3.1%
0.00%	*$48.2*	**$29.2**	**$29.2**	$23.6	-2.5%	-2.5%	-5.8%	0.5%	0.5%	-2.9%
-0.78%	*$44.4*	$26.9	$26.9	$22.1	-1.9%	-1.8%	-5.5%	1.2%	1.2%	-2.5%
-0.86%	*$44.1*	$26.7	$26.7	$21.9	-1.9%	-1.8%	-5.4%	1.2%	1.3%	-2.5%
-1.37%	*$41.8*	$25.6	$25.6	$20.8	-1.5%	-1.4%	-5.2%	1.6%	1.7%	-2.2%
-4.95%	*$29.5*	$18.5	$18.4	$14.9	1.1%	1.4%	-3.5%	4.3%	4.6%	**-0.5%**
-7.64%	*$23.2*	$14.3	$14.3	$11.6	3.1%	3.3%	-2.3%	6.3%	6.6%	**0.7%**
Cost to Maintain: [3]		$31.1	$31.1	$13.5				**0.0%**	**0.0%**	**0.0%**
2006 Spending: [4]		**$30.0**	**$30.0**	**$30.0**				0.3%	0.3%	-4.0%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the NHS.

[2] The funding mechanism employed will affect both the portion of spending that HERS directs toward the NHS, and the relative impacts of that spending.

[3] The amounts are projected to be sufficient to maintain 2026 adjusted average user costs on the NHS at 2006 levels.

[4] The amount shown reflects actual capital highway spending by all levels of government on the NHS in 2006.

Source: Highway Economic Requirements System.

Exhibit 7-16 shows that if combined public and private highway capital investment on types of improvements modeled in HERS were sustained at 2006 levels in constant dollar terms, and distributed among investments in NHS system expansion, NHS system rehabilitation, and non-NHS facilities in the manner recommended by the model, then improvements in average speeds and average delay would be expected if variable rate user charges were applied on a widespread basis. If such charges were not applied, then average NHS speeds would be expected to decline from 52.3 miles per hour to 51.2 miles per hour, and average delay per VMT on the NHS would be expected to increase by 7.5 to 7.8 percent. Assuming funding from non-user sources or fixed rate user charges, HERS predicts that maintaining average NHS speeds and delay per VMT would require an annual increase in constant dollar investment of somewhere between 1.67 percent and 2.93 percent.

Exhibit 7-16 also shows that if variable rate user charges were applied, for any given funding level HERS would recommend directing a smaller percentage of total investment towards NHS system expansion. The model projects that the combination of variable rate user charges and the operational and ITS deployments assumed as part of these analyses would be particularly effective in combating congestion on the NHS, thus reducing the relative attractiveness of adding capacity to the NHS relative to improving other parts of the system.

Exhibit 7-16

Projected Changes in 2026 Average Speeds and Travel Delay on the NHS Compared With 2006 Levels for Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]				Average Speed on the NHS			Percent Change in Average Delay per VMT on the NHS		
		NHS System Expansion [2]			Funding Mechanism			Funding Mechanism		
		Funding Mechanism								
	Total HERS Spending	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$115.7*	$43.2			55.4			-27.1%		
7.45%	*$111.5*	$41.7	$41.3		55.3	55.7		-25.6%	-29.8%	
6.70%	*$102.0*	$38.0	$38.0		54.8	55.3		-21.7%	-25.8%	
6.41%	*$98.6*	$36.8	$36.6		54.7	55.1		-20.5%	-24.3%	
5.25%	*$86.1*	$31.9	$31.6		54.1	54.4		-14.9%	-18.0%	
5.15%	*$85.1*	$31.6	$31.2		54.0	54.3		-14.4%	-17.3%	
5.03%	*$84.0*	$31.1	$30.8		53.9	54.3		-13.9%	-16.8%	
4.65%	*$80.4*	$29.6	$29.4		53.7	54.0		-12.1%	-14.5%	
4.55%	*$79.5*	$29.2	$29.0	$20.4	53.6	53.9	56.1	-11.3%	-13.8%	-34.0%
4.17%	*$76.1*	$27.8	$27.6	$19.3	53.4	53.7	55.9	-9.7%	-11.8%	-33.0%
3.30%	*$69.0*	$25.1	$24.8	$17.3	53.0	53.1	55.7	-5.2%	-6.4%	-30.9%
3.21%	*$68.3*	$24.9	$24.5	$17.1	52.9	53.0	55.7	-4.9%	-6.0%	-30.7%
3.07%	*$67.2*	$24.4	$24.2	$16.8	52.8	53.0	55.6	-4.2%	-5.4%	-30.3%
2.96%	*$66.4*	$24.0	$23.8	$16.6	52.7	52.9	55.6	-3.8%	-5.0%	-30.1%
2.93%	*$66.2*	$24.0	$23.7	$16.5	**52.7**	**52.8**	55.6	**-3.6%**	**-4.9%**	-30.0%
1.67%	*$57.6*	$20.9	$20.9	$13.8	**52.0**	**52.1**	55.1	**1.1%**	**0.4%**	-26.4%
0.83%	*$52.6*	$19.3	$19.1	$12.5	51.6	51.7	54.9	4.4%	4.4%	-24.3%
0.34%	*$50.0*	$18.2	$18.1	$11.7	51.4	51.4	54.7	6.2%	6.3%	-23.0%
0.00%	*$48.2*	$17.5	$17.4	$11.2	51.2	51.2	54.6	7.5%	7.8%	-22.1%
-0.78%	*$44.4*	$15.9	$15.9	$10.3	50.7	50.7	54.4	11.8%	12.3%	-20.6%
-0.86%	*$44.1*	$15.8	$15.8	$10.2	50.7	50.6	54.4	12.2%	12.8%	-20.4%
-1.37%	*$41.8*	$15.0	$15.1	$9.5	50.5	50.4	54.2	14.2%	14.9%	-19.2%
-4.95%	*$29.5*	$10.7	$10.7	$6.4	48.7	48.5	53.1	27.3%	29.1%	-12.6%
-7.64%	*$23.2*	$8.1	$8.2	$4.8	47.5	47.3	52.4	36.4%	38.9%	-10.2%
				2006 Baseline Values:	**52.3**	**52.3**	**52.3**			

[1] *The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the NHS.*

[2] *The amounts shown represent the portion of spending that HERS directed toward NHS system expansion rather than system rehabilitation, which varies depending on the funding mechanism employed.*

Source: Highway Economic Requirements System.

Impact of Future Investment on NHS Pavement Ride Quality

Exhibit 7-17 shows how NHS pavement ride quality (based on the IRI defined in Chapter 3) could be affected by the total amount invested in types of capital improvements modeled in HERS, particularly NHS system rehabilitation expenditures. Although adding new, smooth lanes to the NHS via investments in NHS system expansion would positively affect average ride quality, system rehabilitation investments would tend to have a significantly greater impact on these performance indicators.

As indicated in *Exhibit 7-17*, HERS projects that if base year funding levels were sustained in constant dollar terms and distributed in the manner recommended by the model among NHS and non-NHS improvements, the percent of NHS travel occurring on pavements with an IRI value below 95 (defined

Exhibit 7-17

Projected Changes in 2026 Pavement Ride Quality on the NHS Compared With 2006 Levels for Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]				Percent of NHS VMT on Pavements With IRI<95			Percent Change in Average IRI on the NHS		
		NHS System Rehabilitation [2] Funding Mechanism			Funding Mechanism			Funding Mechanism		
	Total HERS Spending	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$115.7*	$21.8			89.6%			-33.7%		
7.45%	*$111.5*	$21.3	$21.3		88.9%	89.2%		-32.8%	-33.2%	
6.70%	*$102.0*	$20.0	$20.0		86.7%	86.9%		-29.8%	-30.2%	
6.41%	*$98.6*	$19.5	$19.7		85.8%	86.2%		-28.2%	-29.0%	
5.25%	*$86.1*	$17.8	$18.0		82.2%	82.6%		-23.7%	-24.2%	
5.15%	*$85.1*	$17.6	$17.8		81.9%	82.3%		-23.3%	-23.9%	
5.03%	*$84.0*	$17.5	$17.6		81.6%	81.8%		-22.8%	-23.4%	
4.65%	*$80.4*	$17.0	$17.0		80.4%	80.4%		-21.2%	-21.6%	
4.55%	*$79.5*	$16.9	$16.9	$18.2	80.0%	80.1%	85.7%	-20.7%	-21.0%	-27.8%
4.17%	*$76.1*	$16.3	$16.4	$17.7	78.7%	79.0%	84.6%	-18.9%	-19.2%	-26.4%
3.30%	*$69.0*	$15.3	$15.3	$16.5	76.2%	76.1%	81.9%	-15.4%	-15.5%	-23.1%
3.21%	*$68.3*	$15.2	$15.2	$16.4	76.0%	75.7%	81.6%	-15.1%	-15.1%	-22.8%
3.07%	*$67.2*	$15.1	$15.1	$16.2	75.5%	75.4%	81.3%	-14.2%	-14.4%	-22.4%
2.96%	*$66.4*	$14.9	$14.9	$16.1	75.1%	75.0%	80.9%	-13.1%	-13.3%	-21.8%
2.93%	*$66.2*	$14.8	$14.9	$16.0	75.0%	74.9%	80.8%	-13.0%	-13.2%	-21.7%
1.67%	*$57.6*	$13.4	$13.4	$14.4	71.0%	70.9%	76.4%	-5.7%	-5.8%	-16.2%
0.83%	*$52.6*	$12.5	$12.6	$13.4	68.5%	68.4%	73.4%	**-2.1%**	**-2.3%**	-12.7%
0.34%	*$50.0*	$12.1	$12.1	$12.9	67.0%	67.0%	71.5%	**0.6%**	**0.4%**	-10.1%
0.00%	*$48.2*	$11.7	$11.8	$12.5	65.9%	65.9%	70.1%	2.7%	2.6%	-8.3%
-0.78%	*$44.4*	$11.0	$11.0	$11.8	63.4%	63.3%	67.6%	6.0%	6.3%	-5.3%
-0.86%	*$44.1*	$10.9	$10.9	$11.7	63.1%	63.1%	67.3%	6.4%	6.6%	-5.0%
-1.37%	*$41.8*	$10.5	$10.5	$11.3	**61.6%**	**61.5%**	**65.8%**	8.7%	8.9%	**-2.9%**
-4.95%	*$29.5*	$7.7	$7.7	$8.4	**52.5%**	**52.4%**	**55.0%**	26.9%	27.8%	**13.1%**
-7.64%	*$23.2*	$6.2	$6.2	$6.9	47.6%	47.5%	49.2%	39.5%	40.1%	25.2%
				2006 Baseline Values:	**57.0%**	**57.0%**	**57.0%**			

[1] *The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the NHS.*

[2] *The amounts shown represent the portion of spending that HERS directed toward NHS system rehabilitation rather than system expansion, which varies depending on the funding mechanism employed.*

Source: Highway Economic Requirements System.

in Chapter 3 as the threshold for "good" ride quality) could improve from 57.0 percent to 70.1 percent assuming variable rate user charges were widely adopted, or to 65.9 percent if they were not. As shown in *Exhibit 7-17*, HERS would recommend spending more on NHS system rehabilitation if variable rate charges were imposed than if they were not, which accounts for some of the difference in projected pavement performance. It should also be noted that it would not be cost-beneficial to bring the percent of NHS VMT on pavements with good ride quality above 85 to 90 percent; the benefits of further improvements in terms of reductions in vehicle operating and other user costs would be outweighed by their capital costs, and the costs associated with work zone delays.

Exhibit 7-17 also shows that while average NHS ride quality would be expected to improve if combined public and private capital investment were sustained at base year levels in constant dollar terms, and variable rate user charges were broadly imposed. If such charges were not imposed, HERS predicts that average NHS ride quality could be sustained if spending on types of improvements considered in the model were to increase by between 0.34 percent and 0.83 percent annually in constant dollar terms.

Impacts of Interstate System Investments Modeled by HERS

The Interstate System is the most recognizable subset of the highway system; unlike the broader NHS of which it is a part, the Interstate System has standard design and signing requirements. This section examines the total spending modeled in HERS, identifying the portion of this investment that is directed by the model to the Interstate System, and the impacts that such investment could have on future Interstate System conditions and performance.

Impact of Future Investment on Interstate User Costs

Exhibit 7-18 describes how average total user costs and adjusted average user costs on the Interstate System are influenced by the total amount invested on the system, and the financing mechanisms utilized to support such investment. As discussed earlier in this chapter, the adjusted average user cost figures offset the impacts of the improvements in future fuel efficiency assumed as part of the analysis, in order to provide a better measure of the impact that changes in system conditions and performance have on highway user costs. The first 24 investment levels described in *Exhibit 7-18* correspond to the systemwide spending levels explored earlier in this chapter that are analytically significant in terms of systemwide investment impacts; the next row has been included to specifically identify the costs associated with maintaining adjusted average user costs for each of the three types of funding mechanisms, while the last row shows the impacts of sustaining capital investment on the Interstate System at 2006 levels in constant dollar terms for each funding mechanism.

Exhibit 7-18 shows that if combined public and private highway capital investment on types of improvements modeled in HERS were sustained in constant dollar terms at their current level of $48.2 billion and funded by either non-user sources or fixed rate user charges, the model would recommend that $20.0 billion be directed to the Interstate System; this is considerably more than the $12.8 billion identified in *Exhibit 7-1* as having been spent on the Interstate System for HERS-modeled improvement types in 2006. Alternatively, if variable-rate user charges were adopted, HERS would recommend that $14.9 billion of current funding be directed toward the Interstate System, which still exceeds current spending for HERS-modeled types of Interstate spending. The analyses presented in Chapter 8 include comparisons of current Interstate spending with selected future Interstate investment scenarios.

Exhibit 7-18

Projected Changes in 2026 Highway User Costs on the Interstate System Compared With 2006 Levels

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]: Total HERS Capital Outlay	Spending on Interstates, Funding Mechanism [2]: Non-User Sources	Spending on Interstates, Funding Mechanism [2]: Fixed Rate User Charges	Spending on Interstates, Funding Mechanism [2]: Variable Rate User Charges	Percent Change in User Costs on the Interstate System — Average User Costs, Funding Mechanism [2]: Non-User Sources	Average User Costs: Fixed Rate User Charges	Average User Costs: Variable Rate User Charges	Adjusted Average User Costs, Funding Mechanism [2]: Non-User Sources	Adjusted Average User Costs: Fixed Rate User Charges	Adjusted Average User Costs: Variable Rate User Charges
7.76%	*$115.7*	$40.6			-9.4%			-6.1%		
7.45%	*$111.5*	$39.4	$38.8		-9.2%	-9.6%		-5.9%	-6.3%	
6.70%	*$102.0*	$36.2	$36.5		-8.7%	-9.1%		-5.3%	-5.8%	
6.41%	*$98.6*	$35.5	$35.6		-8.5%	-8.9%		-5.2%	-5.6%	
5.25%	*$86.1*	$32.3	$32.2		-7.8%	-8.1%		-4.4%	-4.8%	
5.15%	*$85.1*	$32.1	$31.7		-7.7%	-8.0%		-4.4%	-4.7%	
5.03%	*$84.0*	$31.8	$31.4		-7.7%	-7.9%		-4.3%	-4.5%	
4.65%	*$80.4*	$30.4	$30.3		-7.3%	-7.6%		-3.9%	-4.2%	
4.55%	*$79.5*	$30.1	$30.0	$23.5	-7.2%	-7.5%	-9.5%	-3.8%	-4.1%	-6.2%
4.17%	*$76.1*	$29.1	$28.9	$22.7	-7.0%	-7.2%	-9.3%	-3.6%	-3.8%	-6.0%
3.30%	*$69.0*	$26.9	$26.7	$20.8	-6.2%	-6.4%	-8.9%	-2.8%	-3.0%	-5.6%
3.21%	*$68.3*	$26.6	$26.5	$20.7	-6.2%	-6.3%	-8.9%	-2.7%	-2.9%	-5.6%
3.07%	*$67.2*	$26.2	$26.1	$20.4	-6.0%	-6.2%	-8.8%	-2.6%	-2.7%	-5.5%
2.96%	*$66.4*	$25.9	$25.8	$20.1	-5.9%	-6.0%	-8.8%	-2.4%	-2.6%	-5.5%
2.93%	*$66.2*	$25.9	$25.8	$20.0	-5.9%	-6.0%	-8.8%	-2.4%	-2.6%	-5.4%
1.67%	*$57.6*	$23.1	$23.1	$17.6	-4.7%	-4.9%	-8.1%	-1.3%	-1.4%	-4.7%
0.83%	*$52.6*	$21.7	$21.6	$16.3	-4.2%	-4.2%	-7.6%	-0.7%	-0.7%	-4.3%
0.34%	*$50.0*	$20.7	$20.6	$15.5	-3.8%	-3.8%	-7.3%	**-0.3%**	**-0.2%**	-3.9%
0.00%	*$48.2*	$20.0	$20.0	$14.9	-3.5%	-3.4%	-7.1%	**0.1%**	**0.1%**	-3.7%
-0.78%	*$44.4*	$18.4	$18.4	$14.0	-2.6%	-2.6%	-6.8%	0.9%	1.0%	-3.4%
-0.86%	*$44.1*	$18.3	$18.3	$13.9	-2.6%	-2.5%	-6.8%	1.0%	1.0%	-3.4%
-1.37%	*$41.8*	**$17.7**	**$17.7**	**$13.1**	-2.3%	-2.2%	-6.5%	1.3%	1.4%	-3.1%
-4.95%	*$29.5*	**$12.7**	**$12.7**	**$9.4**	1.1%	1.4%	-4.4%	4.8%	5.1%	**-0.9%**
-7.64%	*$23.2*	$9.9	$9.9	$7.3	3.6%	3.9%	-3.0%	7.4%	7.7%	**0.6%**
Cost to Maintain: [3]		$20.2	$20.2	$8.0				**0.0%**	**0.0%**	**0.0%**
2006 Spending: [4]		**$12.8**	**$12.8**	**$12.8**				4.8%	5.0%	-2.9%

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the Interstate System.

[2] The funding mechanism employed will affect both the portion of spending that HERS directs toward the Interstate System, and the relative impacts of that spending.

[3] The amounts are projected to be sufficient to maintain adjusted average user costs on the Interstate System at 2006 levels.

[4] The amount shown reflects actual highway capital spending by all levels of government on the Interstate System in 2006.

Source: Highway Economic Requirements System.

In general, for any given funding level, HERS would direct a lower percentage of total investment towards the Interstate System if variable rate user charges were applied, than if they were not. Such charges would generally be easier to apply and more effective in reducing congestion on the types of high volume, restricted access facilities that constitute the Interstate System, which would reduce the potential benefits that could be achieved by widening such facilities. Consequently, the benefit-cost ratios associated with Interstate investments would tend to be lower, making it more likely that investments on other routes would be selected in a constrained funding environment.

If variable rate user charges were widely adopted, HERS projects that combined public and private highway capital investment on the Interstate System could be significantly reduced from the existing level, while still maintaining adjusted average user costs at base year levels. In the absence of such charges, HERS projects that maintaining adjusted average user costs on the Interstate System would require an annual increase of 0.00 percent to 0.34 percent per year in spending on the types of capital improvements modeled in HERS, as well as a significant redirection of such resources towards the Interstate System and away from non-Interstate routes.

Impact of Future Investment on Interstate System Speeds and Delays

Exhibit 7-19 describes how average speed and average delay per VMT on the Interstate System is influenced by alternative financing mechanisms and the amount expended for types of improvements modeled in HERS, particularly investments in Interstate System expansion. Widening existing Interstate routes or building new routes in existing corridors would have a greater impact on speeds and delay than would investments in system rehabilitation such as the reconstruction or resurfacing of lanes on existing Interstate routes.

Exhibit 7-19 shows that if combined public and private highway capital investment on types of improvements modeled in HERS were sustained at 2006 levels in constant dollar terms and distributed among investments in Interstate System expansion, Interstate System rehabilitation, and non-Interstate facilities in the manner recommended by the model, then improvements in average speeds and average delay would be expected if variable rate user charges were applied on a widespread basis. If such charges were not applied, then average Interstate System speeds would be expected to decline, even if funding were redirected to the Interstate System from other types of highway facilities to support system expansion expenditures of $12.7 billion to $12.8 billion per year. In contrast, the amount identified in *Exhibit 7-1* earlier in this chapter as actual spending by all levels of government for Interstate System expansion in 2006 was $7.1 billion.

Impact of Future Investment on Interstate Pavement Ride Quality

Exhibit 7-20 shows how pavement ride quality (based on the IRI defined in Chapter 3) of the Interstate System could be affected by the total amount invested in types of capital improvements modeled in HERS, particularly Interstate System rehabilitation expenditures. Although adding new, smooth lanes to the Interstate System via investments in system expansion would positively affect average ride quality, system rehabilitation investments would tend to have a significantly greater impact on these performance indicators.

As indicated in *Exhibit 7-20*, HERS projects that if base year funding levels were sustained in constant dollar terms, and distributed in the manner recommended by the model among Interstate and non-Interstate improvements, the percent of NHS travel occurring on pavements with an IRI value below 95 (defined in Chapter 3 as the threshold for "good" ride quality) could be expected to improve from 63.3 percent to somewhere between 77.0 percent and 78.1 percent depending on the financing mechanism utilized. Such results would be dependent on an increase in the portion of total HERS-modeled investment directed towards Interstate System rehabilitation from the 2006 level of $5.7 billion to approximately $7.1 billion to $7.3 billion. *Exhibit 7-20* also shows that an investment of this level could be sufficient to improve average Interstate pavement ride quality; larger improvements (i.e., reductions in IRI) could be achieved if variable rate user charges were imposed.

Exhibit 7-19

Projected Changes in 2026 Average Speeds and Travel Delay on the Interstate System Compared With 2006 Levels for Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]				Average Speed on the Interstate System			Percent Change in Average Delay per VMT on Interstates		
		Interstate System Expansion [2] Funding Mechanism			Funding Mechanism			Funding Mechanism		
	Total HERS Spending	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges	Non-User Sources	Fixed Rate User Charges	Variable Rate User Charges
7.76%	*$115.7*	$28.7			64.7			-43.5%		
7.45%	*$111.5*	$27.6	$27.2		64.5	65.1		-41.4%	-46.1%	
6.70%	*$102.0*	$25.1	$25.2		63.8	64.4		-35.5%	-41.2%	
6.41%	*$98.6*	$24.5	$24.5		63.6	64.2		-34.1%	-39.4%	
5.25%	*$86.1*	$22.0	$21.8		62.8	63.3		-28.0%	-32.0%	
5.15%	*$85.1*	$21.8	$21.4		62.7	63.2		-27.4%	-30.9%	
5.03%	*$84.0*	$21.6	$21.2		62.6	63.1		-26.7%	-30.2%	
4.65%	*$80.4*	$20.5	$20.3		62.3	62.7		-24.1%	-27.0%	
4.55%	*$79.5*	$20.2	$20.1	$13.8	62.2	62.6	66.1	-23.2%	-26.3%	-53.1%
4.17%	*$76.1*	$19.5	$19.3	$13.1	61.9	62.2	65.9	-21.6%	-23.8%	-51.8%
3.30%	*$69.0*	$17.7	$17.5	$11.8	61.1	61.3	65.6	-14.9%	-16.5%	-48.9%
3.21%	*$68.3*	$17.5	$17.3	$11.7	61.1	61.3	65.5	-14.5%	-15.9%	-48.6%
3.07%	*$67.2*	$17.2	$17.1	$11.5	60.9	61.1	65.5	-13.7%	-15.0%	-48.1%
2.96%	*$66.4*	$17.0	$16.8	$11.4	60.8	60.9	65.4	-13.2%	-14.6%	-47.8%
2.93%	*$66.2*	$17.0	$16.8	$11.3	**60.7**	60.9	65.4	-13.1%	-14.4%	-47.7%
1.67%	*$57.6*	$15.0	$15.0	$9.5	**59.6**	**59.8**	64.7	-6.6%	-7.5%	-42.5%
0.83%	*$52.6*	$14.0	$13.8	$8.7	59.1	**59.1**	64.3	-2.2%	**-1.7%**	-39.2%
0.34%	*$50.0*	$13.3	$13.1	$8.2	58.7	58.7	64.0	**0.0%**	**0.4%**	-37.6%
0.00%	*$48.2*	$12.8	$12.7	$7.8	58.4	58.4	63.8	1.6%	2.2%	-36.3%
-0.78%	*$44.4*	$11.6	$11.6	$7.2	57.7	57.6	63.5	8.4%	8.7%	-34.3%
-0.86%	*$44.1*	$11.5	$11.6	**$7.1**	57.6	57.6	63.5	9.0%	9.3%	-34.1%
-1.37%	*$41.8*	$11.1	$11.1	$6.6	57.4	57.3	63.3	11.2%	11.8%	-32.2%
-4.95%	*$29.5*	**$7.9**	**$7.9**	$4.5	54.5	54.2	61.5	31.7%	34.2%	-22.2%
-7.64%	*$23.2*	**$6.0**	**$6.1**	$3.3	52.6	52.3	60.2	46.5%	50.0%	-19.0%
				2006 Baseline Values:	**59.7**	**59.7**	**59.7**			

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the Interstate System.

[2] The amounts shown represent the portion of spending that HERS directed toward Interstate system expansion rather than system rehabilitation, which varies depending on the funding mechanism employed.

Source: Highway Economic Requirements System.

It should be noted that it would not be cost-beneficial to bring the percent of Interstate VMT on pavements with good ride quality above 91 to 95 percent; the benefits of further improvements in terms of reductions in vehicle operating and other user costs would be outweighed by their capital costs, and the costs associated with work zone delays.

Exhibit 7-20

Projected Changes in 2026 Pavement Ride Quality on the Interstate System Compared With 2006 Levels for Different Possible Funding Levels, and Financing Mechanisms

Annual Percent Change Relative to 2006	Average Annual HERS-Modeled Capital Investment (Billions of 2006 Dollars) [1]: Total HERS Spending	Interstate System Rehabilitation [2] — Funding Mechanism: Non-User Sources	Interstate System Rehabilitation [2] — Funding Mechanism: Fixed Rate User Charges	Interstate System Rehabilitation [2] — Funding Mechanism: Variable Rate User Charges	Percent of Interstate VMT on Pavements with IRI<95 — Funding Mechanism: Non-User Sources	Percent of Interstate VMT on Pavements with IRI<95 — Funding Mechanism: Fixed Rate User Charges	Percent of Interstate VMT on Pavements with IRI<95 — Funding Mechanism: Variable Rate User Charges	Percent Change in Average IRI on the Interstate — Funding Mechanism: Non-User Sources	Percent Change in Average IRI on the Interstate — Funding Mechanism: Fixed Rate User Charges	Percent Change in Average IRI on the Interstate — Funding Mechanism: Variable Rate User Charges
7.76%	*$115.7*	$11.9			95.0%			-34.8%		
7.45%	*$111.5*	$11.7	$11.7		94.7%	95.0%		-34.3%	-34.7%	
6.70%	*$102.0*	$11.1	$11.2		93.3%	93.5%		-32.1%	-32.5%	
6.41%	*$98.6*	$11.0	$11.1		92.7%	93.1%		-31.2%	-32.0%	
5.25%	*$86.1*	$10.3	$10.4		90.4%	90.5%		-27.6%	-28.3%	
5.15%	*$85.1*	$10.2	$10.3		90.1%	90.4%		-27.4%	-28.2%	
5.03%	*$84.0*	$10.2	$10.2		89.9%	90.0%		-27.1%	-27.6%	
4.65%	*$80.4*	$9.9	$10.0		88.8%	88.8%		-25.1%	-25.9%	
4.55%	*$79.5*	$9.9	$9.9	$9.7	88.5%	88.7%	91.5%	-24.8%	-25.3%	-29.4%
4.17%	*$76.1*	$9.7	$9.7	$9.5	87.7%	88.1%	90.7%	-23.1%	-23.7%	-28.4%
3.30%	*$69.0*	$9.2	$9.2	$9.0	85.9%	85.8%	88.5%	-20.4%	-20.7%	-25.5%
3.21%	*$68.3*	$9.1	$9.1	$8.9	85.6%	85.5%	88.3%	-20.0%	-20.5%	-25.2%
3.07%	*$67.2*	$9.0	$9.1	$8.9	85.2%	85.1%	88.0%	-18.9%	-19.3%	-24.8%
2.96%	*$66.4*	$8.9	$9.0	$8.8	84.9%	84.8%	87.7%	-17.6%	-18.1%	-24.2%
2.93%	*$66.2*	$8.9	$9.0	$8.7	84.8%	84.8%	87.5%	-17.5%	-18.0%	-24.0%
1.67%	*$57.6*	$8.1	$8.1	$8.0	81.4%	81.3%	83.5%	-9.2%	-9.7%	-18.6%
0.83%	*$52.6*	$7.7	$7.7	$7.6	79.3%	79.2%	81.1%	-6.1%	-6.6%	-15.6%
0.34%	*$50.0*	$7.4	$7.5	$7.3	77.9%	77.9%	79.5%	-2.9%	-3.2%	-12.9%
0.00%	*$48.2*	$7.2	$7.3	$7.1	77.0%	77.0%	78.1%	**-0.3%**	**-0.7%**	-10.8%
-0.78%	*$44.4*	$6.8	$6.8	$6.8	74.3%	74.1%	76.1%	**3.6%**	**3.6%**	-8.2%
-0.86%	*$44.1*	$6.8	$6.8	$6.7	74.0%	74.0%	75.8%	3.8%	3.7%	-7.9%
-1.37%	*$41.8*	**$6.6**	**$6.6**	**$6.5**	**72.6%**	**72.5%**	74.4%	5.7%	5.8%	**-5.6%**
-4.95%	*$29.5*	**$4.8**	**$4.8**	**$4.9**	**62.3%**	**62.3%**	**63.8%**	27.7%	28.7%	**12.7%**
-7.64%	*$23.2*	$3.8	$3.8	$3.9	56.6%	56.5%	**57.5%**	43.4%	43.7%	28.4%
				2006 Baseline Values:	**63.3%**	**63.3%**	**63.3%**			

[1] *The amounts shown represent the average annual investment over 20 years that would occur if annual investment for types of capital improvements modeled by HERS grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of HERS-modeled spending on the Interstate System.*

[2] *The amounts shown represent the portion of spending that HERS directed toward Interstate system rehabilitation rather than system expansion, which varies depending on the funding mechanism employed.*

Source: Highway Economic Requirements System.

Impacts of Systemwide Investments Modeled by NBIAS

Exhibit 7-1 shows that of total public and private capital spending on all roads of $78.7 billion in 2006, $10.1 billion was utilized for types of improvements modeled in NBIAS. This section projects the potential impacts on system performance of raising or lowering this $10.1 billion in constant dollar terms by various annual rates over 20 years. These percentage increases are also applied to the $78.7 billion in the findings presented in this section; this acknowledges that the improvements reflected in NBIAS represent only one piece of total capital investment, and that the types of improvements reflected in HERS or those that are not reflected in either model should also be considered when projecting the impacts of different overall levels of combined public and private investment. The figures presented in this section pertain only to bridge system rehabilitation; expenditures associated with bridge system expansion are modeled separately as part of the capacity expansion analysis in the HERS model.

As noted earlier, the NBIAS model does not contain the types of revenue linkage procedures that are included in HERS and cannot directly assess the potential impacts of alternative financing mechanisms for bridges. Consequently, the fixed and variable rate charges assumed in HERS have been set at a level sufficient to cover the costs of implementing the NBIAS-modeled improvements for each of the funding levels analyzed.

Q&A

How does the NBIAS definition of bridge deficiencies compare with the information on structurally deficient bridges reported in Chapter 3?

NBIAS considers bridge deficiencies and corrective improvements at the level of individual bridge elements. The economic backlog of bridge deficiencies estimated by NBIAS thus consists of the cost of all improvements to bridge elements that would be justified on both engineering and economic grounds. It includes many improvements on bridges with certain components that may warrant repair, rehabilitation, or replacement, but whose overall condition is not sufficiently deteriorated for them to be classified as structurally deficient.

The corrective actions recommended by NBIAS would include those aimed at addressing structural deficiencies, as well as some functional deficiencies. System expansion needs for both highways and bridges are addressed separately as part of the HERS model analysis.

Impact of Future Investment on Overall Bridge Conditions

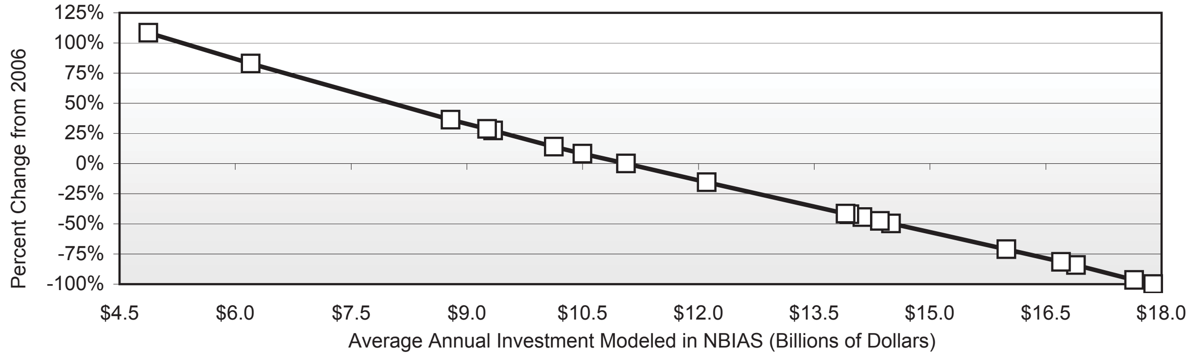
The NBIAS model considers bridge deficiencies at the level of individual bridge elements based on engineering criteria, and computes an initial value for the cost of a set of corrective actions that would address all such deficiencies. NBIAS tracks this "backlog" of potential bridge improvements over time, re-computing it to account for corrective actions taken and for the ongoing deterioration of bridge elements. A portion of this engineering-based backlog represents potential corrective actions that would not pass a benefit-cost test, and thus would not be implemented by the model, even if available funding were unlimited. Such potential actions are not included in the statistics presented in this report, which focus on an economic backlog representing the cost of improving all bridge deficiencies if the benefits of doing so exceed the costs. Changes in the economic bridge investment backlog can be viewed as a proxy for changes in overall bridge conditions.

Exhibit 7-21 describes how the economic backlog of system rehabilitation investments for bridges are influenced by the total amount invested in the types of capital improvements modeled in NBIAS. The model projects that if combined public and private bridge system rehabilitation spending were sustained at 2006 levels in constant dollar terms, then the economic backlog for bridges would be expected to increase by 13.9 percent above its 2006 level of $98.9 billion; if investment were to increase by 0.83 percent annually in constant dollar terms, this could be sufficient to prevent the economic backlog for bridges from increasing. NBIAS projects that if combined public and private bridge system rehabilitation spending were to increase by 5.15 percent annually in constant dollar terms, this would be sufficient to completely eliminate the economic backlog of bridge deficiencies. Investment above that level would not be considered cost-beneficial.

Exhibit 7-21 also identifies separate components of the overall bridge investment backlog, identifying the portion associated with bridge replacement; bridge improvement, including the raising, strengthening, and widening of existing bridges; and bridge rehabilitation and repair. The reason that most of the backlog is associated with bridge replacement is that these are the investments that NBIAS tends to defer when

Exhibit 7-21

Projected Changes in 2026 Bridge Investment Backlog Compared With 2006 Levels for Different Possible Funding Levels



Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]		2026 Bridge Investment Backlog for System Rehabilitation (Billions of 2006 Dollars)[2]				Percent Change in Bridge Backlog Compared to 2006
	Total Capital Outlay	Spending Modeled in NBIAS	Replacement	Improvement (Raising, Strengthening, and Widening)	Rehabilitation and Repair	Total	
5.15%	*$139.0*	$17.9	$0.0	$0.0	$0.0	$0.0	**-100.0%**
5.03%	*$137.1*	$17.6	$2.0	$0.0	$1.4	$3.5	-96.5%
4.65%	*$131.2*	$16.9	$8.5	$0.5	$6.5	$15.5	-84.3%
4.55%	*$129.7*	$16.7	$10.0	$0.6	$7.7	$18.3	-81.5%
4.17%	*$124.2*	$16.0	$16.8	$1.3	$10.4	$28.5	-71.2%
3.30%	*$112.6*	$14.5	$33.2	$2.1	$14.4	$49.7	-49.7%
3.21%	*$111.5*	$14.4	$35.0	$2.1	$14.7	$51.8	-47.6%
3.07%	*$109.7*	$14.1	$37.8	$2.2	$14.9	$55.0	-44.4%
2.96%	*$108.4*	$14.0	$39.8	$2.3	$15.1	$57.1	-42.2%
2.93%	*$108.0*	$13.9	$40.4	$2.3	$15.1	$57.8	-41.5%
1.67%	*$94.0*	$12.1	$63.9	$3.0	$16.5	$83.4	-15.6%
0.83%	*$85.9*	$11.1	$78.4	$3.2	$17.2	$98.8	**0.0%**
0.34%	*$81.5*	$10.5	$86.1	$3.3	$17.6	$107.0	8.2%
0.00%	*$78.7*	$10.1	$91.3	$3.4	$17.8	$112.6	13.9%
-0.78%	*$72.5*	$9.3	$104.0	$3.5	$18.4	$125.8	27.3%
-0.86%	*$71.9*	$9.3	$105.3	$3.5	$18.4	$127.2	28.6%
-1.37%	*$68.3*	$8.8	$112.5	$3.6	$18.7	$134.8	36.4%
-4.95%	*$48.2*	$6.2	$156.8	$3.7	$20.4	$180.9	83.0%
-7.64%	*$37.9*	$4.9	$181.2	$3.8	$21.0	$206.0	108.3%
				2006 Baseline Values:		**$98.9**	

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by spending modeled in NBIAS; the figures for total capital outlay are included to reflect other spending not modeled in NBIAS.

[2] The amounts shown do not reflect system expansion needs; the bridge components of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

available funding is constrained as the high capital costs associated with them frequently causes their benefit-cost ratios to be lower than potential improvement, rehabilitation, or repair actions.

NBIAS computes the average benefit-cost ratio for bridge improvements to be somewhere in the range of 3.5 to 10.2 depending on the overall level of investment being implemented, compared to an average benefit-cost ratio of 1.7 to 2.8 for bridge rehabilitation and repair actions, and an average benefit-cost ratio of 1.4 to 2.1 for bridge replacement actions. The marginal benefit-cost ratios associated with these averages are naturally lower, in that marginal ratios pertain to the last, and least cost-beneficial, project funded within a given budget. NBIAS estimates that the lowest benefit-cost ratio for any project implemented in 2026 would be 1.0 if spending grows at an annual rate of 5.15 percent, approximately 1.2 if spending grows at 1.67 percent annually, and approximately 1.5 if spending declines by 0.78 percent per year. It should be noted that the computation of benefit-cost ratios in NBIAS is not as robust as that in HERS, and that the model may not be capturing the full range of benefits associated with certain types of bridge investments, particularly in regards to keeping bridges open and thus avoiding detours.

Impacts of NHS Investments Modeled by NBIAS

Exhibit 7-22 identifies the portion of the total economic bridge investment backlog that is attributable to bridges on the NHS, and how that backlog would be influenced by the amount of combined public and

Exhibit 7-22

Projected Changes in 2026 Bridge Investment Backlog on the NHS Compared With 2006 Levels for Different Possible Funding Levels

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars) [1]			2026 NHS Bridge Backlog [2] (Billions of 2006 Dollars)	Percent Change in Bridge Backlog Compared to 2006
	Total Capital Outlay	Spending Modeled in NBIAS			
		Total	On NHS		
5.15%	*$139.0*	*$17.9*	$7.7	**$0.0**	**-100.0%**
5.03%	*$137.1*	*$17.6*	$7.6	$1.3	-97.4%
4.65%	*$131.2*	*$16.9*	$7.4	$5.3	-89.6%
4.55%	*$129.7*	*$16.7*	$7.3	$6.2	-87.8%
4.17%	*$124.2*	*$16.0*	$7.1	$10.1	-80.1%
3.30%	*$112.6*	*$14.5*	$6.5	$18.4	-63.8%
3.21%	*$111.5*	*$14.4*	$6.5	$19.4	-61.8%
3.07%	*$109.7*	*$14.1*	$6.4	$20.9	-58.9%
2.96%	*$108.4*	*$14.0*	$6.3	$22.4	-55.9%
2.93%	*$108.0*	*$13.9*	$6.3	$22.6	-55.5%
1.67%	*$94.0*	*$12.1*	$5.6	$34.5	-32.1%
0.83%	*$85.9*	*$11.1*	$5.1	$42.4	-16.5%
0.34%	*$81.5*	*$10.5*	$4.9	$46.0	-9.4%
0.00%	*$78.7*	*$10.1*	$4.8	$48.2	-5.1%
-0.78%	*$72.5*	*$9.3*	$4.5	$54.1	6.5%
-0.86%	*$71.9*	*$9.3*	$4.5	$54.6	7.5%
-1.37%	*$68.3*	*$8.8*	$4.3	$57.8	13.8%
-4.95%	*$48.2*	*$6.2*	$3.2	$78.4	54.3%
-7.64%	*$37.9*	*$4.9*	$2.5	$91.1	79.3%
Cost to Maintain:[3]			$4.7	**$50.8**	**0.0%**
2006 Spending:[4]			**$4.3**	$57.3	12.8%
2006 Baseline Values:			**$4.3**	**$50.8**	

[1] The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by portion of NBIAS-modeled spending on the NHS.

[2] The amounts shown do not reflect system expansion needs; the bridge components of such needs are addressed as part of the HERS model analysis.

[3] The amount shown is projected to be sufficient to maintain the economic bridge backlog at its baseline 2006 level.

[4] The amount shown reflects actual capital spending by all levels of government on NHS bridges in 2006.

Source: National Bridge Investment Analysis System.

private investment on the NHS for types of capital improvements modeled in NBIAS. The first 19 investment levels described in *Exhibit 7-22* correspond to the systemwide spending levels in *Exhibit 7-21*; the next row has been included to specifically identify the costs associated with maintaining the NHS bridge backlog at its 2006 level of $50.8 billion, while the last row shows the impacts of sustaining investment on the NHS at 2006 levels in constant dollar terms.

Exhibit 7-22 shows that if combined public and private highway capital investment on types of improvements modeled in NBIAS were sustained in constant dollar terms at their current level of $10.1 billion, the model would recommend that $4.8 billion be directed to the NHS; this is above the $4.3 billion identified in *Exhibit 7-1* as having been spent on the NHS for NBIAS-modeled improvement types in 2006. It is projected that this level of investment would result in a decrease in the economic backlog for NHS bridges of approximately 5.1 percent. NBIAS predicts that the economic backlog for NHS bridges could be maintained at base year levels if average annual investment on the NHS for the types of improvements modeled in NBIAS were to rise to $4.7 billion in constant 2006 dollars, while the economic backlog could potentially be eliminated by an investment averaging approximately $7.7 billion annually in constant 2006 dollars.

Impacts of Interstate Investments Modeled by NBIAS

Exhibit 7-23 describes how the economic backlog for Interstate bridges could be influenced by the amount of combined public and private investment on the Interstate System for the types of capital improvements modeled in NBIAS. The first 19 investment levels described in *Exhibit 7-23* correspond to the systemwide spending levels in *Exhibit 7-21*. The next row has been included to specifically identify the costs associated with maintaining the Interstate bridge backlog at its 2006 level of $33.4 billion, while the last row shows the impacts of sustaining investment on Interstate bridges at 2006 levels in constant dollar terms.

Exhibit 7-23 shows that if combined public and private highway capital investment on the types of improvements modeled in NBIAS were sustained in constant dollar terms at their current level of $10.1 billion, the model would recommend that $2.9 billion be directed to the Interstate; this is above the $2.5 billion identified in *Exhibit 7-1* as having been spent on the Interstate for NBIAS-modeled improvement types in 2006. It is projected that this level of investment would result in a decrease in the economic backlog for Interstate NHS bridges of approximately 7.8 percent. NBIAS predicts that the economic backlog for Interstate bridges could be maintained at base year levels if average annual investment on the Interstate for the types of improvements modeled in NBIAS were to rise to $2.8 billion in constant 2006 dollars, while the economic backlog could potentially be eliminated by an investment averaging approximately $4.7 billion annually in constant 2006 dollars.

Exhibit 7-23

Projected Changes in 2026 Bridge Investment Backlog on the Interstate System Compared With 2006 Levels for Different Possible Funding Levels

Annual Percent Change Relative to 2006	Average Annual Capital Investment (Billions of 2006 Dollars)[1]			2026 Interstate Bridge Backlog[2] (Billions of 2006 Dollars)	Percent Change in Bridge Backlog Compared to 2006
	Total Capital Outlay	Spending Modeled in NBIAS			
		Total	On Interstate		
5.15%	*$139.0*	*$17.9*	$4.7	**$0.0**	**-100.0%**
5.03%	*$137.1*	*$17.6*	$4.6	$0.7	-97.9%
4.65%	*$131.2*	*$16.9*	$4.5	$2.8	-91.6%
4.55%	*$129.7*	*$16.7*	$4.5	$3.2	-90.4%
4.17%	*$124.2*	*$16.0*	$4.3	$5.3	-84.1%
3.30%	*$112.6*	*$14.5*	$4.0	$10.9	-67.4%
3.21%	*$111.5*	*$14.4*	$4.0	$11.5	-65.6%
3.07%	*$109.7*	*$14.1*	$3.9	$12.7	-62.0%
2.96%	*$108.4*	*$14.0*	$3.7	$12.9	-61.4%
2.93%	*$108.0*	*$13.9*	$3.8	$14.1	-57.8%
1.67%	*$94.0*	*$12.1*	$3.4	$21.9	-34.4%
0.83%	*$85.9*	*$11.1*	$3.1	$26.9	-19.5%
0.34%	*$81.5*	*$10.5*	$3.0	$29.3	-12.3%
0.00%	*$78.7*	*$10.1*	$2.9	$30.8	-7.8%
-0.78%	*$72.5*	*$9.3*	$2.7	$34.7	3.9%
-0.86%	*$71.9*	*$9.3*	$2.7	$35.1	5.1%
-1.37%	*$68.3*	*$8.8*	$2.6	$37.0	10.8%
-4.95%	*$48.2*	*$6.2*	$1.8	$48.1	44.0%
-7.64%	*$37.9*	*$4.9*	$1.5	$58.8	76.0%
		Cost to Maintain:[3]	$2.8	**$33.4**	**0.0%**
		2006 Spending:[4]	**$2.5**	$39.1	17.1%
		2006 Baseline Values:	**$2.5**	**$33.4**	

[1] *The amounts shown represent the average annual investment over 20 years that would occur if annual investment grows by the percentage shown in each row in constant dollar terms. The performance impacts identified in this table are driven by the portion of NBIAS-modeled spending on the Interstate System.*

[2] *The amounts shown do not reflect system expansion needs; the bridge components of such needs are addressed as part of the HERS model analysis.*

[3] *The amount shown is projected to be sufficient to maintain the economic bridge backlog at its baseline 2006 level.*

[4] *The amount shown reflects actual capital spending by all levels of government on Interstate bridges in 2006.*

Source: National Bridge Investment Analysis System.

Potential Transit Capital Investment Impacts

This section of the 2008 C&P Report examines how different types and levels of annual capital investments would affect measures of transit system condition and performance by 2026. The analysis presented in this chapter begins with an overview of the types of capital spending projected by the Transit Economic Requirements Model (TERM). The chapter then moves into an examination of how different annual spending levels impact transit system conditions and performance on a national basis before continuing on with an analysis of how various levels of annual expenditures affect various urbanized areas (UZAs) characterized by differing transit environments.

Types of Capital Spending Projected by TERM

As stated elsewhere in this report, the Federal Transit Administration (FTA) uses TERM, an analysis tool based on engineering and economic concepts, to forecast estimates of total capital investment needs for the U.S. transit industry over a 20-year period. The model uses data from a variety of sources, including State and local transit agencies, the National Transit Database (NTD), and regional Metropolitan Planning Organizations (MPOs) to generate its estimates.

TERM identifies potential investments using asset decay curves relating transit asset condition to age, and in some cases additionally to maintenance and use. TERM also identifies investment levels necessary to achieve stated performance goals based on measures such as vehicle occupancy rates and passenger travel times. The model subsequently uses benefit-cost analysis techniques to limit the actual level of investment forecast to a subgroup of the total investments identified. Investments with benefit-cost ratios of 1.0 or greater are added to the forecast while those with ratios less than one are excluded.

Using the data and techniques described above, TERM develops a forecast that consists of a collection of various investment types that U.S. transit agencies typically undertake to maintain and in some cases improve operations. Specifically, the model forecasts investments intended to: (1) rehabilitate and replace existing assets that are in a state of disrepair or past their useful life; (2) expand the existing transit asset base as required to maintain current performance levels (measured by average riders per vehicle) given projected growth in ridership; and (3) improve performance both for those agency-modes currently experiencing system overcrowding and for those metropolitan areas with transit operating speeds that are well below the national average. All capital investments forecast by TERM must successfully pass the model's benefit-cost analysis before being added to the tally of the Nation's investment needs.

Rehabilitation and Replacement Investments

For the analysis presented in this chapter, TERM estimates the total investment required for ongoing rehabilitation and replacement of the Nation's existing transit assets over a 20-year period. In estimating these types of investments, the model predicts reinvestment in a number of areas, including existing fleet vehicles, maintenance facilities, stations, guideway and trackwork, and train control and traction power systems. The model starts with a detailed inventory of all U.S. transit assets as its foundation and then applies a set of asset-specific decay curves to determine when discrete transit assets in the inventory will require rehabilitation or replacement over the 20-year forecast period under consideration. TERM then

What types of capital spending are not modeled by TERM?

Q&A

TERM does not project all types of capital spending undertaken by U.S. transit agencies. Specifically, the model does not forecast capital expenditures:

- Aimed at improving the safety or security of a transit asset or system beyond existing levels
- That address the specific transportation needs of elderly persons or person with disabilities (i.e., assets purchased using FTA's Section 5310 funds)
- For significant functional improvements (e.g., such as replacement of an existing maintenance facility with a larger and better-equipped structure) to existing transit assets. In other words, TERM replaces most assets "in-kind."

It is important to note that, while TERM does not forecast the types of expenditures described above, some of these investment types (but not all) are included in the actual capital expenditures accounted for in this report, which are taken from information submitted to the NTD by local transit agencies.

records these expenditures, minus any investments that did not pass the model's benefit-cost test, in a tally of national transit capital needs.

The specific rehabilitation and replacement needs estimated by TERM include:

- Elimination of any investment backlog ("deferred investment")
- Routine replacement of assets reaching the end of their useful life
- Mid-life asset rehabilitations
- Annual capital expenditures required to maintain a state of good repair

At the end of a model run, TERM is capable of reporting these investments by mode, asset type, local agency, UZA, State, or FTA region.

Expansion Investments

In addition to the ongoing rehabilitation and replacement of existing assets, agencies also devote a portion of their capital budgets to the procurement or construction of new or expansion assets, including additional vehicles, stations, and new rail guideway and facilities beyond those already in service. Investments in expansion assets can be thought of as serving two distinct purposes. First, the demand for transit services typically increases over time in line with population growth, employment and other factors. To maintain current levels of performance in the face of expanding demand, transit operators must similarly expand the capacity of their services (e.g., an agency may add revenue service vehicles to an existing bus fleet). Failure to accommodate this demand would result in increased vehicle crowding, increased dwell times and decreased operating speeds for existing services. Second, transit operators also invest in expansion projects with the aim of improving current service performance. Such improvements include capital expansion projects (e.g., a new light rail segment) to reduce vehicle crowding or increase average operating speeds. (It is important to note that performance-improving investments are distinct from investments intended to improve the functional aspects of existing assets, which are not estimated by TERM, as described in Q&A box above.)

TERM is designed to address both of these issues. The model, however, forecasts investments to *maintain* current service standards separately from investments to *improve* service standards by employing two distinct modules, allowing the FTA to report the investment forecasts to address each need independently.

Expansion Investments: Maintain Performance

For measures undertaken to maintain existing service levels, the model estimates the amount of investment in new expansion assets that would be required to maintain the quality of existing transit services given projected growth in travel demand. TERM first estimates the rate of growth in transit vehicle fleets required to maintain current vehicle occupancy levels given the anticipated growth rate in transit passenger miles by

UZA. The model also forecasts investments in the expansion of other assets needed to support projected fleet growth, including bus maintenance facilities and, in the case of rail systems, additional investment in guideway, trackwork, stations, maintenance facilities, train control, and traction power systems. Asset expansion investment needs are assessed for all agencies reporting to the NTD on a mode-by-mode basis. Note that TERM does not invest in asset expansion for those agency-modes whose current ridership is well below the national average (specifically, where the performance metric of riders per peak vehicle is more than one standard deviation below the national average).

Expansion Investments: Improve Performance

In addition to forecasting investments intended to preserve existing service performance levels, TERM is designed to estimate the level of investment required to improve service performance. Specifically, TERM forecasts two types of performance enhancing investments intended to meet the following objectives:

- Increase average operating speeds for UZAs that are well below the national mean
- Reduce vehicle occupancy for agencies with the highest ratios of passenger trips per peak vehicle

In forecasting speed improvement investments, TERM first identifies each UZA with an average transit operating speed well below the national average. The model then estimates the minimum required investment in a high-speed transit mode (i.e., heavy rail, light rail, or bus rapid transit) required to reach a minimum performance standard, defined as the national average operating speed less one standard deviation. The determination of which high-speed mode to invest in is based on which high-speed modes already exist in that particular UZA; if there is currently no high-speed mode in the UZA, TERM selects a preferred mode of investment based on UZA size. UZAs with populations of less than 1 million are designated to receive bus rapid transit systems, while larger UZAs are designated as recipients of light rail systems. Finally, as with performance maintenance investment forecasts, TERM does not undertake speed-improving investments in UZAs with low levels of reported ridership.

As part of predicting investments to improve performance, TERM also identifies local agency-modes with high vehicle occupancy rates (i.e., high ridership per peak vehicle relative to the national average for that mode). The model then designates investments that provide additional fleet capacity as needed to reduce peak vehicle crowding on these agency-modes to an acceptable level of service, defined as the national average of riders per peak vehicle plus one standard deviation for that mode. If the increase in fleet size is sufficiently large, TERM will also project investments in additional expansion assets such as maintenance facilities and, for rail systems, additional route miles, including guideway, trackwork, stations, train control, and traction power systems.

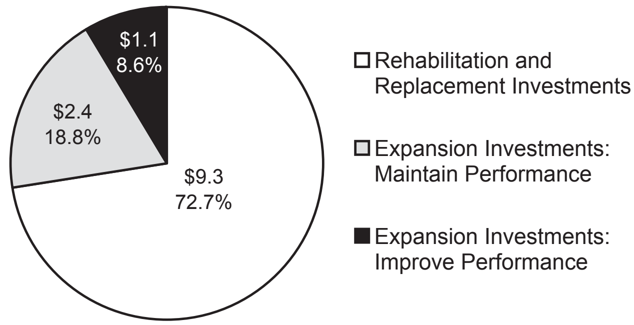
TERM's Benefit-Cost Tests

As stated above, all investments estimated by TERM must successfully pass the model's benefit-cost analysis in order to be added to the tally of the Nation's investment needs. If an investment fails the benefit-cost test (by receiving a benefit-cost ratio of less than one), it is rejected and its costs are not added to the overall investment tally. If the investment passes the benefit-cost test, the investment needs tally is updated to include the investment costs. All of TERM's benefit-cost tests evaluate each proposed investment over a 20-year time period.

Exhibit 7-24 presents the amount of actual capital spending on transit systems in 2006 that corresponds to the investment types modeled in TERM. Of the $12.8 billion spent by U.S. transit agencies on capital projects in 2006, $9.3 billion or 72.7 percent was devoted to rehabilitating and replacing existing assets. The remaining $3.5 billion or 27.3 percent was spent on performance maintenance and improvement investments.

Exhibit 7-24

2006 Transit Capital Expenditures ($ Billions)



Source: National Transit Database.

Impact of Systemwide Investments Modeled by TERM

The specific annual capital spending levels shown in the exhibits in this section typically relate to a particular point of interest. For example, *Exhibit 7-25* presents the expected impact of different levels of average annual capital investment in rehabilitation and replacement investments on average transit assets conditions by the year 2026. Conversely, *Exhibit 7-26*, *Exhibit 7-27* and *Exhibit 7-28* consider the level of investment in expansion assets as required to support differing rates of ridership growth and differing levels of transit performance. The FTA used TERM to produce all analyses.

Impact of Rehabilitation and Replacement Investments on Transit Conditions

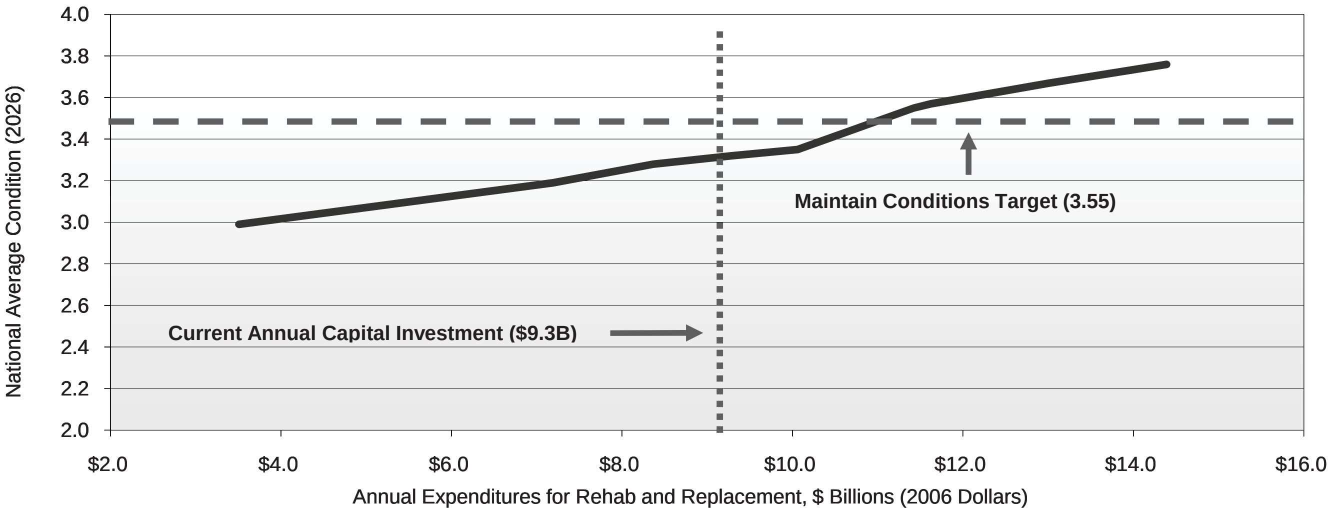
Exhibit 7-25 provides a summary of the impact of differing levels of annual rehabilitation and replacement investments on the future condition of U.S. transit assets. The graph shows the relationship between varying annual expenditures on rehabilitation and replacement activities and the impact of those expenditures on national average transit conditions, with transit conditions improving as annual capital spending increases. Note that the investment levels presented only include those investments that pass TERM's internal benefit-cost test. It is also important to note that the needs estimates shown in *Exhibit 7-25* include investment needs modeled by TERM as well as investment needs not modeled by TERM, such as capital spending intended to improve safety. For this reason, the capital needs estimates shown here are not directly comparable to the needs estimates shown in Chapter 8.

The table in *Exhibit 7-25* presents the same investment and average condition information as the chart above it. This table also presents the average annual percentage increase in constant dollar funding from today's level to achieve each projected condition level and the projected average condition values for transit assets by asset type (in addition to the average value across all asset types).

The vertical line on the graph in *Exhibit 7-25* signifies that U.S. transit agencies spent $9.3 billion in 2006 to rehabilitate and replace antiquated and/or worn equipment. If sustained into the future on an annual basis, TERM estimates that this level of investment would correspond with a national average condition rating of 3.32 for all assets in 2026, a condition below the current average condition rating of 3.55. The average condition of the different asset categories in 2026 under this funding scenario would range between marginal and good as defined in Chapter 3.

Exhibit 7-25

Impact of Rehab-Replacement Investment on Transit Conditions (All Urban and Rural Agencies)



Average Annual Percent Change vs. 2006	Average Annual Investment ($2006 B) Total Capital Outlay[1]	Average Transit Conditions in 2026[2]						Funding Level Description
		Asset Categories					All Transit Assets	
		Guideway	Facilities	Systems	Stations	Vehicles		
3.2%	$14.4	3.95	3.85	3.79	3.25	3.61	3.76	Replace at Condition 3.00
2.3%	$13.0	3.93	3.58	3.66	3.20	3.55	3.67	Improve Conditions
1.2%	$11.6	3.90	3.21	3.58	3.20	3.38	3.57	Replace at Condition 2.50
1.2%	$11.4	3.76	3.50	3.53	3.20	3.38	3.55	Maintain Conditions
0.8%	$10.1	3.61	2.92	3.45	3.16	3.12	3.35	
0.0%	$9.3	3.60	2.88	3.41	3.16	3.03	3.32	2006 Capital Expenditures
-1.0%	$8.4	3.55	2.87	3.32	3.16	2.98	3.28	
-2.5%	$7.2	3.52	2.80	3.04	3.11	2.97	3.19	
-10.6%	$3.5	3.28	2.70	2.79	3.00	2.72	2.99	

[1] *Includes investment in upgrades/betterments, ADA compliance, other improvements to existing assets.*

[2] *Only includes the assets of those agency-modes that pass TERM's benefit-cost test.*

To maintain the existing average condition of U.S. transit assets, agencies would need to increase annual capital spending in constant dollars on rehabilitation and replacement activities by a combined 1.2 percent each year through 2026. This would be equivalent to increasing the current annual level of spending on rehabilitation and replacement from $9.3 billion to an annual average level of $11.4 billion from today through 2026. (Note that the $11.4 billion estimate to maintain conditions includes $10.5 billion in capital spending modeled by TERM plus an additional $0.89 billion for capital spending not estimated by the model—including investments in betterments, safety, and other improvements. Moreover, TERM's $10.5 billion needs estimate to maintain current conditions is not directly comparable to the $10.7 billion cited in Chapter 8 because the latter also includes the investment needs of special service

> **Q&A**
>
> **What is the significance of the *Replace at Condition 2.5* threshold?**
>
> The *Replace at Condition 2.5* threshold is significant as it relates to the Rail Modernization study, released by FTA in April 2009. A state of good repair, for the purposes of the study, was defined using TERM's numerically based condition rating scale of 1 to 5 (poor to excellent) for evaluating transit asset conditions. An asset or a transit system is considered to be in a state of good repair if the asset or system has an estimated condition value of 2.5 or higher (the mid-point between adequate and marginal). The level of investment required to attain and maintain a state of good repair is therefore that amount required to rehabilitate and replace all assets with estimated condition ratings that are less than this minimum condition value.

operators.) TERM predicts that this level of capital investment would ensure that the average condition rating of existing transit assets remain at the current level of 3.55 in 2026, depicted by the horizontal line in the graph.

To improve the average condition rating of transit assets to 3.67, TERM forecasts that agencies would need to accelerate annual spending even more, from $9.3 billion to an average of $13.0 billion through 2026. This would be equivalent to increasing current levels of annual capital expenditures by an average of 2.3 percent each year.

Finally, if transit agencies adopted more aggressive policies for replacing capital assets once their condition ratings deteriorated to 3.0, capital expenditures would need to increase to $14.4 billion per year through 2026 (which is equivalent to a 3.2 percent average annual increase). This level of annual spending on rehabilitation and replacement activities, according to estimates made by TERM, would increase the average condition rating of all assets from a current level of 3.55 to an average of 3.76 by the year 2026.

Impact of All Expansion Investments on Transit Ridership

While capital spending on rehabilitation and replacement initiatives primarily benefits the physical condition of transit assets, expansion investments are typically undertaken to accommodate projected growth in ridership and/or to improve service performance (the result of which encourages additional ridership).

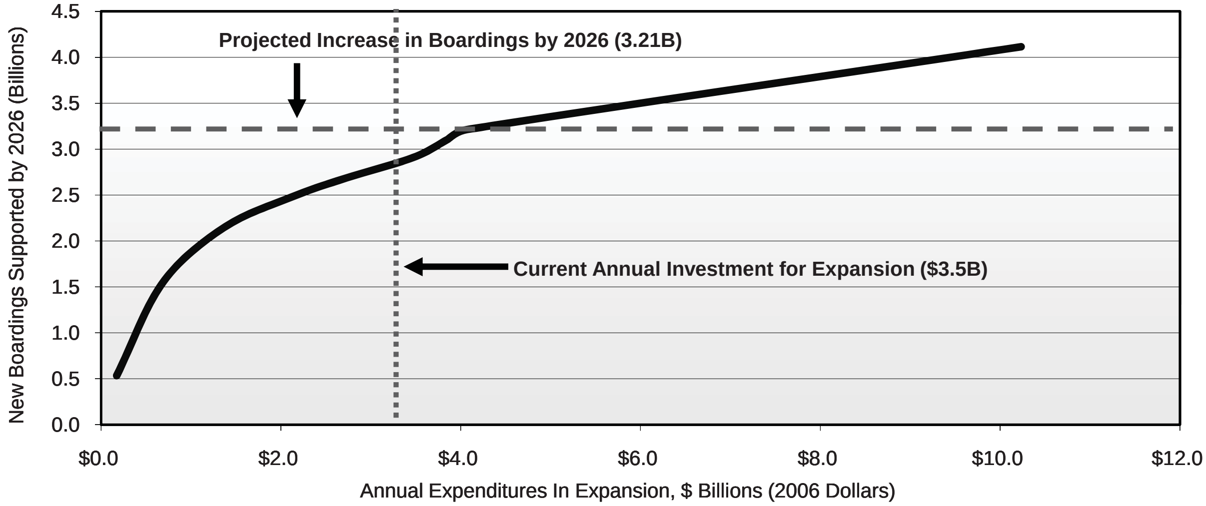
Exhibit 7-26 shows the relationship between annual capital spending on expansion investments and the additional number of annual passenger boardings that transit systems would be able to support by 2026. It is important to note that this exhibit presents the combined impact of two types of expansion investments. This includes expansions to **maintain current system performance** given projected growth in transit ridership (such that the current annual number of riders per peak vehicle is maintained) and investments to **improve performance** for those transit systems with high vehicle occupancies or low average operating speeds (by further expanding existing capacity or introducing new rail services). Each of these two investment types are considered in greater detail in subsequent sections. The exhibit illustrates the implied average annual growth in new riders directly supported by these investments. The upward sloping curve of the graph indicates that higher levels of investment are required to support greater numbers of riders, ensuring that current vehicle occupancy rates are maintained through 2026.

As shown by the vertical line on the graph in *Exhibit 7-26*, U.S. transit agencies spent $3.5 billion on expansion investments in 2006. This level of annual funding for expansion projects, if preserved over a 20-year period, could allow U.S. transit service providers to support 2.91 billion new passenger boardings by 2026. As demonstrated in the exhibit, keeping expenditures at 2006 levels could support 1.3 percent average annual growth in new passenger boardings.

The Nation's MPOs expect passenger boardings to increase at an annual rate of 1.5 percent. To accommodate this level of anticipated growth, transit operators would need to increase annual capital spending on expansion investments to $4.1 billion annually from their current annual level of about $3.5 billion, an amount equivalent to a 1.5 percent average annual increase in expansion expenditures through 2026. TERM forecasts that this level of annual funding could support 3.21 billion additional annual passenger boardings by 2026 (represented by the horizontal line on the graph in *Exhibit 7-26*), while maintaining vehicle occupancy rates at current levels. It is important to emphasize here that the preceding scenario represents the level of capital investment required to *maintain* current service performance levels, given the projected 1.5 percent average annual growth in passenger boardings. Some natural growth in ridership will occur regardless of whether the transit industry invests in advance of the projected increase.

Exhibit 7-26

New Ridership Supported by Expansion Investments (All Urban and Rural Agencies)



Average Annual Percent Change vs. 2006	Average Annual Investment ($2006 B)	Total New Boardings and Vehicle Capacity Utilization by 2026		Funding Level Description
		New Riders Supported (Billions of Annual Boardings)	Average Annual Growth in Boardings*	
9.5%	$10.2	4.12	1.8%	Improve Performance
1.5%	$4.1	3.21	1.5%	Projected Increase in Boardings by 2026
1.0%	$3.9	3.11	1.4%	
0.0%	$3.5	2.91	1.3%	2006 Capital Expenditures (all expansion)
-2.5%	$2.7	2.67	1.2%	
-5.0%	$2.1	2.48	1.2%	
-10.0%	$1.4	2.15	1.0%	
-20.0%	$0.7	1.55	0.8%	
-50.0%	$0.2	0.53	0.3%	

* *As compared to total urban ridership in 2006.*

Source: Transit Economic Requirements Model.

However, in the absence of investment to accommodate that ridership increase, it should be anticipated that average vehicle occupancies would increase and result in a decline in service performance from today's levels.

Conversely, if transit operators wish to support the number of new boardings anticipated in 2026 and *improve* the performance of their systems, they would need to allocate an even higher level of capital funds for expansion investments. For example, *Exhibit 7-26* presents the annual capital spending on expansion projects required both to maintain current transit performance levels on all systems and to improve performance on systems with high vehicle occupancies and/or with low operating speeds (this specific scenario is described further in Chapter 8). To improve performance, the level of annual capital funds expended on expansion investments would need to increase to $10.2 billion, which is $6.7 billion more than the amount spent in 2006.

The analysis in *Exhibit 7-26* has considered expansion investments designed to both maintain current performance (i.e., vehicle occupancies) and improve performance. The next two sections consider the expected performance impacts of these two types of expenditures under differing levels of investment.

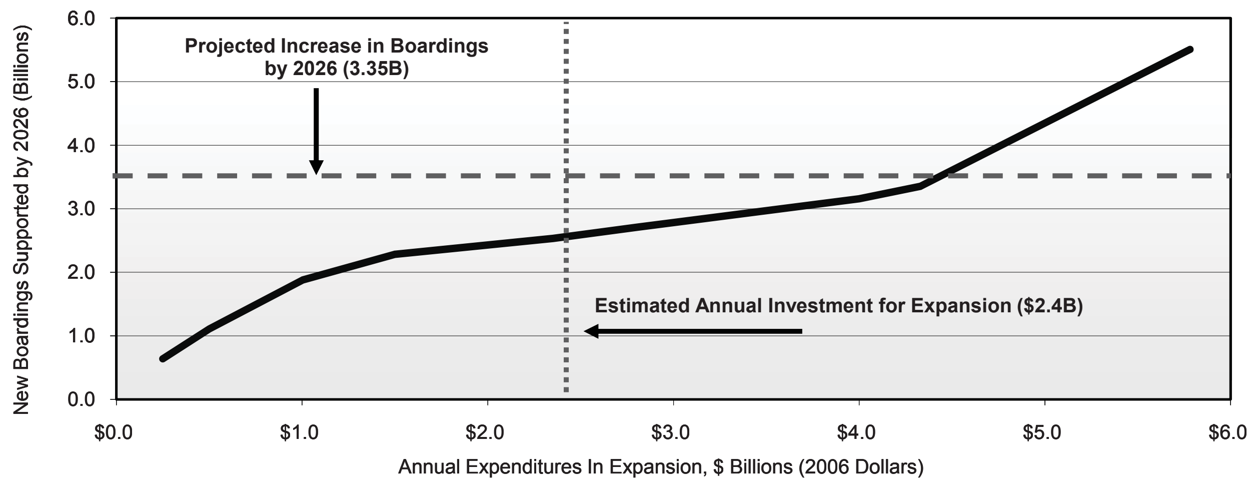
Impact of Performance Maintenance Investments

Transit agencies that serve markets with increasing demand in ridership would need to make investments to expand service capacity in order to maintain performance at current service levels. In the absence of investing in such expansion projects, ridership growth would result in an increased number of riders per vehicle and furthermore may also lead to decreasing operating speeds. The decrease in operating speeds would be a direct result of larger volumes of riders who would otherwise board and alight from the same, fixed number of revenue vehicles. To prevent this from occurring, agencies experiencing and anticipating new growth would need to invest continually in additional capacity to accommodate ridership while maintaining current performance.

Exhibit 7-27 shows the relationship between investments made to maintain existing performance and new annual passenger boardings supported by those investments by the year 2026. The graph clearly indicates that increased levels of annual capital spending would support more new passenger boardings by 2026. The exhibit also depicts the capacity utilization (defined as passengers per vehicle) for commuter rail, heavy rail, light rail, and motor bus vehicles under the various funding scenarios **assuming that the 1.5 percent annual increase in ridership as projected by the Nation's MPOs is fully realized**. Under this assumption, investment at levels lower than required to maintain performance will necessarily result in increased capacity utilization (i.e., crowding) and hence decreased system performance.

Exhibit 7-27

Annual Investment to Support Projected Rider Growth (All Urban and Rural Agencies)



Average Annual Investment ($2006 B)	Total New Boardings and Vehicle Capacity Utilization by 2026: New Riders Supported (Billions of Annual Boardings)	Average Annual Growth in Boardings*	Passengers Per Vehicle (Assuming MPO Growth Rate Projections): Commuter Rail	Heavy Rail	Light Rail	Motor Bus	Funding Level Description
$5.8	5.51	2.3%	32.30	22.24	22.68	8.85	Growth 50% higher than forecast
$4.3	3.35	1.5%	36.85	24.29	30.34	10.97	MPO projected increase in boardings
$4.0	3.16	1.4%	36.85	25.33	30.34	10.98	
$2.8	2.71	1.3%	37.02	29.00	30.34	11.01	
$2.4	2.53	1.2%	39.49	29.36	30.34	11.21	2006 Capital Expenditures (maintain performance investments)
$1.5	2.28	1.1%	44.37	30.71	33.96	11.41	
$1.0	1.88	0.9%	46.82	30.71	41.54	12.18	
$0.5	1.11	0.5%	46.82	30.71	53.99	13.48	
$0.3	0.64	0.3%	46.82	30.71	53.99	14.92	

* *As compared to total urban ridership in 2006.*

Source: Transit Economic Requirements Model.

In 2006, as depicted by the vertical line on the graph in *Exhibit 7-27*, transit agencies spent an estimated $2.4 billion to expand the capacity of existing transit infrastructure. If continued, TERM predicts that this level of annual capital spending would allow U.S. transit operators to accommodate 2.53 billion additional passenger boardings by 2026, causing capacity utilization rates for most modes of transit to increase. For example, the average number of riders per vehicle is projected to increase from 10.97 to 11.21 passengers for motor bus, from 36.85 to 39.49 for commuter rail, and from 24.29 to 29.36 for heavy rail; in contrast, light rail's average number of riders is projected to remain the same at 30.34.

Passenger boardings, as projected by the Nation's MPOs, are expected to grow at an average rate of 1.5 percent per year. This means that U.S. transit operators should expect demand for transit services to increase by 3.35 billion passenger boardings. This increased level is depicted by the horizontal line in the graph in *Exhibit 7-27*. To maintain performance standards in the wake of the anticipated increase in demand, it is projected that transit service providers would need to increase annual capital spending on projects that maintain performance to an estimated average annual level of $4.3 billion per year, up $1.9 billion per year from the current annual spending level of $2.4 billion. TERM estimates that this level of annual capital spending would ensure that current vehicle capacity utilization rates for all modes are maintained through 2026.

If total ridership were to increase 50 percent more than currently projected (i.e., if ridership growth reaches 2.3 percent per year versus the forecast of 1.5 percent per year growth), average annual capital expenditures on performance maintaining investments would need to increase to $5.8 billion through 2026. This could permit transit service providers to accommodate 5.51 billion additional annual passenger boardings by 2026 while maintaining current vehicle capacity utilization. (It is important to note that the passengers per vehicle numbers in *Exhibit 7-27* represent expected capacity utilization if the transit ridership expands at the rate projected by the nation's MPOs. For example, on the top line of *Exhibit 7-27*, the passenger per vehicle numbers represent expected capacity utilization if the transit industry expands to accommodate a 2.3 percent annual ridership increase; but, this would occur only if a 1.5 percent annual growth materializes. This would imply a drop in capacity utilization.)

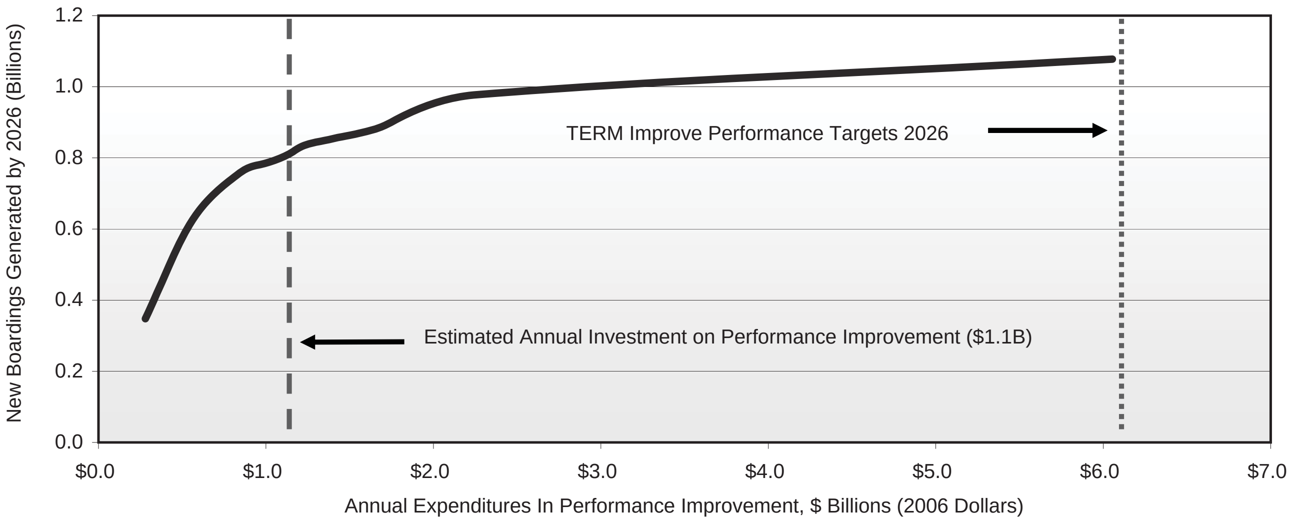
Impact of Performance-Improving Investments

In addition to making investments intended to maintain existing performance standards, U.S. transit agencies also invest in additional assets, such as vehicles and supporting infrastructure, to improve the performance of their operations. As described above, TERM considers two types of performance-improving investments. The first expands the revenue vehicle fleets and related supporting infrastructure of existing transit operations that are currently overcrowded as defined by TERM. The second invests in new guideway systems (e.g., heavy rail, light rail or bus rapid transit, depending on the size of the urbanized area and the presence of any preexisting rail modes) as needed to improve the overall average speed of transit in the specific urbanized area where the average transit operating speed is well below the national average.

Exhibit 7-28 shows the relationship between annual performance improvement expenditures and new passenger boardings generated by those investments by 2026 and reflects TERM's preferential investment in those projects with the highest benefit-cost ratios (which tend to translate into higher ridership benefits per investment dollar). In other words, TERM invests first in those projects with the highest ridership benefits (on the left hand side of the graph) followed by investment in less beneficial projects as the overall level of expenditure increases (on the right hand side).

Exhibit 7-28

Rider Growth Generated by Performance Improvement Investments (All Urban and Rural Agencies)



Average Annual Investment ($2006 B)	Total New Ridership by 2026					Average Transit Operating Speed (MPH)	Funding Level Description
	New Annual Boardings by 2026 (Billions)	Average Annual Growth in New Boardings[1]	Capacity Utilization[2]				
			Heavy Rail	Light Rail	Motor Bus		
$6.1	1.08	0.54%	26.02	31.66	na	13.60	Improve performance target
$2.2	0.98	0.49%	27.97	32.46	na	13.12	
$1.7	0.89	0.44%	na	32.49	na	13.09	
$1.4	0.85	0.43%	na	32.49	na	13.08	
$1.2	0.84	0.42%	na	32.49	na	13.06	
$1.1	0.81	0.41%	na	32.49	na	na	2006 Capital Expenditures (improve performance investments)
$1.0	0.79	0.40%	na	33.48	11.00	na	
$0.8	0.76	0.38%	na	na	11.06	na	
$0.6	0.62	0.32%	na	na	11.25	na	
$0.3	0.35	0.18%	na	na	12.02	na	

[1] *As compared to total urban ridership in 2006.*

[2] *Only includes those agenices and UZA's identified for performance improvements.*

Source: Transit Economic Requirements Model.

Exhibit 7-28 also displays capacity utilization for heavy rail, light rail, and motor bus, as well as the average transit operating speed for all modes. Note that these utilization and average operating speed values are only presented for those UZAs, and at those investment levels, where TERM has identified a performance-improving investment (hence an "na" value indicates no new investment at that level of expenditures). The pattern of investments in this table suggests TERM tends to assess the highest benefits per dollar invested for bus and the lowest for heavy rail. It also suggests that investments in capacity improvements for existing transit modes tend to generate higher benefits than those that increase a UZA's overall operating speed.

The vertical line on the left in *Exhibit 7-28* indicates that transit agencies spent an estimated $1.1 billion on performance enhancing investments in 2006, a level of spending that would support 0.81 billion additional annual boardings by 2026.

The second vertical line on the graph in *Exhibit 7-28* represents the level of investment in constant dollars required to improve the performance of transit operators that tend to experience significant crowding and UZAs with low average operating speeds for transit (the specifics of this "improve performance" scenario are discussed further in Chapter 8). To realize these improvements, transit agencies would need to increase annual expenditures to an estimated level of $6.1 billion. This level of annual spending could support 1.08 billion additional annual passenger boardings by 2026 and would allow the average transit operating speed to increase to 13.6 miles per hour. By increasing capital expenditures to $6.1 billion per year, transit agencies would decrease capacity utilization rates for systems exhibiting the highest utilization rates.

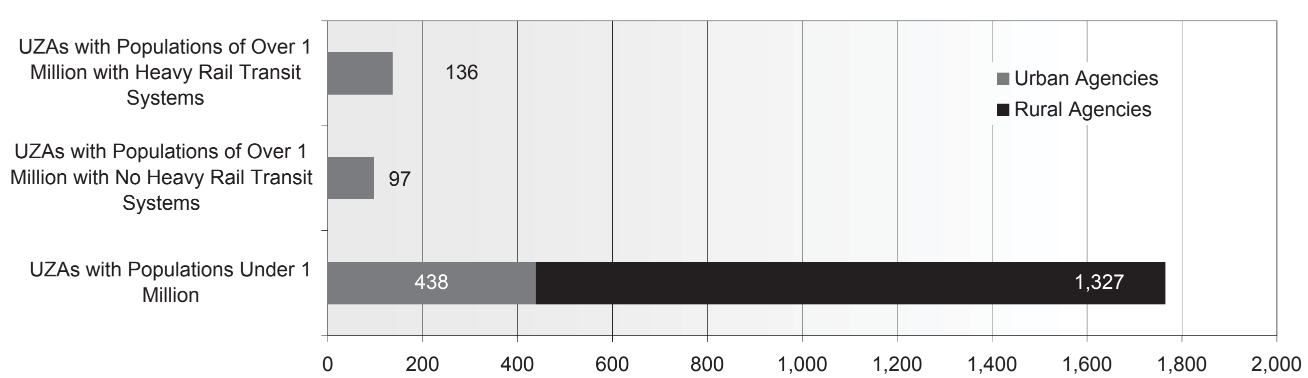
Impact of Investments Modeled by TERM

The remainder of this chapter focuses on how different levels of annual capital investment in the U.S. transit infrastructure affect urbanized areas with dissimilar transit investment needs. Specifically, this section explores the impact of capital expenditures by transit agencies grouped into one of three distinct UZA groupings: (1) large metropolitan areas with heavy rail transit systems; (2) large metropolitan areas without heavy rail transit systems; and (3) smaller metropolitan and rural areas.

The figures below reveal that there are significant differences between the supply of and demand for public transportation services within the different types of urbanized areas. As shown in *Exhibit 7-29*, one of the fundamental differences lies in the fact that, as a group, smaller metropolitan and rural areas are served by a plethora of small- and medium-sized transit agencies. In 2006, there were 1,765 transit agencies operating in cities with populations of less than 1 million. This contrasts sharply with the other two UZA segments: larger cities with heavy rail systems were patronized by 136 agencies in 2006, while cities without heavy rail operators were only served by 97 agencies.

Exhibit 7-29

Distribution of Urban and Rural Agencies by UZA Segment



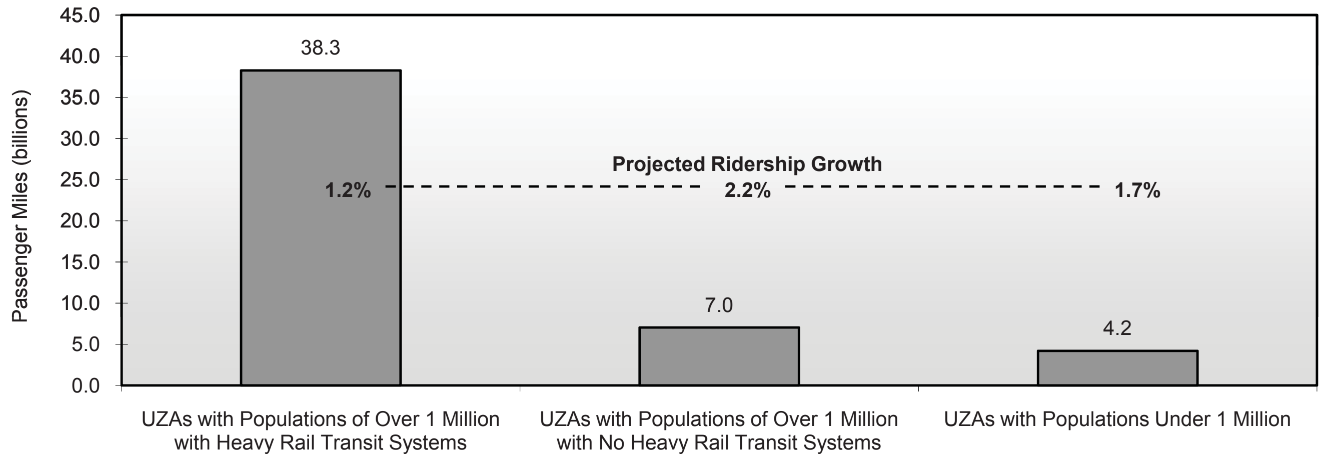
Source: National Transit Database.

There are also wide discrepancies in the demand for public transportation services in the three different UZA segments. As shown in *Exhibit 7-30*, total passenger miles varied widely with transit riders in large municipalities, with heavy rail systems consuming 38.3 billion passenger miles in 2006. Passenger miles consumed in these cities in 2006 were more than the total passenger miles recorded for the other two UZA segments combined.

It is interesting to note, however, that the largest cities with heavy rail transit operators are expected to experience the least amount of growth in ridership in the near future. Ridership in large cities without heavy rail transit systems is anticipated to grow at an annual average rate of 2.2 percent, while ridership in smaller cities and rural areas is forecast to increase at a yearly average rate of 1.7 percent.

Exhibit 7-30

2006 Total Passenger Miles and Projected Annual Ridership Growth by UZA Segment



Source: National Transit Database and Transit Economic Requirements Model.

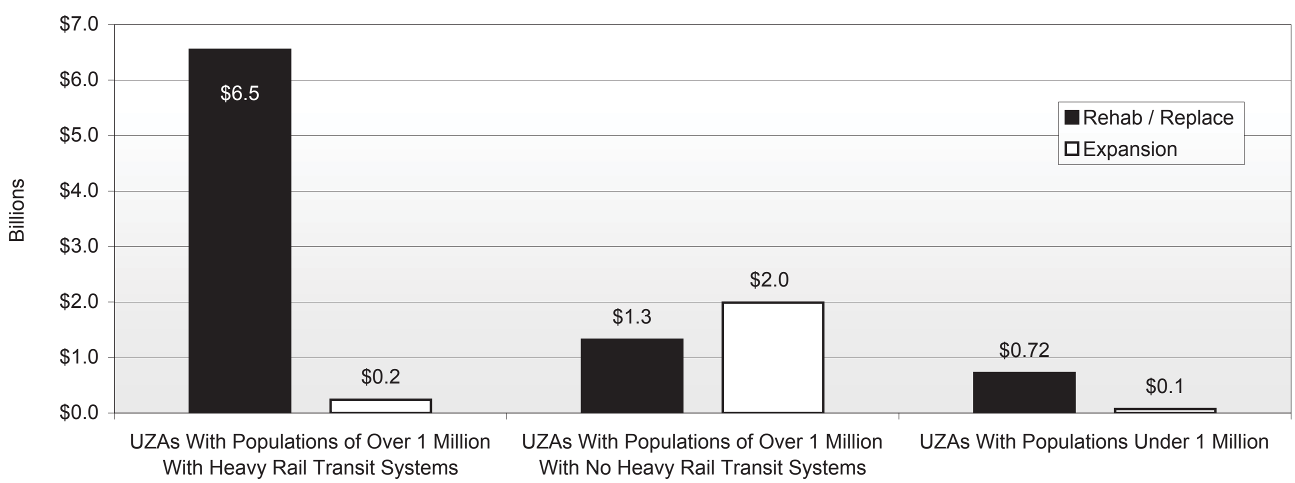
Transit service providers in these different UZA segments also have unique investments needs, as shown in *Exhibit 7-31*. Because they tend to operate older, more heavily utilized transportation networks, transit operators in large metropolitan areas with heavy rail transit systems, on average, spend a higher proportion of their capital budgets rehabilitating and replacing existing assets. This is illustrated in *Exhibit 7-31*, which shows that agencies in these UZAs in 2006 devoted a total of $6.5 billion, or 96.5 percent of their capital spending, to rehabilitation and replacement activities.

On the other hand, large metropolitan areas lacking heavy rail transit services typically exhibit higher rates of transit ridership growth, creating a need for agencies in these areas to invest in expansion projects. Consequently, when compared to agencies in the first UZA segment, these agencies are likely to devote more capital spending to expansion investments, as shown in *Exhibit 7-31.* In fact, these operators allocated their capital spending almost equally between rehabilitation/replacement and expansion investments in 2006.

Finally, transit operators in small metropolitan areas have investment needs similar to agencies in cities with heavy rail transit systems because smaller UZAs are not experiencing high absolute levels of transit ridership growth. As shown in *Exhibit 7-31*, agencies operating in cities with populations of less than 1 million

Exhibit 7-31

2006 Capital Spending by Urbanized Area and Type of Investment



Source: Transit Economic Requirements Model.

focused a majority of capital spending in 2006 on rehabilitation and replacement investments. Transit service providers in large metropolitan areas with heavy rail transit systems similarly focused the majority of their capital investments on rehabilitating and replacing worn or antiquated assets.

Given the differences between the different UZA segments outlined above, it is instructive to explore the variance in investment needs for the separate groupings. The following analyses explore the effect of both expansion investments and rehabilitation and replacement investments under all three UZA segments.

Urbanized Areas With Populations of More Than 1 Million With Heavy Rail Transit Systems

Large metropolitan areas with heavy rail transit systems represent the most significant share of the Nation's existing investment in transit assets, tend to have high levels of investment in older assets, and have the highest levels of transit use. Most of these cities have mature transit systems and relatively low rates of ridership growth. Key examples of UZAs in this group include New York (including northern New Jersey and western areas of Connecticut), Boston, Philadelphia, Chicago and Washington, D.C. Given these characteristics, these urban areas tend to have the largest rehabilitation and replacement investments needs but lower levels of expansion investments (at least on a percentage growth basis). The following sections of this chapter focus on how rehabilitation and replacement investments, as well as capital spending devoted to expansion projects, affect transit systems in large metropolitan areas with heavy rail transit systems.

Rehabilitation and Replacement Investments

Exhibit 7-32 shows the forecasted impact of rehabilitation and replacement investments on the future condition of transit assets owned by agencies located in large metropolitan areas with heavy rail transit systems. (For this analysis, large metropolitan areas are defined as cities with populations of more than 1 million.)

As shown by the vertical line in the graph, transit agencies in large urbanized areas expended $6.5 billion in 2006 on projects intended to rehabilitate and replace worn transit assets. If agencies continue to invest at this pace, then TERM forecasts that the average condition rating of assets in 2026 would be 3.32, which is below the current average condition rating of 3.51.

In order for agencies in large urbanized areas to maintain the condition of their assets at current levels, TERM anticipates that they would need to increase annual capital spending on rehabilitation and replacement activities from $6.5 billion to $8.0 billion (a 1.9 percent average annual increase in spending through 2026). It is estimated that this level of annual capital spending, represented by the horizontal line in the graph, would maintain the current asset condition rating at roughly 3.51.

Finally, were transit agencies located in large cities with heavy rail systems to improve conditions to an overall condition rating of 3.63 by 2026 (TERM's improve conditions scenario as described in Chapter 8), TERM estimates that annual capital spending would need to increase from $6.5 billion to $8.9 billion (a 2.8 percent average annual increase in spending through 2026).

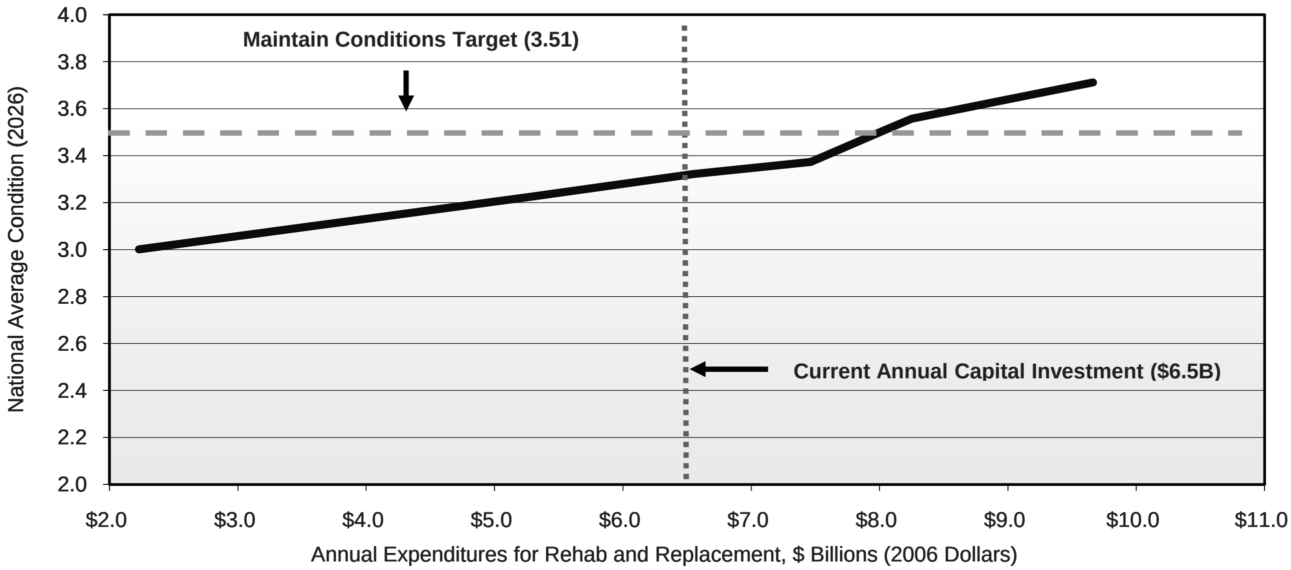
Expansion Investments

In addition to maintaining existing assets, transit agencies in large urbanized areas with heavy rail transit systems must also invest in expansion programs in order to accommodate the growth in demand for transit services. As transit demand in large cities increases, agencies would need to expand the transit service capacity base to prevent existing performance levels from declining.

Exhibit 7-33 displays how the level of annual spending on expansion investments influences the number of new passenger boardings that transit agencies would be able to support in 2026 without compromising their

Exhibit 7-32

Impact of Investment on Transit Conditions (Over 1 Million Population, With Heavy Rail)



Average Annual Percent Change vs. 2006	Average Annual Investment ($2006 B)[1]	Average Transit Conditions in 2026[2]						Funding Level Description
		Asset Categories					All Transit Assets	
		Guideway	Facilities	Systems	Stations	Vehicles		
3.6%	$9.7	3.87	3.78	3.78	3.21	3.63	3.71	Replace at Condition 3.00
2.8%	$8.9	3.85	3.40	3.65	3.15	3.58	3.63	Improve Conditions
2.2%	$8.2	3.83	3.14	3.57	3.15	3.45	3.56	Replace at Condition 2.50
1.9%	$8.0	3.69	3.33	3.51	3.15	3.45	3.51	Maintain Conditions
1.2%	$7.5	3.55	3.07	3.45	3.12	3.20	3.37	
0.0%	$6.5	3.51	3.04	3.34	3.13	3.13	3.32	2006 Capital Expenditures
-2.1%	$5.3	3.48	2.92	3.03	3.07	3.11	3.22	
-11.9%	$2.2	3.22	2.82	2.76	2.95	2.83	3.00	

[1] *Only includes investments modeled by TERM.*

[2] *Only includes the assets of those agency-modes that pass TERM's benefit-cost test.*

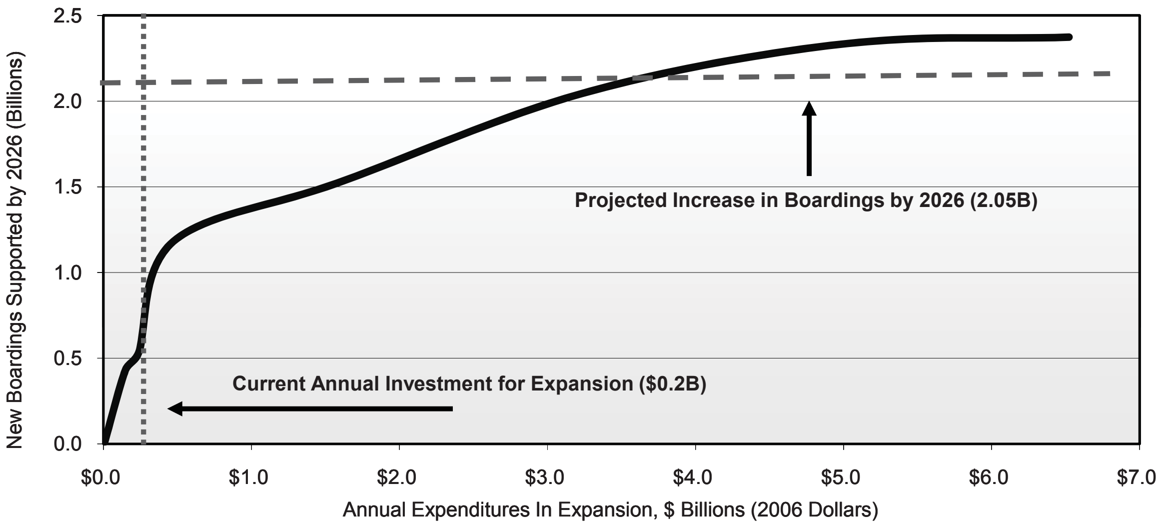
Source: Transit Economic Requirements Model.

current levels of performance. As depicted by the vertical line in the graph in *Exhibit 7-33*, capital spending on expansion projects in large metropolitan areas in 2006 was an estimated $0.2 billion. If expansion investments continue at this pace, then TERM projects the number of additional annual passenger boardings supported in 2026 would be 0.54 billion. This level of investment, however, is not anticipated to allow transit operators to meet the 1.3 percent average annual growth in ridership projected for UZAs of this type, suggesting that performance levels would decline for these agencies if current levels of expansion investments were continued without addressing expansion appropriately.

To maintain existing performance standards, TERM projects that transit agencies in large cities would need to increase annual capital spending on new assets to an average level of $3.3 billion through 2026. It is estimated that this level of annual expenditure would allow transit agencies to keep pace with the anticipated number of additional annual passenger boardings, forecast to reach a level of 2.05 billion by 2026. This level of new boarding is represented by the horizontal line in the graph in *Exhibit 7-33*.

Exhibit 7-33

New Ridership Supported by Expansion Investments (UZAs Over 1 Million, With Heavy Rail)



Average Annual Percent Change vs. 2006	Average Annual Investment ($B)	New Riders Supported (Billions of Annual Boardings)	Average Annual Growth in Boardings*	Funding Level Description
26.8%	$6.5	2.37	1.5%	Improve Performance
24.8%	$5.0	2.33	1.4%	
22.3%	$3.3	2.05	1.3%	Projected Increase in Boardings by 2026
15.9%	$1.6	1.53	1.0%	
6.0%	$0.5	1.18	0.8%	
0.0%	$0.2	0.54	0.4%	2006 Capital Expenditures
-4.7%	$0.1	0.43	0.3%	
-50.0%	$0.01	0.01	0.01%	

* *As compared to total urban ridership in 2006.*

Source: Transit Economic Requirements Model.

To improve performance, TERM estimates that transit operators would need to increase annual capital spending even further. As shown in *Exhibit 7-33*, projections indicate that annual capital expenditures on expansion projects would need to reach $6.5 billion in order to improve performance, as defined in TERM [see Chapter 8]. This level of spending would allow transit service providers to support 2.37 billion more annual passenger boardings by 2026, a 1.5 percent annual rate of increase in ridership, but may represent an inefficient allocation of resources given the expected 1.2 percent ridership growth in large cities with heavy rail.

Urbanized Areas With Populations of More Than 1 Million Without Heavy Rail Transit Systems

Large metropolitan areas that do not have heavy rail transit systems tend to have newer light rail systems and higher rates of transit ridership growth. These characteristics suggest that transit operators in these cities tend to devote a larger proportion of spending to expansion investments on existing, relatively newer modes of rapid transit, rather than on rehabilitation and replacement projects (as compared to the large, mature transit markets with heavy rail). Key examples of major transit UZAs in this group include Dallas, San Diego, St. Louis, Denver, San Jose, and Sacramento. This section focuses on the impact that rehabilitation and replacement investments, as well as expansion investments, have on transit agencies in these large cities without existing heavy rail modes.

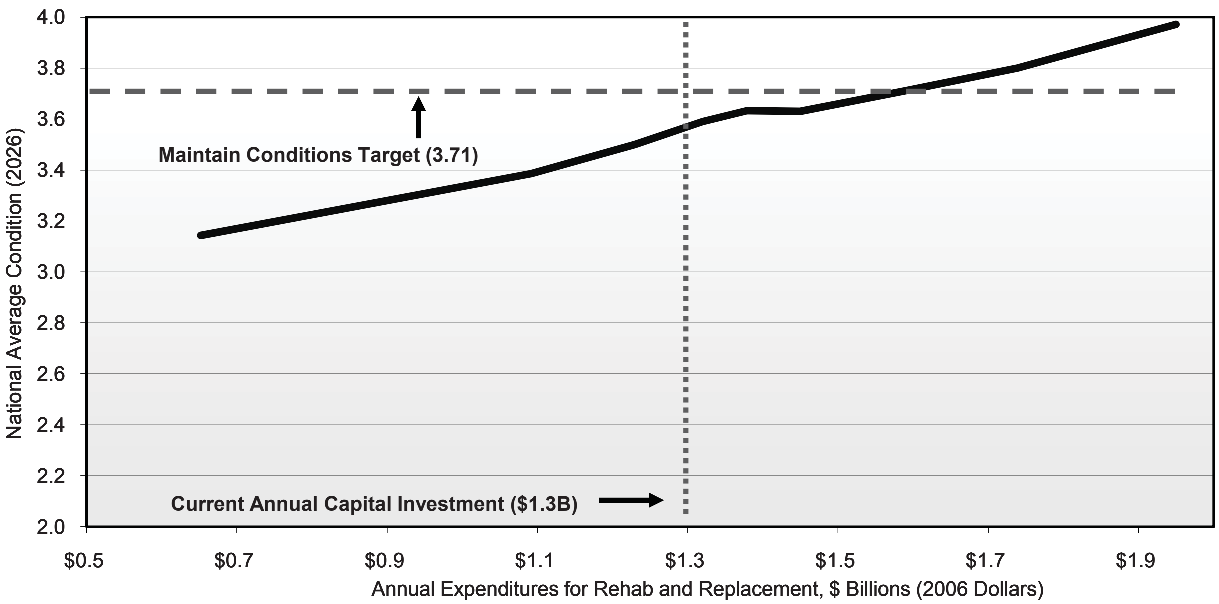
Rehabilitation and Replacement Investments

Exhibit 7-34 displays the effect that rehabilitation and replacement expenditures are expected to have on the future condition of transit assets located in urbanized areas with population of more than 1 million but without heavy rail transit investments.

The level of capital spending dedicated to rehabilitating and replacing assets in 2006 in large cities without heavy rail transit systems was $1.3 billion. This is depicted by the vertical line in the graph in *Exhibit 7-34*. Note that this level of funding is significantly less than the $6.5 billion of capital spending devoted to rehabilitation and replacement in large cities with heavy rail operators. This difference reflects the significantly larger proportion of investment in existing transit assets in those UZAs with heavy rail versus those without heavy rail.

Exhibit 7-34

Impact of Investment on Transit Conditions (UZAs Over 1 Million, No Heavy Rail)



Average Annual Percent Change vs. 2006	Average Annual Investment ($B)[1]	Average Transit Conditions in 2026[2] Asset Categories: Guideway	Facilities	Systems	Stations	Vehicles	All Transit Assets	Funding Level Description
3.6%	$2.0	4.58	3.77	3.94	4.02	3.54	3.97	Replace at Condition 3.00
2.6%	$1.7	4.49	3.46	3.88	3.80	3.43	3.80	Improve Conditions
1.7%	$1.6	4.22	3.46	3.86	3.79	3.33	3.71	Maintain Conditions
0.9%	$1.5	4.19	3.25	3.78	3.75	3.29	3.63	
0.4%	$1.4	4.50	3.09	3.68	3.86	3.13	3.63	Replace at Condition 2.50
0.0%	$1.3	4.15	3.18	3.77	3.74	3.18	3.59	2006 Capital Expenditures
-0.7%	$1.2	4.11	3.15	3.74	3.73	3.09	3.50	
-1.9%	$1.1	4.02	3.07	3.17	3.72	3.06	3.39	
-7.4%	$0.7	3.77	2.87	3.12	3.63	2.65	3.14	

[1] *Primarily in-kind replacement.*

[2] *Only includes the assets of those agency-modes that pass TERM's benefit-cost test.*

Source: Transit Economics Requirements Model.

Future condition ratings for transit assets in these areas, as shown in the exhibit, are projected to decline from the current level of 3.71 to reach 3.59 in 2026 assuming that the current level of annual capital spending on rehabilitation and replacement investments were to continue through 2026.

To maintain conditions in large metropolitan areas without heavy rail service, transit operators are projected to need to increase spending to an average annual level of $1.6 billion through 2026. This level of capital spending is projected to allow the average condition rating of all transit assets to be maintained at 3.71 by 2026, as depicted by the horizontal line in the graph in *Exhibit 7-34*.

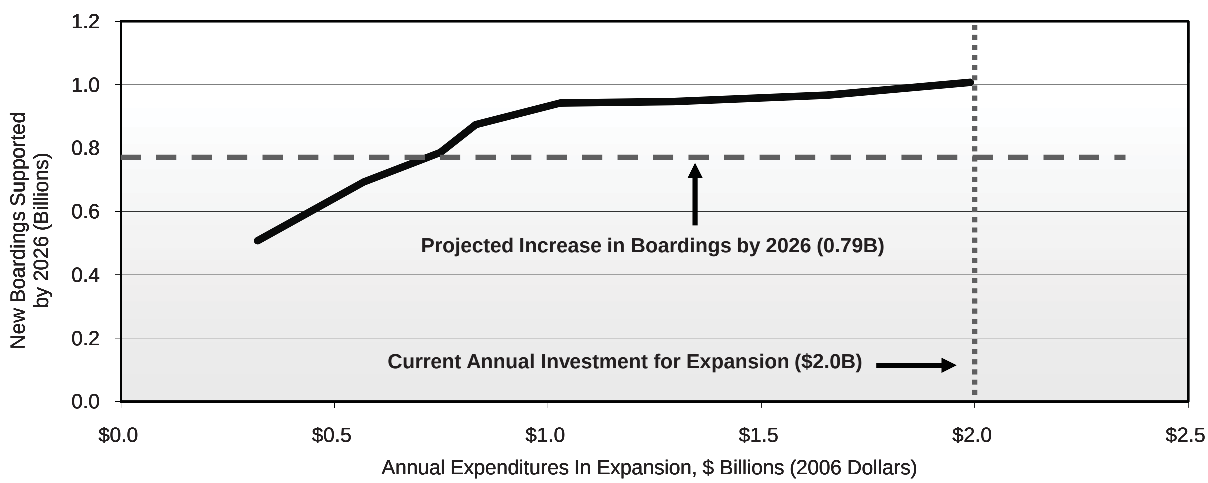
To improve the conditions to those defined by TERM's improve conditions scenario (as defined in Chapter 8), it is estimated that annual capital spending by transit agencies would need to increase to $1.7 billion annually or $0.4 billion above their level in 2006. Under this annual funding scenario, TERM forecasts that the average condition rating for all transit assets would increase to 3.80 by 2026.

Expansion Investments

Exhibit 7-35 shows how the level of annual spending on new assets impacts the number of new passenger boardings that transit agencies in this UZA group would be able to support by 2026. In 2006 transit agencies in these urban areas spent an estimated $2.0 billion on expansion investments. This level of annual capital spending, shown by the vertical line on the graph in *Exhibit 7-35*, is projected to support an estimated 1.01 billion additional passenger boardings if this level of spending is maintained through 2026.

Exhibit 7-35

New Ridership Supported by Expansion Investments (UZAs Over 1 Million, No Heavy Rail)



Average Annual Percent Change vs. 2006	Average Annual Investment ($2006 B)	New Riders Supported (Billions of Annual Boardings)	Average Annual Growth in Boardings*	Funding Level Description
0.0%	$2.0	1.01	2.6%	Improve Performance & 2006 Capital Expenditures
-1.8%	$1.7	0.97	2.6%	
-4.3%	$1.3	0.95	2.5%	
-6.8%	$1.0	0.94	2.5%	
-9.3%	$0.8	0.87	2.4%	
-10.6%	$0.7	0.79	2.2%	Projected Increase in Boardings by 2026
-14.3%	$0.6	0.69	2.0%	
-23.6%	$0.3	0.51	1.5%	

* *As compared to total urban ridership in 2006.*

Source: Transit Economic Requirements Model.

This current level of expenditures is higher than the estimated $0.7 billion in annual investment required to support the expected number of new riders as forecast by the Nation's MPOs (represented by the horizontal line on the graph) and is equal to the estimated $2.0 billion in annual expenditures required to improve performance for this UZA group as defined by TERM's improve performance scenario [see Chapter 8]. This may represent an inefficient allocation of resources given expected ridership growth rates.

Urbanized Areas With Populations of Less Than 1 Million

Rail transit seldom exists in metropolitan areas that have fewer than 1 million people. These areas are primarily served by transit agencies that operate motor bus services. When compared to the other two metropolitan area groupings analyzed in this section of the chapter, the cities in this segment are dominated by a large number of small to mid-size bus transit agencies and furthermore include many very small operators located in small urban and rural environments. Examples of the larger UZAs in this group include Hartford, Louisville, Richmond, Omaha, and Dayton.

Rehabilitation and Replacement Investments

Exhibit 7-36 illustrates the impact of varying levels of annual rehabilitation and replacement investments on future conditions at transit agencies operating in urbanized areas with populations of less than 1 million. As shown by the vertical line in the graph, annual capital expenditures were $0.7 billion in 2006. TERM projects that if transit agencies in small cities continue to invest at this pace, the average condition rating of assets in 2026 would be 2.70, well below their current average condition rating of 3.72. With the exception of guideway and stations, all asset types would remain between poor or adequate condition, as defined in Chapter 3.

Conversely, to maintain current conditions through the year 2026, TERM predicts that this group of transit agencies would need to expend roughly $1.3 billion on an annual basis. This amount of investment, as shown by the horizontal line in the graph in *Exhibit 7-36*, is predicted to allow condition ratings at transit agencies in small cities to remain at 3.72. Under this funding scenario, transit assets in all asset categories would remain between adequate and good condition in 2026.

For conditions at these transit agencies to improve by 2026 (as defined by TERM's "improve performance scenario"), capital expenditures on rehabilitation and replacement activities would need to increase to $1.32 billion from the current spending level of $0.7 billion. This amount of investment would allow the average transit condition rating to improve to 3.74.

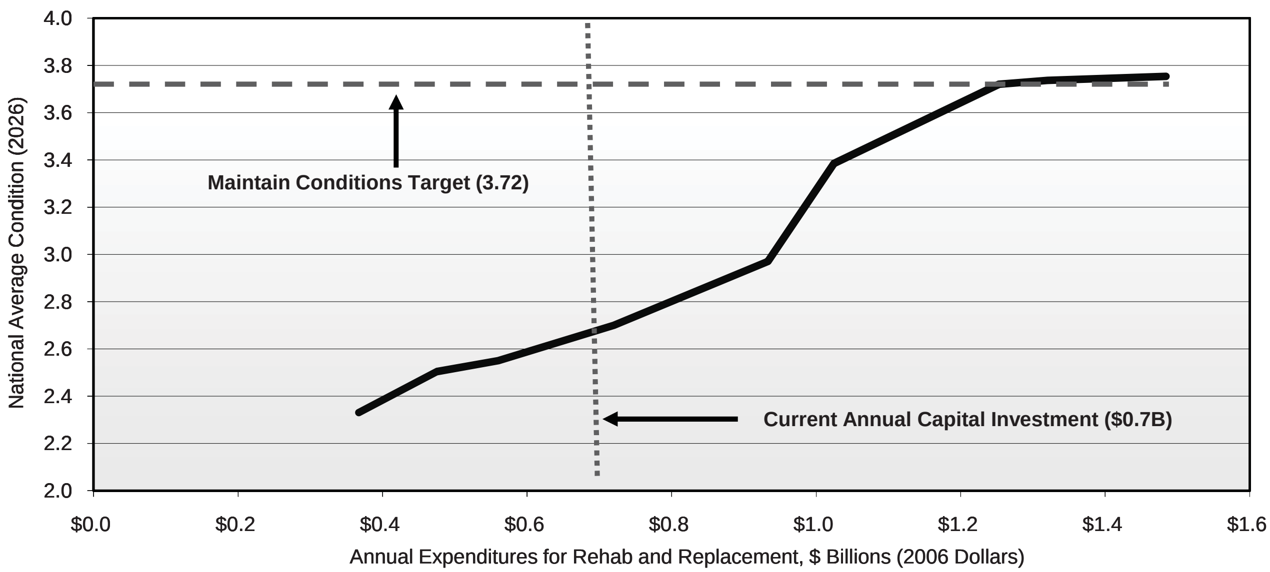
Expansion Investments

Similar to other regions of the country, metropolitan areas with populations of less than 1 million are expected to experience increases in transit ridership by 2026. In light of this growth in demand, transit agencies will need to invest in additional assets in order to maintain the existing performance levels of their systems. Specifically, the projected rate of increase in ridership for this group of UZAs averages 1.7 percent, which is significantly higher than the 1.3-percent rate of increase projected for large UZAs with heavy rail but well below the 2.2 percent rate of increase projected for the larger UZAs without existing heavy rail investment.

Exhibit 7-37 shows the impact that annual capital expenditures in expansion investments have on the number of additional annual boardings supported by 2026. As shown by the vertical line in the graph, transit agencies in small urbanized areas, as modeled in TERM, spent an estimated $0.1 billion on expansion investments in 2006. If capital spending continued at this pace, transit agencies in this UZA group would

Exhibit 7-36

Impact of Investment on Transit Conditions (UZAs Under 1 Million)



Average Annual Percent Change vs. 2006	Average Annual Investment ($B)[1]	Average Transit Conditions in 2026[2]						Funding Level Description
		Asset Categories					All Transit Assets	
		Guideway	Facilities	Systems	Stations	Vehicles		
6.5%	$1.5	4.72	3.80	3.78	3.96	3.57	3.75	Replace at Condition 3.00
5.5%	$1.3	4.71	3.80	3.78	3.96	3.49	3.74	Improve Conditions
5.0%	$1.3	4.66	3.80	3.78	3.96	3.38	3.72	Maintain Conditions
3.3%	$1.0	4.64	3.46	3.82	4.04	3.25	3.38	Replace at Condition 2.50
2.4%	$0.9	4.00	2.55	2.96	3.67	3.27	2.97	
0.0%	$0.7	3.98	2.43	2.96	3.65	2.89	2.70	2006 Capital Expenditures
-2.5%	$0.6	3.96	2.40	2.96	3.62	2.42	2.55	
-4.0%	$0.5	3.96	2.39	2.84	3.48	2.26	2.50	
-6.9%	$0.4	3.85	2.29	2.77	3.26	1.88	2.33	

[1] *Primarily in-kind replacement.*

[2] *Only includes the assets of those agency-modes that pass TERM's benefit-cost test.*

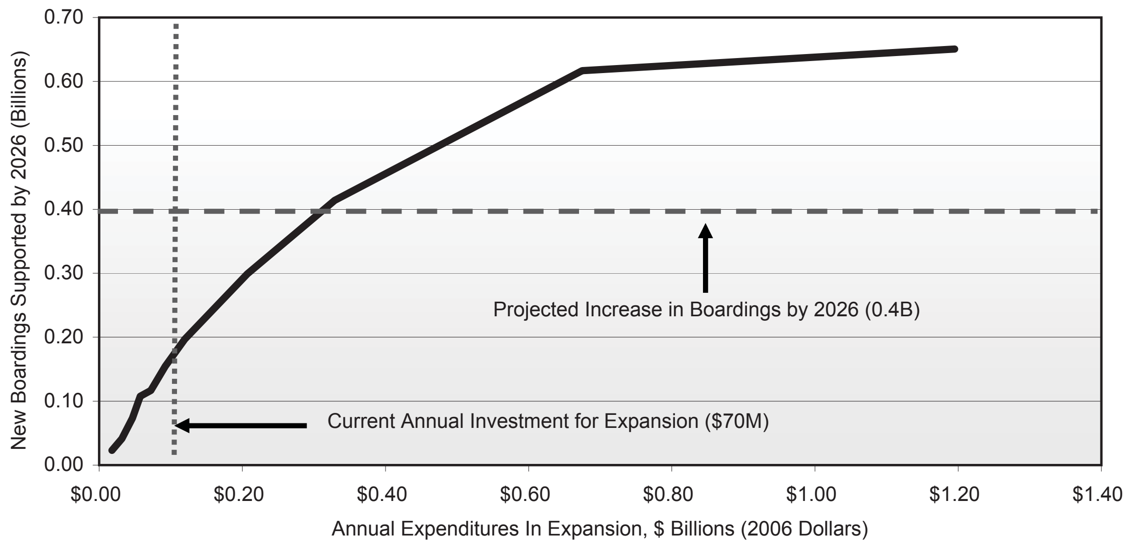
Source: Transit Economic Requirements Model.

be able to support an additional 0.12 billion boardings in 2026 (an average annual rate of increase of 0.5 percent).

Demand for transit services in these small urbanized areas, is expected to increase by 0.41 billion boardings by 2026 (or 1.7 percent annually). To have adequate capacity to support this higher number of riders, transit agencies would need to increase capital spending on expansion investments threefold to $0.3 billion, an amount represented by the horizontal line in the graph in *Exhibit 7-37*. To improve performance in line with TERM's "improve performance" scenario, transit agencies would need to accelerate the pace of annual capital spending to $1.2 billion annually through 2026, or approximately 12 times the amount spent in 2006; however, this may represent an inefficient allocation of resources given projected ridership increases for small cities and rural areas.

Exhibit 7-37

New Ridership Supported by Expansion Investments (UZAs Under 1 Million)



Average Annual Percent Change vs. 2006	Average Annual Investment ($B)	New Riders Supported (Billions of Annual Boardings)	Average Annual Growth in Boardings*	Funding Level Description
23.0%	$1.2	0.65	2.5%	Improve Performance
18.5%	$0.7	0.62	2.4%	
13.0%	$0.3	0.41	1.7%	Projected Increase in Boardings by 2026
9.3%	$0.2	0.30	1.3%	
4.6%	$0.1	0.20	0.9%	
2.1%	$0.1	0.15	0.7%	
0.0%	$0.1	0.12	0.5%	2006 Capital Expenditures
-1.7%	$0.1	0.11	0.5%	
-3.6%	$0.0	0.07	0.3%	
-9.2%	$0.0	0.04	0.2%	
-14.5%	$0.0	0.02	0.1%	

* *As compared to total urban ridership in 2006.*

Source: Transit Economic Requirements Model.

Comparison

The layout and content of Part II of this edition of the C&P report, including Chapters 7 through 10, has been restructured significantly relative to that of recent editions. Much of the material presented in this chapter represents extensions to more limited analyses presented in Chapters 9, 11, and 12 of the 2006 C&P Report. This material is presented earlier in this edition of the report to describe the set of analytical building blocks upon which the selected capital investment scenarios presented in Chapter 8 were developed, and to emphasize the fact that these scenarios represent only selected points on a broad continuum of possible future investment levels.

Exhibits 7-38 and *7-39* provide a crosswalk between the information presented in the exhibits located in the highway and transit sections of this chapter, respectively, and the location of comparable information in the 2006 C&P Report.

Highways and Bridges

As discussed in the highway section of this chapter, the Highway Economic Requirements System (HERS) model has been modified to allow the exploration of linkages between different types of financing mechanisms used to generate revenues for highway investment, and the relationship between alternative investment levels and future system performance.

The Highway section of this chapter examines three broad types of financing mechanisms: those involving non-user sources (such as property taxes or general governmental revenues), fixed rate user charges (such as a vehicle miles traveled [VMT] charge or fuel tax), and variable rate user charges (such as congestion pricing). The bulk of the analyses in the 2006 edition focused primarily on fixed rate user financing mechanisms; the non-user and variable-rate user financing options were addressed as sensitivity analyses in Chapter 10 of the 2006 C&P Report.

Exhibit 7-1 relates the capital expenditure information presented in Chapter 6 to the types of improvements evaluated in the HERS and the National Bridge Investment Analysis System (NBIAS) models. *Exhibit 7-2* describes the assumptions made in terms of the ramping up or down of spending levels on a year-by-year basis. *Exhibits 7-3* and *7-4* identify the difference between current spending and the alternative levels of future combined public and private spending that were analyzed, and identify changes in fixed rate user charges or variable rate user charges that would align revenues with these spending levels.

Exhibits 7-5 through *7-13* compare the potential impacts of alternative spending levels on a variety of conditions and performance measures on a systemwide basis as computed by HERS. This information is comparable to that presented on a more limited basis in Chapter 9 of the 2006 C&P Report. *Exhibit 7-14* provides a funding level description that summarizes why specific funding levels were selected for analysis, and identifies the minimum benefit-cost ratios associated with each of these levels.

Exhibits 7-15 through *7-17* compare the potential impacts of alternative spending levels on a variety of National Highway System (NHS) conditions and performance measures as computed by HERS; *Exhibits 7-18* through *7-20* present comparable values for the Interstate system. The 2006 C&P Report included this type of information in Chapter 12 for rural and urban portions of the NHS, and in Chapter 11 for rural and urban portions of the Interstate system.

Exhibit 7-38

Cross-Reference Between Chapter 7 Highway Section Exhibits and the Location of Comparable Information in the 2006 C&P Report

Chapter 7 Exhibit	Location of Comparable Information in the 2006 C&P Report
Exhibit 7-1	No direct equivalent for base year spending. Similar information for Investment scenarios shown in Exhibit 7-5.
Exhibit 7-2	No direct equivalent.
Exhibit 7-3	No direct equivalent.
Exhibit 7-4	No direct equivalent.
Exhibit 7-5	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-4.
Exhibit 7-6	No direct equivalent. Similar information for VMT growth rates presented in Exhibit 9-7.
Exhibit 7-7	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-4.
Exhibit 7-8	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-3.
Exhibit 7-9	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-3.
Exhibit 7-10	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-2.
Exhibit 7-11	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-2.
Exhibit 7-12	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-1.
Exhibit 7-13	"Fixed Rate User Charges" values are comparable to information shown in Exhibit 9-1.
Exhibit 7-14	No direct equivalent. Benefit-cost ratios discussed in Appendix A (page A-3).
Exhibit 7-15	No direct equivalent. Similar information for rural NHS and urban NHS presented in Exhibits 12-13 and 12-15.
Exhibit 7-16	No direct equivalent. Similar information for rural NHS and urban NHS presented in Exhibits 12-13 and 12-15.
Exhibit 7-17	No direct equivalent. Similar information for rural NHS and urban NHS presented in Exhibits 12-12 and 12-14.
Exhibit 7-18	No direct equivalent. Similar information for rural Interstate and urban Interstate presented in Exhibits 11-16 and 11-18.
Exhibit 7-19	No direct equivalent. Similar information for rural Interstate and urban Interstate presented in Exhibits 11-16 and 11-18.
Exhibit 7-20	No direct equivalent. Similar information for rural Interstate and urban Interstate presented in Exhibits 11-15 and 11-17.
Exhibit 7-21	Comparable to information shown in Exhibit 9-8.
Exhibit 7-22	Comparable to information shown in Exhibit 12-16.
Exhibit 7-23	Comparable to information shown in Exhibit 11-19.

Exhibits 7-21, 7-22, and *7-23* compare the potential impacts of alternative spending levels on the backlog of economic bridge investments as computed by NBIAS for all bridges, NHS bridges, and Interstate bridges, respectively. Comparable statistics were presented in Chapter 9, Chapter 12, and Chapter 11 of the 2006 C&P Report.

Transit

The transit section of this chapter focuses primarily on how different types and levels of annual capital investments may impact conditions and performance by 2026. Much of the information presented has no direct equivalent in the 2006 C&P Report.

Exhibit 7-24 provides the 2006 actual transit capital expenditures of $12.8 billion as they correspond to the investment scenarios modeled in TERM as a basis for the analysis throughout the chapter.

Exhibit 7-39

Cross-Reference Between Chapter 7 Transit Section Exhibits and the Location of Comparable Information in the 2006 C&P Report

Chapter 7 Exhibit	Location of Comparable Information in the 2006 C&P Report
Exhibit 7-24	No direct equivalent. Based on partial data presented in Exhibit 7-8 and 7-9.
Exhibit 7-25	No direct equivalent.
Exhibit 7-26	No direct equivalent.
Exhibit 7-27	No direct equivalent.
Exhibit 7-28	No direct equivalent.
Exhibit 7-29	No direct equivalent.
Exhibit 7-30	No direct equivalent.
Exhibit 7-31	No direct equivalent.
Exhibit 7-32	No direct equivalent.
Exhibit 7-33	No direct equivalent.
Exhibit 7-34	No direct equivalent.
Exhibit 7-35	No direct equivalent.
Exhibit 7-36	No direct equivalent.
Exhibit 7-37	No direct equivalent. Similar information for average investment by scenario, mode, and area population provided in Exhibit 7-10.

Exhibits 7-25 to *7-28* present the impact of systemwide investments modeled by TERM with specific areas of focus. *Exhibit 7-25* focuses on the impact of rehabilitation and replacement investments on transit conditions and provides a summary of the impact of differing levels of annual rehabilitation and replacement investments on the future condition of U.S. transit assets. *Exhibit 7-26* presents the impact of expansion investments on transit ridership. This exhibit focuses on the annual capital spending on expansion projects required both to maintain current transit performance levels on all systems and to improve performance on systems with high vehicle occupancies and/or with low operating speeds (this scenario is further detailed in Chapter 8). *Exhibit 7-27* presents the impact of performance maintenance investments and shows the relationship between investments made to maintain existing performance and new annual passenger boardings supported by those investments by 2026. Finally, *Exhibit 7-28* presents the impact of performance improving investments and demonstrates the relationship between annual performance improvement expenditures and new passenger boardings generated by those investments by 2026.

Exhibits 7-29 to *7-38* focus on how different levels of annual capital investment affect urbanized and rural areas differently. *Exhibit 7-29* defines the number of urban and rural agencies by urbanized area (UZA) segment. *Exhibit 7-30* presents the total passenger miles and projected annual ridership growth by UZA segment. *Exhibits 7-29* and *7-30* not only provides context for the remainder of the exhibits in terms of distribution across urban and rural segments, but also delineates urban agencies with heavy rail and those without heavy rail. Three UZA groupings are identified for the remainder of the analyses, including: (1) large metropolitan areas with heavy rail; (2) large metropolitan areas without heavy rail transit systems; and (3) smaller metropolitan and rural areas. Finally, *Exhibits 7-32* to *7-37* present the impact of investment on transit conditions and new ridership supported by expansion investments for the three UZA groupings.

Chapter 8

Selected Capital Investment Scenarios

Selected Highway Capital Investment Scenarios

This section presents a set of future investment scenarios for highways and bridges, building on the analyses presented in Chapter 7 regarding the potential impacts of alternative levels of future investment on various measures of system conditions and performance. Each of these scenarios draw upon the results of analyses developed using the Highway Economic Requirements System (HERS) and the National Bridge Investment Analysis System (NBIAS), but also consider other types of capital investment that are currently beyond the scope of these models. This section is divided into three main parts which examine scenarios for the Interstate Highway System, the National Highway System (NHS), and the overall network of U.S. highways and bridges.

The HERS analyses presented in Chapter 7 compare the potential impacts of alternative funding mechanisms, assuming that any additional revenue needed to support a particular level of investment would be generated from one of three broad categories: non-user sources, fixed rate user based sources, or variable rate user based sources. For each scenario presented in this section, two versions are included. One version assumes that funding would be derived solely from fixed rate user based sources, while the other assumes funding from variable rate user based sources such as congestion pricing. The non-user based funding option is not explored in this section.

The technical accuracy of these scenarios depends on the validity of the technical assumptions underlying the analysis. Chapter 10 explores the impacts of altering some of these assumptions. Chapter 9 discusses some of the key implications of these scenarios. The Introduction to Part II provides critical background information needed to properly interpret these scenarios. It is important to note that each of these scenarios represents what **could** be achieved with a given level of investment assuming an economically driven approach to project selection, as opposed to what **would** be achieved given current decision making practices.

The future spending levels associated with investment scenarios presented in this chapter are all stated in constant 2006 dollars; to apply these values to a particular future year, it would be necessary to adjust them to account for actual or predicted increases in inflation beyond 2006. While the information presented in this section focuses on average annual investment levels associated with each scenario, the scenarios assume gradual increases or decreases in spending in constant dollars, as discussed in Chapter 7 [see *Exhibit 7-2*].

A subsequent section within this chapter explores comparable information for different types of potential future transit investments. This is followed by a section comparing key statistics from the highway and transit sections with the information presented in previous editions of this report.

Scenario Definitions

This section focuses on five selected scenarios for the Interstate System, NHS, and the overall system drawing upon the analyses presented in Chapter 7. These scenarios are intended to be illustrative; none of them is endorsed as a target level of funding. Other points along the continuum of alternative investment levels presented in Chapter 7 would be equally valid, depending on what system condition and performance outcomes are desired. Each of these scenarios are based on combined public and private investment. **The question of what portion should be funded by the Federal government, State governments, local governments, or the private sector is beyond the scope of this report.**

The **Sustain Current Spending scenario** assumes that capital spending is maintained in constant dollar terms at base year 2006 levels over the 20-year period from 2007 through 2026. The scenario also assumes that the distribution of spending will be split among the types of investments modeled in HERS, types of investments modeled in NBIAS, and types of investments that are not currently modeled, based on the 2006 base year percentages reflected in Chapter 7 [see *Exhibit 7-1*]. However, within the amounts reserved for HERS-modeled investment, the scenario reflects the distribution of spending that the model finds most economically attractive, and thus may differ from the actual spending distribution among resurfacing, reconstruction, and widening in 2006. Similarly, the distribution of bridge spending recommended by NBIAS may differ from the actual spending distribution among bridge repair, bridge rehabilitation, and bridge replacement in 2006.

> **Q&A**
>
> **Why is the term "Maximum Economic Investment" applied solely to the variable rate user financing version of the MinBCR=1.0 level?**
>
> The terminology used to describe the various illustrative scenarios in the C&P report has evolved over time to better communicate the nature of the scenarios, and to reduce the potential for confusion. For this edition, the scenarios tied to minimum benefit-cost ratios were given more technical names (i.e., "**MinBCR=1.0 scenario**") in order to make it easier to distinguish among them.
>
> While previous C&P reports had used the term "**Maximum Economic Investment**" to describe any scenario in which a minimum benefit-cost ratio of 1.0 had been applied, the use of the term has been limited to the variable rate user financing version of the "**MinBCR=1.0 scenario**." This change was made to recognize that alternative financing mechanisms, as well as alternative approaches to investment decision making, can both have significant economic implications.
>
> The variable rate financing version of this scenario reflects conditions under which users would be charged an economically rational price to travel on facilities that would be improved only to the extent that such investment was cost-beneficial.

The **MinBCR=1.0 scenario** assumes that combined public and private capital investment gradually increases in constant dollar terms over 20 years up to the point at which all potentially cost-beneficial investments (i.e., those with a benefit-cost ratio or "BCR" of 1.0 or higher) are funded by 2026, and the economic backlog for bridge investment is reduced to zero. This scenario represents an "investment

> **Q&A**
>
> **What are some of the technical limitations of scenarios based on minimum benefit-cost ratios?**
>
> While the **MinBCR=1.0 scenarios** are interesting from a theoretical technical standpoint, they do not represent practical target levels of investment for several reasons. First, available funding is not unlimited, and many decisions on highway and bridge funding levels must be weighed against potential cost-beneficial investments in other government programs and across various industries within the private sector that would produce more benefits to society. Simple cost-benefit analysis is not a commonly utilized capital investment model in the private sector. Instead, firms utilize a rate of return approach and compare various investment options and their corresponding risk. In other words, a project that is barely cost-beneficial would almost certainly not be undertaken when compared to an array of investment options that potentially produce higher returns at equivalent or lower risk. Second, these scenarios do not address practical considerations as to whether the highway and transit construction industries would be capable of absorbing such a large increase in funding within the 20-year analysis period. Such an expansion of infrastructure investment could significantly increase the rate of inflation within these industry sectors, a factor that is not considered in the constant dollar investment analyses presented in this report. Third, the legal and political complexities frequently associated with major highway capacity projects might preclude certain improvements from being made, even if they could be justified on benefit-cost criteria. In particular, the time required to move an urban capacity expansion project from "first thought" to actual completion may well exceed the 20-year analysis period.
>
> While the **MinBCR=1.2** and **MinBCR=1.5 scenarios** address some of these issues by screening out projects that are only marginally cost-beneficial, they still assume that projects are prioritized based on their benefit-cost ratios. That assumption is not consistent with actual patterns of project selection and funding distribution that occur in the real world. Consequently, if investment rose to these levels, there are few mechanisms to ensure these funds would be invested in projects that would be cost-beneficial. As a result, the impacts of any given budget on actual conditions and performance may be far less significant than what is projected as part of these scenarios.

ceiling" beyond which it would not be cost-beneficial to invest, even if available funding were unlimited. The version of this scenario assuming the widespread adoption of variable rate user charges is also described as the "**Maximum Economic Investment**" level, as it reflects conditions under which users would be charged an economically rational price to travel on facilities that would be improved only to the extent that such investment would be cost-beneficial.

The **MinBCR=1.2 scenario** assumes that combined public and private capital investment gradually increases in constant dollar terms over 20 years up to the point at which all potential capital improvements with a benefit-cost ratio of 1.2 or higher are funded by 2026, and the economic backlog for bridge investment is reduced to zero. This scenario was chosen to reflect that funding is not unlimited, and that targeting alternative minimum benefit-cost ratios is a reasonable method for prioritizing investments in a constrained funding environment. Applying a higher minimum benefit-cost ratio cutoff also tends to reduce the risk of investing in potential projects that might initially appear cost-beneficial, but that might not ultimately meet this standard due to unexpected changes in future costs or travel demand. It should be noted that the higher minimum-ratio cutoff applies only to those investments modeled in HERS because the benefit-cost procedures in NBIAS are not yet considered sufficiently robust to support this type of analysis. NBIAS is discussed in more detail in Appendix B.

The **MinBCR=1.5 scenario** assumes that combined public and private capital investment gradually increases in constant dollar terms over 20 years up to the point at which all potential capital improvements with a benefit-cost ratio of 1.5 or higher are funded by 2026, and the economic backlog for bridge investment is reduced to zero. This scenario illustrates how alternative benefit-cost ratio cutoff points in HERS can be utilized to simulate the prioritization of investments in a constrained funding environment. Other minimum benefit-cost ratio points associated with alternative funding levels are identified in Chapter 7 [see *Exhibit 7-14*]. The NBIAS-derived component of this scenario is based on the cost of eliminating the economic bridge investment backlog, rather than being linked to a specific minimum benefit-cost ratio cutoff point.

The **Sustain Conditions and Performance scenario** assumes that combined public and private capital investment gradually changes in constant dollar terms over 20 years to the point at which two key performance indicators in 2026 are maintained at their base year 2006 levels. These indicators are adjusted average user costs (as computed by HERS) and the economic backlog for bridge investment (as computed by NBIAS). They are intended to serve as summary measures of the overall conditions and performance of

Q&A

What are some of the technical limitations of scenarios based on sustaining conditions and performance at base year levels?

The investment scenario estimates outlined in this report represent an estimate of what level of performance **could** be achieved with a given level of funding, not what **would** be achieved with it. While the models assume that projects are prioritized based on their benefit-cost ratios, that assumption is not consistent with actual patterns of project selection and funding distribution that occur in the real world. Consequently, the level of investment identified as the amount sufficient to maintain a certain performance level should be viewed as the minimum amount that would be sufficient, if all other modeling assumptions prove to be accurate.

It is important to recognize that the conditions of "today" (i.e., 2006) in this report differ from the conditions of "today" (i.e., 2004, 2002, etc.) as presented in previous editions of the report. Hence, as the level of current system conditions and performance varies over time, the investment scenarios that are based on maintaining the status quo are effectively targeting something different each time. The reader should bear this in mind when comparing the results of different reports in the series.

It should also be noted that this report uses the term "sustain" in certain scenario titles rather than the term "maintain" that has been used in previous editions. This change was made to reduce confusion, as all of these scenarios reflect capital improvements only, and do not consider routine maintenance costs.

highways and bridges. It should be noted that while this scenario would maintain these summary indicators at base year levels for the system as a whole, the conditions and performance of individual components of the system would vary. The analyses presented in Chapter 7 identify the costs associated with maintaining several other alternative measures of system conditions and performance.

Supplemental Scenarios

Each of the five primary scenarios described above is defined in such a manner that it can draw directly from a single HERS model run and a single NBIAS model run among the range of alternatives presented in Chapter 7. This section also includes two supplemental scenarios that draw from multiple HERS and NBIAS runs in order to estimate the costs of achieving certain objectives beyond those that can be targeted in a single analysis.

The **Sustain Conditions and Performance of System Components scenario** focuses on maintaining specific performance indicators for individual highway functional systems rather than more general indicators for the system as a whole. This scenario combines three elements: (1) the level of system expansion expenditures associated with maintaining average delay per vehicle mile traveled (VMT), (2) the level of system rehabilitation expenditures associated with maintaining average pavement roughness, and (3) the level of system rehabilitation expenditures associated with maintaining the economic investment backlog for bridges. This scenario does not draw directly from the analyses presented in Chapter 7. Instead, it represents a compilation of parts of many separate HERS and NBIAS analyses in which particular performances measures on particular functional systems in 2026 were maintained at base year 2006 levels.

The goal of the **Sustain Conditions and Improve Performance scenario** is to maintain the physical conditions of highways and bridges while improving their operational performance. This scenario represents a combination of two other scenarios; the system rehabilitation expenditures reflected in the scenario are drawn from the **Sustain Conditions and Performance scenario**, while the system expansion expenditures are drawn from the **MinBCR=1.0 scenario**.

Note that these two supplemental scenarios are presented on a systemwide basis only; comparable values for the Interstate and NHS are not separately identified.

Interstate System Scenarios

Exhibits 8-1 and *8-2* describe the derivation of the investment levels for each of five Interstate capital investment scenarios assuming fixed rate user financing and variable rate user financing, respectively. These scenarios each draw from the HERS and NBIAS analyses presented in Chapter 7. The HERS-derived scenario components link back to selected investment levels identified in *Exhibit 7-18*, along with the minimum benefit-cost ratio cutoff points identified in *Exhibit 7-14*. The NBIAS-derived scenario components tie back to selected investment levels identified in *Exhibit 7-23*. Each scenario covers the 20-year period from 2007 to 2026, and the investment levels shown are all stated in constant 2006 dollars.

For the scenarios that target minimum benefit-cost ratio cutoff points, the HERS and NBIAS components can each be linked directly to one of the 24 alternative annual percent systemwide funding growth rates analyzed in Chapter 7; the growth rates associated with these scenarios are identified in *Exhibits 8-1* and *8-2*. This is not the case for scenarios targeting specific spending levels or specific levels of performance (i.e., the first two scenarios in each table); as discussed in Chapter 7, the mix of investments between the Interstate system and other parts of the highway system will be different when such targets are imposed at a systemwide level than if comparable criteria were imposed on the Interstate system alone. As referenced below, certain exhibits in Chapter 7 contain "extra" rows (in addition to the standard set of alternative growth rates) to highlight the Interstate-specific funding levels.

Exhibit 8-1

Definitions of Selected Interstate Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Fixed Rate User Financing

Scenario Name and Description	Scenario Component (And Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars) Modeled Spending	Estimated Non-Modeled	Total	Share of Average Annual Investment
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS	77.5%	$12.8		$12.8	77.5%
	NBIAS	15.1%	$2.5		$2.5	15.1%
	Non-Modeled	7.4%		$1.2	$1.2	7.4%
	Total	100.0%	$15.3	$1.2	**$16.5**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at 2006 levels)	HERS	77.5%	$20.2		$20.2	81.4%
	NBIAS	15.1%	$2.8		$2.8	11.1%
	Non-Modeled	7.4%		$1.8	$1.8	7.4%
	Total	100.0%	$22.9	$1.8	**$24.8**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCR's as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (5.03%)	77.5%	$31.4		$31.4	80.6%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	12.0%
	Non-Modeled	7.4%		$2.9	$2.9	7.4%
	Total	100.0%	$36.1	$2.9	**$39.0**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCR's as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (6.41%)	77.5%	$35.6		$35.6	81.8%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	10.7%
	Non-Modeled	7.4%		$3.2	$3.2	7.4%
	Total	100.0%	$40.3	$3.2	**$43.5**	100.0%
MinBCR=1.0 scenario (Invest in projects with BCR's as low as 1.0 and eliminate economic backlog for bridge rehabilitation)	HERS (7.45%)	77.5%	$38.8		$38.8	82.6%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	9.9%
	Non-Modeled	7.4%		$3.5	$3.5	7.4%
	Total	100.0%	$43.5	$3.5	**$47.0**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-23 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-18 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

The discussion that follows documents the derivation of the five Interstate scenarios in some detail. This information is provided to serve as a roadmap for how one could construct additional scenarios building off of different inputs from Chapter 7 beyond the selected scenarios presented here. It is important to note that these scenarios are intended to be illustrative, and any number of alternative scenarios based on different benefit-cost ratio cutoff points, performance targets, or funding targets could be constructed that would be equally valid from a technical perspective.

Derivation of Scenario Investment Levels

The average annual investment levels shown for the Interstate **Sustain Current Spending scenario** are identical in both *Exhibits 8-1* and *8-2*, and are consistent with the 2006 Interstate spending figures identified in *Exhibit 7-1*. This scenario assumes the continuation of the percentage splits in spending among HERS-modeled, NBIAS-modeled, and non-modeled improvement types. Of the $16.5 billion of capital investment on the Interstate System in 2006, approximately $12.8 billion (or 77.5 percent) was used for types of improvements modeled in HERS, including pavement resurfacing, pavement reconstruction, and capacity additions to the existing highway and bridge network. (The HERS-modeled impacts on adjusted user costs of sustaining the 2006 level of Interstate investment in constant dollar terms are identified for each of the funding mechanisms [non-user sources, fixed rate user charges, and variable rate user charges] in the second extra row

Exhibit 8-2

Definitions of Selected Interstate Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Variable Rate User Financing

Scenario Name and Description	Scenario Component (and Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars)			Share of Average Annual Investment
			Modeled Spending	Estimated Non-Modeled	Total	
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS	77.5%	$12.8		$12.8	77.5%
	NBIAS	15.1%	$2.5		$2.5	15.1%
	Non-Modeled	7.4%		$1.2	$1.2	7.4%
	Total	100.0%	$15.3	$1.2	**$16.5**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at 2006 levels)	HERS	77.5%	$8.0		$8.0	68.8%
	NBIAS	15.1%	$2.8		$2.8	23.7%
	Non-Modeled	7.4%		$0.9	$0.9	7.4%
	Total	100.0%	$10.8	$0.9	**$11.6**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCRs as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (1.67%)	77.5%	$17.6		$17.6	73.1%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	19.4%
	Non-Modeled	7.4%		$1.8	$1.8	7.4%
	Total	100.0%	$22.2	$1.8	**$24.0**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCRs as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (3.30%)	77.5%	$20.8		$20.8	75.6%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	17.0%
	Non-Modeled	7.4%		$2.0	$2.0	7.4%
	Total	100.0%	$25.5	$2.0	**$27.5**	100.0%
Maximum Economic Investment (MinBCR=1.0) scenario (Invest in projects with BCRs as low as 1.0 and eliminate economic bridge backlog)	HERS (4.45%)	77.5%	$23.5		$23.5	77.2%
	NBIAS (5.15%)	15.1%	$4.7		$4.7	15.4%
	Non-Modeled	7.4%		$2.3	$2.3	7.4%
	Total	100.0%	$28.1	$2.3	**$30.4**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-23 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-18 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

appended to the bottom of Exhibit 7-18.) Approximately $2.5 billion (or 15.1 percent) was used for types of bridge repair, rehabilitation, and replacement improvements modeled in NBIAS. (The impacts of sustaining this level of investment in constant dollar terms are identified in the second extra row appended to the bottom of *Exhibit 7-23*.) The remaining $1.2 billion (or 7.4 percent) went for types of capital improvements not currently addressed by either HERS or NBIAS, including various safety enhancements, environmental enhancements, and traffic operations improvements.

Each of the Interstate System scenarios assume that the share of average annual investment directed towards non-modeled capital improvements will remain at the 2006 level of 7.4 percent. Consequently, the amounts identified as estimated non-modeled spending in *Exhibits 8-1* and *8-2* are proportionally larger or smaller than the 2006 spending level of $1.2 billion, based on the change in modeled spending relative to the 2006 baseline.

Q&A

Why does the analysis assume that the share of the future highway investment scenario estimates for non-modeled items would match their share of current spending?

No data are currently available that would justify an assumption that the percentage of capital spending devoted to these investments would (or should) change in the future. In the absence of such data, it is thus reasonable to assume that their share of future investment under each scenario would approximate their share of current spending.

The average annual investment levels for the Interstate **Sustain Conditions and Performance scenario** for 2007 to 2026 assuming fixed rate user financing is $24.8 billion, as shown in *Exhibit 8-1; Exhibit 8-2* identifies the comparable annual figure assuming the widespread adoption of variable rate user charges (i.e., congestion pricing) as $11.6 billion in constant 2006 dollars. The HERS-modeled components of these totals are $20.2 billion and $8.0 billion, respectively. (The impacts of sustaining these levels of investment in constant dollar terms over 20 years are identified in the first extra row appended to the bottom of *Exhibit 7-18*.) The NBIAS-modeled component is identical in both exhibits, totaling $2.8 billion because NBIAS does not consider alternative financing mechanisms. (The impacts of sustaining this level of investment in constant dollar terms are identified in the first extra row appended to the bottom of *Exhibit 7-23*.) The estimated non-modeled portion of the scenario differs proportionally in response to the differences between the HERS-derived figures.

As shown in *Exhibit 8-1*, the average annual investment level for the period 2007 to 2026 for the Interstate **MinBCR=1.5 scenario** assuming financing from fixed rate user charges is $39.0 billion. This includes a HERS-derived component of $31.4 billion, stated in constant 2006 dollars. (*Exhibit 7-14* links the benefit-cost ratio cutoff point with an annual spending growth rate of 5.03 percent assuming fixed rate user financing, which in turn is linked to $31.4 billion of spending on HERS-modeled improvements on the Interstate system in *Exhibit 7-18*.) *Exhibit 8-2* identifies an average annual investment for the Interstate **MinBCR=1.5 scenario** of $24.0 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $17.6 billion. (*Exhibit 7-14* links the benefit-cost ratio cutoff point with an annual spending growth rate of 1.67 percent assuming variable rate user financing, which in turn is linked to $17.6 billion of spending on HERS-modeled improvements on the Interstate system in *Exhibit 7-18*.) The $4.7 billion NBIAS-derived component shown in both *Exhibits 8-1* and *8-2* represents the average annual level of investment to eliminate the economic bridge investment backlog. (*Exhibit 7-23* identifies this figure, which is associated with an annual constant dollar growth rate of 5.15 percent.)

The average annual investment level over 20 years for the Interstate **MinBCR=1.2 scenario** assuming financing from fixed rate user charges is $43.5 billion stated in constant 2006 dollars, including a HERS-derived component of $35.6 billion, as shown in *Exhibit 8-1*. (This HERS component is linked to an annual spending growth rate of 6.41 percent in *Exhibit 7-18*, which is the rate associated with a minimum benefit-cost ratio of 1.2 in *Exhibit 7-14*.) *Exhibit 8-2* identifies an average annual investment for the Interstate **MinBCR=1.2 scenario** of $27.5 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $20.8 billion. (This HERS component is linked to an annual spending growth rate of 3.30 percent in *Exhibit 7-18*, which is the rate associated with a minimum benefit-cost ratio of 1.2 in *Exhibit 7-14*, assuming variable rate user financing.) The $4.7 billion NBIAS-derived component shown in both *Exhibits 8-1* and *8-2* represents the average annual level of investment to eliminate the economic bridge investment backlog.

The average annual investment level over 20 years for the Interstate **MinBCR=1.0 scenario** assuming financing from fixed rate user charges is $47.0 billion stated in constant 2006 dollars, including a HERS-derived component of $38.8 billion, as shown in *Exhibit 8-1*. (This HERS component is linked to an annual spending growth rate of 7.45 percent in *Exhibit 7-18*, which is the rate associated with a minimum benefit-cost ratio of 1.0 in *Exhibit 7-14*.) *Exhibit 8-2* identifies an average annual investment for the Interstate **Maximum Economic Investment (MinBCR=1.0) scenario** of $30.4 billion stated in constant 2006 dollars assuming the widespread adoption of variable user charges such as congestion pricing, including a HERS-derived component of $23.5 billion. (This HERS component is linked to an annual spending growth rate of 4.45 percent in *Exhibit 7-18*, which is the rate associated with a minimum benefit-cost ratio of 1.0 in *Exhibit 7-14*, assuming variable rate user financing.) The $4.7 billion NBIAS-derived component shown in both *Exhibits 8-1* and *8-2* represents the average annual level of investment to eliminate the economic bridge investment backlog.

Investment Scenario Estimates by Improvement Type

Exhibit 8-3 compares the distribution of highway and bridge capital outlay among the 20-year Interstate capital investment scenarios defined in *Exhibits 8-1* and *8-2*. The amounts identified as the bridge portion of the System Rehabilitation category correspond to the NBIAS-modeled portion of each scenario, while System Enhancement spending corresponds to the non-modeled portion of each scenario as estimated in *Exhibits 8-1* and *8-2*. The HERS-modeled portion of each scenario is split between the System Expansion category and the highway portion of the System Rehabilitation category.

For the **versions of the scenarios assuming fixed rate user financing**, the percentage of capital investment devoted to System Expansion rises as the average annual investment level rises. While 42.6 percent of combined public and private capital investment on Interstates was devoted to System Expansion in 2006, the Interstate **Sustain Current Spending scenario** suggests this percentage should be increased to 48.3 percent, were this level of investment to be sustained over 20 years in constant dollar terms. This suggests that the current performance of the Interstate system is better in terms of physical conditions than in terms of operational performance. If investment were to rise to the Interstate **Sustain Conditions and Performance scenario** level, the analysis suggests that 51.9 percent of Interstate capital investment be directed to System Expansion; the Interstate **MinBCR=1.0 scenario** would direct 57.8 percent of capital investment towards System Expansion. These findings suggest that there are substantial opportunities for potentially cost-beneficial investments in Interstate System Expansion if sufficient funding were available to implement them, but that many of these investments have benefit-cost ratios that are relatively low, due to the large construction costs associated with these types of investments.

Q&A

Can highway capacity be expanded without building new roads and bridges or adding new lanes to existing facilities?

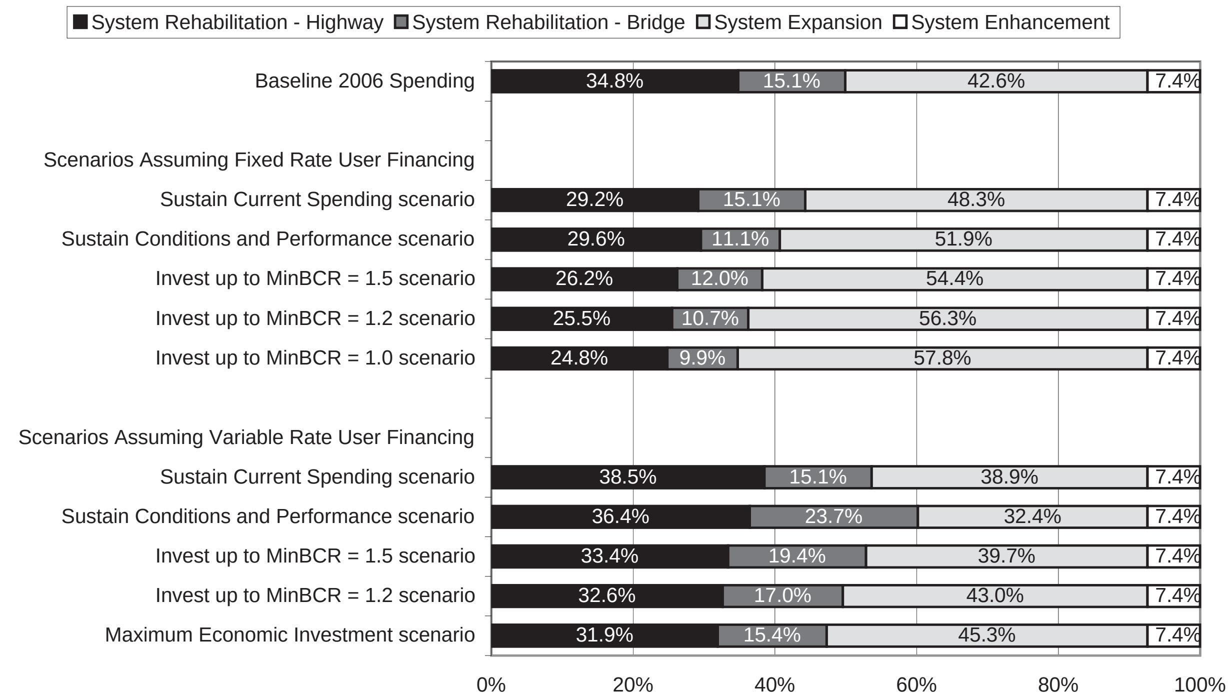
Yes. The "System Expansion" investment levels identified in this chapter reflect a need for a certain amount of effective highway capacity, which could be met by traditional expansion or by other means. In some cases, effective highway capacity can be increased by improving the utilization of the existing infrastructure rather than by expanding it. The investment scenario estimates presented in this report consider the impact of some of the most significant operations strategies and deployments on highway system performance; these relationships are described in more detail in Appendix A.

The methodology used to estimate the system expansion component of the investment scenarios also allows high-cost capacity improvements to be considered as an option for segments with high volumes of projected future travel, but have been coded by States as infeasible for conventional widening. Conceptually, such improvements might consist of new highways or bridges in the same corridor (or tunneling or double-decking on an existing alignment), but the capacity upgrades could also come through other transportation improvements, such as a parallel fixed-guideway transit line or mixed-use, high-occupancy vehicle/bus lanes.

For the **versions of the scenarios assuming variable rate user financing**, the percentage of capital investment devoted to system expansion would be lower than if only fixed rate user financing were utilized, but would still rise as the average annual investment level rises. If investment were to decline in constant dollar terms to the Interstate **Sustain Conditions and Performance scenario** level, the analysis suggests that 32.4 percent of Interstate capital investment be directed to System Expansion; this share would rise to 38.9 percent for the Interstate **Sustain Current Spending scenario**, but would still remain below the 42.6 percent of combined public and private capital investment on Interstates devoted to System Expansion

Exhibit 8-3

Distribution of Capital Improvement Types for Selected Interstate Highway Capital Investment Scenarios for 2007 to 2026



	Average Annual Investment (Billions of 2006 Dollars)					
	System Rehabilitation					
Scenario Name and Description	**Highway [1]**	**Bridge [2]**	**Total**	**System Expansion [3]**	**System Enhance-ment**	**Total**
Baseline 2006 Spending	$5.8	$2.5	$8.3	$7.1	$1.2	**$16.5**
Scenarios Assuming Fixed Rate User Financing						
Sustain Current Spending scenario	$4.8	$2.5	$7.3	$8.0	$1.2	**$16.5**
Sustain Conditions and Performance scenario	$7.3	$2.8	$10.1	$12.9	$1.8	**$24.8**
Invest up to MinBCR = 1.5 scenario	$10.2	$4.7	$14.9	$21.2	$2.9	**$39.0**
Invest up to MinBCR = 1.2 scenario	$11.1	$4.7	$15.8	$24.5	$3.2	**$43.5**
Invest up to MinBCR = 1.0 scenario	$11.7	$4.7	$16.3	$27.2	$3.5	**$47.0**
Scenarios Assuming Variable Rate User Financing						
Sustain Current Spending scenario	$6.4	$2.5	$8.9	$6.4	$1.2	**$16.5**
Sustain Conditions and Performance scenario	$4.2	$2.8	$7.0	$3.8	$0.9	**$11.6**
Invest up to MinBCR = 1.5 scenario	$8.0	$4.7	$12.7	$9.5	$1.8	**$24.0**
Invest up to MinBCR = 1.2 scenario	$9.0	$4.7	$13.7	$11.8	$2.0	**$27.5**
Maximum Economic Investment scenario (MinBCR = 1.0)	$9.7	$4.7	$14.4	$13.8	$2.3	**$30.4**

[1] Values shown correspond to amounts in Exhibit 7-20.

[2] Values shown correspond to amounts in Exhibit 7-23.

[3] Values shown correspond to amounts in Exhibit 7-19.

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

in 2006. If investment were to rise to the Interstate **Maximum Economic Investment scenario** level, the analysis suggests that 45.3 percent of Interstate capital investment be directed to System Expansion. These findings suggest that the widespread adoption of congestion pricing strategies would reduce the attractiveness of System Expansion relative to System Rehabilitation, though there would still be opportunities for potentially cost-beneficial investments of all kinds.

Investment Scenario Impacts

Exhibit 8-4 summarizes the potential impacts of the 20-year Interstate capital investment scenarios defined in *Exhibits 8-1* and *8-2*, on selected measures of system conditions and performance. The Interstate **Sustain Conditions and Performance scenario** would by definition be associated with a 0.0 percent change in adjusted average user costs and the bridge investment backlog, as the scenario is designed to represent a level of investment that could allow the 2026 values for these indicators to match their base year 2006 values. For the version of this scenario that **assumes fixed rate user financing**, average delay per VMT is projected to increase by 2.1 percent, while average pavement roughness (as measured by the International Roughness Index [IRI] as defined in Chapter 3) would decline by 1.9 percent. This suggests a tradeoff between improved physical conditions and a worsening of operational performance. The opposite is true for the version

Q&A

Why do the fixed rate financing versions of many of the scenarios result in lower average IRI values than their variable rate financing counterparts?

This difference is largely attributable to the lower overall investment levels associated with the variable rate financing versions of the scenarios. The variable rate user financing version of the **Sustain Current Spending Scenario** (the one scenario for which the investment levels for both the fixed and variable versions is identical), results in significantly better ride quality than its fixed user financing counterpart.

Another factor pertains to the reduced number of widening actions taken by HERS for the analyses assuming the adoption of variable rate user charges. As discussed in Chapter 7, when HERS adds new lanes to an existing facility, it also resurfaces or reconstructs all of the existing lanes. In some cases, these pavement improvements occur earlier in the life of the pavement than would normally be the case in the absence of the widening action, and would not have been cost-beneficial on their own. Consequently, the reduced number of widening actions taken by HERS under the variable rate funding analyses causes some of these pavement actions to be deferred beyond the 20-year period considered as part of this analysis.

Exhibit 8-4

Projected Changes in 2026 Interstate System Peformance Indicators Compared With 2006 for Selected Interstate Highway Capital Investment Scenarios

	Average Annual Investment (Billions of 2006 Dollars)	Percent Change in:			
Scenario Name and Description		**Adjusted Average User Costs [1]**	**Average Delay Per VMT [2]**	**Average IRI [3]**	**Bridge Investment Backlog [4]**
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$16.5	5.0%	33.9%	28.2%	17.1%
Sustain Conditions and Performance scenario	$24.8	**0.0%**	2.1%	-1.9%	**0.0%**
Invest up to MinBCR=1.5 scenario	$39.0	-4.5%	-30.2%	-27.6%	-100.0%
Invest up to MinBCR=1.2 scenario	$43.5	-5.6%	-39.4%	-32.0%	-100.0%
Invest up to MinBCR=1.0 scenario	$47.0	-6.3%	-46.1%	-34.7%	-100.0%
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$16.5	-2.9%	-31.1%	-4.5%	17.1%
Sustain Conditions and Performance scenario	$11.6	**0.0%**	-19.9%	22.2%	**0.0%**
Invest up to MinBCR=1.5 scenario	$24.0	-4.7%	-42.5%	-18.6%	-100.0%
Invest up to MinBCR=1.2 scenario	$27.5	-5.6%	-48.9%	-25.5%	-100.0%
Maximum Economic Investment scenario (MinBCR=1.0)	$30.4	-6.2%	-53.1%	-29.4%	-100.0%

[1] Values shown correspond to amounts in Exhibit 7-18.

[2] Values shown correspond to amounts in Exhibit 7-19.

[3] Values shown correspond to amounts in Exhibit 7-20.

[4] Values shown correspond to amounts in Exhibit 7-23.

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

of this scenario **assuming variable rate user financing**, under which average delay per VMT is projected to decrease by 19.9 percent while average IRI increases by 22.2 percent. This suggests that the operational performance improvements associated with the widespread adoption of congestion pricing would be sufficient to allow a significant reduction in Interstate capital spending while still having the same net impact on the costs experienced by highway users.

Relative to the scenario focusing on sustaining current conditions and performance, those scenarios with higher average annual levels of investment would be expected to result in overall improvements to the system, as measured by their impacts on adjusted average user costs and other performance indicators. The potential for reductions to average delay per VMT is relatively large, as strategic investments in Interstate System Expansion, coupled with the continued deployment of intelligent transportation systems (ITS) on a growing share of the Interstate System, has the potential to significantly improve operating performance, particularly when applied in conjunction with congestion pricing.

Comparison of Scenario Investment Levels With Base Year Spending

Exhibit 8-5 compares the combined public and private capital investment levels associated with each of the selected Interstate scenarios with actual Interstate capital spending in 2006. By definition, the Interstate **Sustain Current Spending scenario** matches base year spending in constant dollar terms.

Among the **versions of the scenarios assuming fixed rate user financing**, the difference in average annual investment levels relative to the 2006 baseline ranges from 49.8 percent for the Interstate **Sustain Conditions and Performance scenario** up to 183.9 percent for the Interstate **MinBCR=1.0 scenario**.

Exhibit 8-5

Comparison of Selected Interstate Highway Capital Investment Scenarios for 2007 to 2026 With Base Year 2006 Interstate Capital Spending

Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)	Difference Relative to 2006 Spending on Interstates		Annual Percent Increase to Support Scenario Investment [1]	Annual Revenues Generated From Variable Rate User Charges [2]
		(Billions of 2006 Dollars)	Percent		
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$16.5	$0.0	0.0%	0.00%	$0.0
Sustain Conditions and Performance scenario	$24.8	$8.2	49.8%	3.71%	$0.0
Invest up to MinBCR=1.5 scenario	$39.0	$22.5	135.7%	7.61%	$0.0
Invest up to MinBCR=1.2 scenario	$43.5	$27.0	163.1%	8.52%	$0.0
Invest up to MinBCR=1.0 scenario	$47.0	$30.4	183.9%	9.15%	$0.0
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$16.5	$0.0	0.0%	0.00%	$26.7
Sustain Conditions and Performance scenario	$11.6	-$4.9	-29.7%	-3.49%	$29.9
Invest up to MinBCR=1.5 scenario	$24.0	$7.5	45.3%	3.43%	$23.6
Invest up to MinBCR=1.2 scenario	$27.5	$11.0	66.5%	4.64%	$21.6
Maximum Economic Investment scenario (MinBCR=1.0)	$30.4	$13.9	83.8%	5.49%	$20.1

[1] *This percentage represents the annual percent changes relative to 2006 that would be required to achieve the average annual funding level specified for the scenario.*

[2] *Amounts shown represent the portion of the revenues from variable rate user charges identified in Exhibit 7-4 that would be generated on the Interstate System as computed in the HERS run used to develop the scenario.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Exhibit 8-5 also identifies the annual increase in combined public and private capital investment that would be sufficient to produce the average annual investment levels identified for each scenario. A constant dollar spending growth rate of 3.71 percent would be sufficient to support the Interstate **Sustain Conditions and Performance scenario**; the equivalent growth rate associated with the Interstate **MinBCR=1.5 scenario** would be 7.61 percent.

Among the **versions of the scenarios assuming fixed rate user financing**, the average annual investment level for the Interstate **Sustain Conditions and Performance scenario** is 29.7 percent lower than actual Interstate capital spending in 2006; *Exhibit 8-5* indicates that spending could decline by 3.49 percent annually in constant dollar terms and still generate sufficient funding to support this scenario. The average annual investment level for the Interstate **Maximum Economic Investment scenario** exceeds base year 2006 Interstate capital spending by 83.8 percent. Achieving this average annual investment level could be accomplished by increasing combined public and private Interstate capital spending by 5.49 percent per year.

Exhibit 8-5 also identifies the estimated annual revenues that might be generated from the Interstate System assuming the widespread adoption of congestion pricing. These revenues are a subset of the projected revenue from variable rate user charges identified in Chapter 7 for the highway system as a whole [see *Exhibit 7-4*]. Based on the assumptions underlying the analyses presented in these scenarios, the additional revenues generated from congestion charges on the Interstate System would be more than adequate to support an increase from current Interstate spending up to the **Interstate Maximum Economic Investment scenario**, if these revenues were used for this purpose.

National Highway System Scenarios

Exhibits 8-6 and *8-7* describe the derivation of the investment levels for each of five NHS capital investment scenarios assuming fixed rate user financing and variable rate user financing, respectively. These scenarios each draw from the HERS and NBIAS analyses presented in Chapter 7. The HERS-derived scenario components link back to selected investment levels identified in *Exhibit 7-15*, along with the minimum benefit-cost ratio cutoff points identified in *Exhibit 7-14*. The NBIAS-derived scenario components tie back to selected investment levels identified in *Exhibit 7-22*. Each scenario covers the 20-year period from 2007 to 2026, and the investment levels shown are all stated in constant 2006 dollars.

For the scenarios that target minimum benefit-cost ratio cutoff points, the HERS and NBIAS components can each be linked directly to one the 24 alternative annual percent systemwide funding growth rates analyzed in Chapter 7; the growth rates associated with these scenarios are identified in *Exhibits 8-6* and *8-7*. This is not the case for scenarios targeting specific spending levels or specific levels of performance; as discussed in Chapter 7, the mix of investments between the NHS and other parts of the highway system will be different when such targets are imposed at a systemwide level that if comparable criteria were imposed on the NHS alone. As referenced below, certain exhibits in Chapter 7 contain "extra" rows (in addition to the standard set of alternative growth rates) to highlight the NHS-specific funding levels.

The discussion that follows documents the derivation of the five NHS scenarios in some detail. This information is provided to serve as a roadmap for how one could construct additional scenarios building off of different inputs from Chapter 7 beyond the selected scenarios presented here. **It is important to note that these scenarios are intended to be illustrative, and any number of alternative scenarios based on different benefit-cost ratio cutoff points, performance targets, or funding targets could be constructed that would be equally valid from a technical perspective.**

Exhibit 8-6

Definitions of Selected NHS Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Fixed Rate User Financing

Scenario Name and Description	Scenario Component (And Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars) Modeled Spending	Estimated Non-Modeled	Total	Share of Average Annual Investment
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS	80.8%	$30.0		$30.0	80.8%
	NBIAS	11.6%	$4.3		$4.3	11.6%
	Non-Modeled	7.6%		$2.8	$2.8	7.6%
	Total	100.0%	$34.3	$2.8	**$37.1**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at 2006 levels)	HERS	80.8%	$31.1		$31.1	80.4%
	NBIAS	11.6%	$4.7		$4.7	12.1%
	Non-Modeled	7.6%		$2.9	$2.9	7.6%
	Total	100.0%	$35.8	$2.9	**$38.7**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCR's as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (5.03%)	80.8%	$48.4		$48.4	79.7%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	12.7%
	Non-Modeled	7.6%		$4.6	$4.6	7.6%
	Total	100.0%	$56.1	$4.6	**$60.7**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCR's as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (6.41%)	80.8%	$56.2		$56.2	81.3%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	11.1%
	Non-Modeled	7.6%		$5.2	$5.2	7.6%
	Total	100.0%	$63.9	$5.2	**$69.2**	100.0%
MinBCR=1.0 scenario (Invest in projects with BCR's as low as 1.0 and eliminate economic backlog for bridge rehabilitation)	HERS (7.45%)	80.8%	$62.6		$62.6	82.3%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	10.1%
	Non-Modeled	7.6%		$5.8	$5.8	7.6%
	Total	100.0%	$70.3	$5.8	**$76.1**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-22 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-15 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Derivation of Scenario Investment Levels

The average annual investment levels shown for the NHS **Sustain Current Spending scenario** are identical in both *Exhibits 8-6* and *8-7*, and are consistent with the 2006 NHS spending figures identified in *Exhibit 7-1*. This scenario assumes the continuation of the percentage splits in spending among HERS-modeled, NBIAS-modeled, and non-modeled improvement types. Of the $37.1 billion of capital investment on the NHS in 2006, approximately $30.0 billion (or 80.8 percent) was used for types of improvements modeled in HERS, including pavement resurfacing, pavement reconstruction, and capacity additions to the existing highway and bridge network. (The impacts of sustaining this level of investment in constant dollar terms are identified in the second extra row appended to the bottom of *Exhibit 7-15*.) Approximately $4.3 billion (or 11.6 percent) was used for types of bridge repair, rehabilitation, and replacement improvements modeled in NBIAS. (The impacts of sustaining this level of investment in constant dollar terms are identified in the second extra row appended to the bottom of *Exhibit 7-22*.) The remaining $2.8 billion (or 7.6 percent) went for types of capital improvements not currently addressed by either HERS or NBIAS, including various safety enhancements, environmental enhancements, and traffic operations improvements.

Exhibit 8-7

Definitions of Selected NHS Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Variable Rate User Financing

Scenario Name and Description	Scenario Component (And Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars) Modeled Spending	Estimated Non-Modeled	Total	Share of Average Annual Investment
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS	80.8%	$30.0		$30.0	80.8%
	NBIAS	11.6%	$4.3		$4.3	11.6%
	Non-Modeled	7.6%		$2.8	$2.8	7.6%
	Total	100.0%	$34.3	$2.8	**$37.1**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at 2006 levels)	HERS	80.8%	$13.5		$13.5	68.7%
	NBIAS	11.6%	$4.7		$4.7	23.8%
	Non-Modeled	7.6%		$1.5	$1.5	7.6%
	Total	100.0%	$18.2	$1.5	**$19.6**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCR's as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (1.67%)	80.8%	$28.3		$28.3	72.6%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	19.8%
	Non-Modeled	7.6%		$2.9	$2.9	7.6%
	Total	100.0%	$36.0	$2.9	**$38.9**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCR's as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (3.30%)	80.8%	$33.8		$33.8	75.3%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	17.1%
	Non-Modeled	7.6%		$3.4	$3.4	7.6%
	Total	100.0%	$41.5	$3.4	**$44.9**	100.0%
Maximum Economic Investment (MinBCR=1.0) scenario (Invest in projects with BCR's as low as 1.0 and eliminate economic bridge backlog)	HERS (4.45%)	80.8%	$38.6		$38.6	77.1%
	NBIAS (5.15%)	11.6%	$7.7		$7.7	15.4%
	Non-Modeled	7.6%		$3.8	$3.8	7.6%
	Total	100.0%	$46.3	$3.8	**$50.1**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-22 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-15 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Each of the NHS scenarios assume that the share of average annual investment directed towards non-modeled capital improvements will remain at the 2006 level of 7.6 percent. Consequently, the amounts identified as estimated non-modeled spending in *Exhibits 8-6* and *8-7* are proportionally larger or smaller than the 2006 spending level of $2.8 billion, based on the change in modeled spending relative to the 2006 baseline.

The average annual investment levels for the NHS **Sustain Conditions and Performance scenario** for 2007 to 2026 assuming fixed rate user financing is $38.7 billion, as shown in *Exhibit 8-6*, while *Exhibit 8-7* identifies the comparable annual figure assuming the widespread adoption of variable rate user charges (i.e., congestion pricing) as $19.6 billion in constant 2006 dollars. The HERS-modeled components of these totals are $31.1 billion and $13.5 billion, respectively. (The impacts of sustaining these levels of investment in constant dollar terms over 20 years are identified in the first extra row appended to the bottom of *Exhibit 7-15*). The NBIAS modeled component is identical in both exhibits, totaling $4.7 billion, as NBIAS does not consider alternative financing mechanisms. (The impacts of sustaining this level of investment in constant dollar terms are identified in the first extra row appended to the bottom of *Exhibit 7-22*.) The estimated non-modeled portion of the scenario differs proportionally in response to the differences between the HERS-derived figures.

As shown in *Exhibit 8-6*, the average annual investment level for the period 2007 to 2026 for the NHS **MinBCR=1.5 scenario** assuming financing from fixed rate user charges is $60.7 billion, including a HERS-derived component of $48.4 billion, stated in constant 2006 dollars. (*Exhibit 7-14* links the benefit-cost ratio cutoff point with an annual spending growth rate of 5.03 percent assuming fixed rate user financing, which in turn is linked to $48.4 billion of spending on HERS-modeled improvements on the NHS in *Exhibit 7-15*.) *Exhibit 8-7* identifies an average annual investment for the NHS **MinBCR=1.5 scenario** of $38.9 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $28.3 billion. (*Exhibit 7-14* links the benefit-cost ratio cutoff point with an annual spending growth rate of 1.67 percent assuming variable rate user financing, which in turn is linked to $28.3 billion of spending on HERS-modeled improvements on the NHS in *Exhibit 7-15*.) The $7.7 billion NBIAS-derived component shown in both *Exhibits 8-6* and *8-7* represents the average annual level of investment to eliminate the economic bridge investment backlog. (*Exhibit 7-22* identifies this figure, which is associated with an annual constant dollar growth rate of 5.15 percent.)

The average annual investment level over 20 years for the NHS **MinBCR=1.2 scenario** assuming financing from fixed rate user charges is $69.2 billion stated in constant 2006 dollars, including a HERS-derived component of $56.2 billion, as shown in *Exhibit 8-6*. (This HERS component is linked to an annual spending growth rate of 6.41 percent in *Exhibit 7-15*, which is the rate associated with a minimum benefit-cost ratio of 1.2 in *Exhibit 7-14*.) *Exhibit 8-7* identifies an average annual investment for the NHS **MinBCR=1.2 scenario** of $44.9 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $33.8 billion. (This HERS component is linked to an annual spending growth rate of 3.30 percent in *Exhibit 7-15*, which is the rate associated with a minimum benefit-cost ratio of 1.2 in *Exhibit 7-14*, assuming variable rate user financing.) The $7.7 billion NBIAS-derived component shown in both *Exhibits 8-6* and *8-7* represents the average annual level of investment to eliminate the economic bridge investment backlog.

The average annual investment level over 20 years for the NHS **MinBCR=1.0 scenario** assuming financing from fixed rate user charges is $76.1 billion stated in constant 2006 dollars, including a HERS-derived component of $62.6 billion, as shown in *Exhibit 8-6*. (This HERS component is linked to an annual spending growth rate of 7.45 percent in *Exhibit 7-15*, which is the rate associated with a minimum benefit-cost ratio of 1.0 in *Exhibit 7-14*.) *Exhibit 8-7* identifies an average annual investment for the NHS **Maximum Economic Investment (MinBCR=1.0) scenario** of $50.1 billion stated in constant 2006 dollars assuming the widespread adoption of variable user charges such as congestion pricing, including a HERS-derived component of $38.6 billion. (This HERS component is linked to an annual spending growth rate of 4.45 percent in *Exhibit 7-15*, which is the rate associated with a minimum benefit-cost ratio of 1.0 in *Exhibit 7-14*, assuming variable rate user financing.) The $7.7 billion NBIAS-derived component shown in both *Exhibits 8-6* and *8-7* represents the average annual level of investment to eliminate the economic bridge investment backlog.

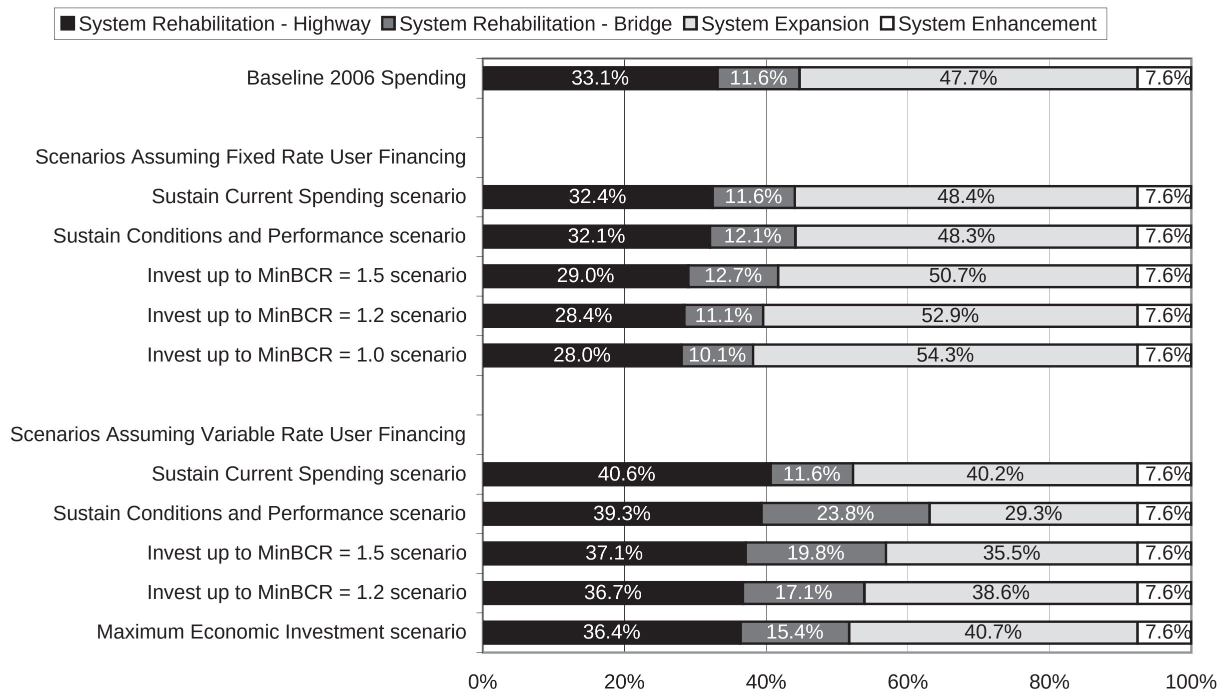
Investment Scenario Estimates by Improvement Type

Exhibit 8-8 compares the distribution of highway and bridge capital outlay among the 20-year NHS capital investment scenarios defined in *Exhibits 8-6* and *8-7*. The amounts identified as the bridge portion of the System Rehabilitation category correspond to the NBIAS-modeled portion of each scenario, while System Enhancement spending corresponds to the non-modeled portion of each scenario as estimated in *Exhibits 8-6* and *8-7*. The HERS-modeled portion of each scenario is split between the System Expansion category and the highway portion of the System Rehabilitation category.

For the **versions of the scenarios assuming fixed rate user financing**, the percentage of capital investment devoted to system expansion rises as the average annual investment level rises. While 47.7 percent of

Exhibit 8-8

Distribution of Capital Improvement Types for Selected NHS Highway Capital Investment Scenarios for 2007 to 2026



Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)					
	System Rehabilitation			System Expansion [3]	System Enhance-ment	Total
	Highway [1]	Bridge [2]	Total			
Baseline 2006 Spending	$12.3	$4.3	$16.6	$17.7	$2.8	**$37.1**
Scenarios Assuming Fixed Rate User Financing						
Sustain Current Spending scenario	$12.0	$4.3	$16.3	$17.9	$2.8	**$37.1**
Sustain Conditions and Performance scenario	$12.4	$4.7	$17.1	$18.7	$2.9	**$38.7**
Invest up to MinBCR=1.5 scenario	$17.6	$7.7	$25.3	$30.8	$4.6	**$60.7**
Invest up to MinBCR=1.2 scenario	$19.7	$7.7	$27.4	$36.6	$5.2	**$69.2**
Invest up to MinBCR=1.0 scenario	$21.3	$7.7	$29.0	$41.3	$5.8	**$76.1**
Scenarios Assuming Variable Rate User Financing						
Sustain Current Spending scenario	$15.1	$4.3	$19.4	$14.9	$2.8	**$37.1**
Sustain Conditions and Performance scenario	$7.7	$4.7	$12.4	$5.8	$1.5	**$19.6**
Invest up to MinBCR=1.5 scenario	$14.4	$7.7	$22.1	$13.8	$2.9	**$38.9**
Invest up to MinBCR=1.2 scenario	$16.5	$7.7	$24.2	$17.3	$3.4	**$44.9**
Maximum Economic Investment scenario (MinBCR=1.0)	$18.2	$7.7	$25.9	$20.4	$3.8	**$50.1**

[1] Values shown correspond to amounts in Exhibit 7-17.

[2] Values shown correspond to amounts in Exhibit 7-22.

[3] Values shown correspond to amounts in Exhibit 7-16.

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

combined public and private capital investment on the NHS was devoted to System Expansion in 2006, the NHS **Sustain Current Spending scenario** suggests this percentage should be increased to 48.4 percent, were this level of investment to be sustained over 20 years in constant dollar terms. This suggests that the current performance of the NHS is better in terms of physical conditions than in terms of operational performance. If investment were to rise to the NHS **Sustain Conditions and Performance scenario** level, the analysis suggests that 48.3 percent of NHS capital investment be directed to System Expansion; the NHS **MinBCR=1.0 scenario** would direct 54.3 percent of capital investment towards System Expansion. These findings suggest that there are a substantial opportunities for potentially cost-beneficial investments in NHS System Expansion if sufficient funding were available to implement them, but that many of these investments have relatively low benefit-cost ratios, due to the large construction costs associated with these types of investments.

For the **versions of the scenarios assuming variable rate user financing**, the share of capital investment devoted to System Expansion would rise as the average annual investment level rises, but would remain well below the baseline 2006 value of 47.7 percent. As discussed in Chapter 7, variable congestion pricing would tend to reduce VMT growth in the peak period, thus reducing the need to take widening actions to accommodate the growth. If investment were to decline in constant dollar terms to the NHS **Sustain Conditions and Performance scenario** level, the analysis suggests that 29.3 percent of NHS capital investment be directed to System Expansion; this share would rise to 40.7 percent for the NHS **Maximum Economic Investment scenario**. These findings suggest that the widespread adoption of congestion pricing strategies would reduce the relative attractiveness of System Expansion relative to System Rehabilitation, though there would still be opportunities for potentially cost-beneficial investments of all kinds.

Investment Scenario Impacts

Exhibit 8-9 summarizes the potential impacts of the 20-year NHS capital investment scenarios defined in *Exhibits 8-6* and *8-7,* on selected measures of system conditions and performance. The NHS **Sustain Conditions and Performance scenario** would by definition be associated with a 0.0 percent change in

Exhibit 8-9

Projected Changes in 2026 NHS System Peformance Indicators Compared With 2006 for Selected NHS Highway Capital Investment Scenarios

Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)	Percent Change in: Adjusted Average User Costs [1]	Average Delay Per VMT [2]	Average IRI [3]	Bridge Investment Backlog [4]
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$37.1	0.3%	6.7%	1.1%	12.8%
Sustain Conditions and Performance scenario	$38.7	0.0%	5.1%	-1.2%	0.0%
Invest up to MinBCR=1.5 scenario	$60.7	-3.6%	-16.8%	-23.4%	-100.0%
Invest up to MinBCR=1.2 scenario	$69.2	-4.7%	-24.3%	-29.0%	-100.0%
Invest up to MinBCR=1.0 scenario	$76.1	-5.4%	-29.8%	-33.2%	-100.0%
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$37.1	-4.0%	-27.9%	-18.3%	12.8%
Sustain Conditions and Performance scenario	$19.6	0.0%	-11.4%	17.7%	0.0%
Invest up to MinBCR=1.5 scenario	$38.9	-3.8%	-26.4%	-16.2%	-100.0%
Invest up to MinBCR=1.2 scenario	$44.9	-4.6%	-30.9%	-23.1%	-100.0%
Maximum Economic Investment scenario (MinBCR=1.0)	$50.1	-5.2%	-34.0%	-27.8%	-100.0%

[1] *Values shown correspond to amounts in Exhibit 7-15.*

[2] *Values shown correspond to amounts in Exhibit 7-16.*

[3] *Values shown correspond to amounts in Exhibit 7-17.*

[4] *Values shown correspond to amounts in Exhibit 7-22.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

adjusted average user costs and the bridge investment backlog, as the scenario is designed to represent a level of investment that could allow the 2026 values for these indicators to match their base year 2006 values. For the version of this scenario that **assumes fixed rate user financing**, average delay per VMT is projected to increase by 5.1 percent, while average pavement roughness (as measured by IRI as defined in Chapter 3) would decline by 1.2 percent. This suggests a tradeoff between improved physical conditions and a worsening of operational performance. The opposite is true for the version of this scenario **assuming variable rate user financing**, under which average delay per VMT is projected to decrease by 11.4 percent while average IRI increases by 17.7 percent. This suggests that the operational performance improvements associated with the widespread adoption of congestion pricing would be sufficient to allow a significant reduction in NHS capital spending while still having the same net impact on the costs experienced by highway users.

Relative to the scenario focusing on sustaining current conditions and performance, those scenarios with higher average annual levels of investment would be expected to result in overall improvements to the system, as measured by their impacts on adjusted average user costs and other performance indicators. The potential for reductions to average delay per VMT is relatively large, as strategic investments in NHS System Expansion, coupled with the continued deployment of ITS on a growing share of the NHS, has the potential to significantly improve operating performance, particularly when applied in conjunction with congestion pricing.

It should be noted that while the variable rate user financing version of the **Sustain Conditions and Performance** scenario is projected to result in higher average IRI than the fixed rate version of the scenario, this is largely attributable to its much lower level of investment. As the Sustain Current Spending scenario demonstrates, given a fixed budget level, variable rate user financing would tend to result in lower average IRI than would fixed rate user financing.

Comparison of Scenario Investment Levels With Base Year Spending

Exhibit 8-10 compares the combined public and private capital investment levels associated with each of the selected NHS scenarios with actual NHS capital spending in 2006. By definition, the NHS **Sustain Current Spending scenario** matches base year spending in constant dollar terms.

Among the **versions of the scenarios assuming fixed rate user financing**, the difference in average annual investment levels relative to the 2006 baseline ranges from 4.4 percent for the NHS **Sustain Conditions and Performance scenario** up to 105.1 percent for the NHS **MinBCR=1.0 scenario**. *Exhibit 8-10* also identifies the annual increase in combined public and private capital investment that would be sufficient to produce the average annual investment levels identified for each scenario. A constant dollar spending growth rate of 0.41 percent would be sufficient to support the NHS **Sustain Conditions and Performance scenario**; the equivalent growth rate associated with the NHS **MinBCR=1.5 scenario** would be 4.49 percent.

Among the **versions of the scenarios assuming fixed rate user financing**, the average annual investment level for the NHS **Sustain Conditions and Performance scenario** is 47.0 percent lower than actual NHS capital spending in 2006; *Exhibit 8-10* indicates that highway capital spending could decline by 6.54 percent annually in constant dollar terms and still generate sufficient funding to support this scenario. The average annual investment level for the NHS **Maximum Economic Investment scenario** exceeds base year 2006 NHS capital spending by 35.3 percent. Achieving this average annual investment level could be accomplished by increasing combined public and private NHS capital spending by 2.79 percent per year.

Exhibit 8-10 also identifies the estimated annual revenues that might be generated from the NHS assuming the widespread adoption of congestion pricing. These revenues are a subset of the projected revenue from

Exhibit 8-10

Comparison of Selected NHS Highway Capital Investment Scenarios for 2007 to 2026 With Base Year 2006 NHS Capital Spending

Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)	Difference Relative to 2006 Spending on the NHS		Annual Percent Increase to Support Scenario Investment [1]	Annual Revenues Generated From Variable Rate User Charges [2]
		(Billions of 2006 Dollars)	Percent		
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$37.1	$0.0	0.0%	0.00%	$0.0
Sustain Conditions and Performance scenario	$38.7	$1.6	4.4%	0.41%	$0.0
Invest up to MinBCR=1.5 scenario	$60.7	$23.6	63.7%	4.49%	$0.0
Invest up to MinBCR=1.2 scenario	$69.2	$32.1	86.5%	5.62%	$0.0
Invest up to MinBCR=1.0 scenario	$76.1	$39.0	105.1%	6.43%	$0.0
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$37.1	$0.0	0.0%	0.00%	$33.9
Sustain Conditions and Performance scenario	$19.6	-$17.4	-47.0%	-6.54%	$42.9
Invest up to MinBCR=1.5 scenario	$38.9	$1.8	4.9%	0.46%	$34.7
Invest up to MinBCR=1.2 scenario	$44.9	$7.9	21.2%	1.80%	$32.0
Maximum Economic Investment scenario (MinBCR=1.0)	$50.1	$13.1	35.3%	2.79%	$30.0

[1] This percentage represents the annual percent changes relative to 2006 that would be required to achieve the average annual funding level specified for the scenario.

[2] Amounts shown represent the portion of the revenues from variable rate user charges identified in Exhibit 7-4 that would be generated on the NHS as computed in the HERS run used to develop the scenario.

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

variable rate user charges identified in Chapter 7 for the highway system as a whole [see *Exhibit 7-4*]. Based on the assumptions underlying the analyses presented in these scenarios, the additional revenues generated from congestion charges on the NHS would be more than adequate to support an increase in NHS spending up to the **NHS Maximum Economic Investment scenario** if these revenues were used for this purpose.

Systemwide Scenarios

Exhibits 8-11 and *8-12* describe the derivation of the investment levels for each of five systemwide capital investment scenarios assuming fixed rate user financing and variable rate user financing, respectively. For each of these scenarios, the HERS and NBIAS components can be linked back to one of the 24 alternative funding levels analyzed in Chapter 7. The HERS-derived scenario components link back to selected investment levels identified in *Exhibit 7-5*, along with the minimum benefit-cost ratio cutoff points identified in *Exhibit 7-14*. The NBIAS-derived scenario components tie back to selected investment levels identified in *Exhibit 7-21*. Each scenario covers the 20-year period from 2007 to 2026, and the investment levels shown are all stated in constant 2006 dollars.

Exhibits 8-11 and *8-12* identify the systemwide constant dollar growth rate associated with each of the investment scenario components to provide a link back to the analysis of the potential impacts of these funding levels presented in various exhibits in Chapter 7. By definition, the **Sustain Current Spending scenario** is associated with annual growth rates of 0.0 percent for all of its components. The **Sustain Conditions and Performance scenario** is associated with an annual growth rate of 0.83 percent for its

NBIAS component; the equivalent growth rates for its HERS component are 3.07 percent assuming fixed rate user financing or -1.37 percent assuming variable rate user financing.

The NBIAS component for the **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0 scenarios** is associated with an annual constant dollar growth rate of 5.15 percent for its NBIAS component. Assuming fixed rate user financing, the annual growth rates associated with HERS components of these three scenarios are 5.03 percent, 6.41 percent, and 7.45 percent, respectively; the comparable growth rates assuming variable rate user financing are 1.67 percent, 3.30 percent, and 4.45 percent, respectively.

Q&A

What are the minimum benefit-cost ratios associated with the HERS components each of the systemwide scenarios?

The systemwide annual spending growth rates identified in *Exhibits 8-11* and *8-12* are included to provide a link to the performance indicators associated with those growth rates presented in various exhibits in Chapter 7. *Exhibit 7-14* indicates that the HERS minimum benefit-cost ratios associated with the 0.0 percent growth rate associated with the **Sustain Current Spending Scenario** are 2.89 for the fixed rate user financing version and 1.90 assuming variable rate user financing.

For the **Sustain Conditions and Performance scenario**, the 3.07 percent annual spending growth rate associated with the HERS component of the fixed rate user financing version is linked to a minimum benefit-cost ratio of 1.98. The 1.37 percent annual spending decrease associated with the HERS component of the variable rate user financing version of this scenario is linked to a minimum BCR of 2.25.

By definition, the minimum benefit-cost ratios associated with the **MinBCR=1.5 scenario**, the **MinBCR=1.2 scenario**, and the **MinBCR=1.0 scenario** are 1.5, 1.2, and 1.0, respectively.

The discussion that follows documents the derivation of the six investment scenarios in some detail. This information is provided to serve as a roadmap for how one could construct additional scenarios building off of different inputs from Chapter 7 beyond the selected scenarios presented here. It is important to note that these scenarios are intended to be illustrative, and any number of alternative scenarios based on different benefit-cost ratio cutoff points, performance targets, or funding targets could be constructed that would be equally valid from a technical perspective.

Derivation of Scenario Investment Levels

The average annual investment levels shown for the **Sustain Current Spending scenario** are identical in both *Exhibits 8-11* and *8-12*, and are consistent with the 2006 spending figures identified in *Exhibit 7-1*. This scenario assumes the continuation of the percentage splits in spending among HERS-modeled, NBIAS-modeled, and non-modeled improvement types. Of the $78.7 billion of highway capital investment by all levels of government in 2006, approximately $48.2 billion (or 61.3 percent) was used for types of improvements modeled in HERS, including pavement resurfacing, pavement reconstruction, and capacity additions to the existing highway and bridge network. Approximately $10.1 billion (or 12.9 percent) was used for types of bridge repair, rehabilitation, and replacement improvements modeled in NBIAS. The remaining $20.3 billion (or 25.9 percent) went for types of capital improvements not currently addressed by either HERS or NBIAS ($8.2 billion), including various safety enhancements, environmental enhancements, and traffic operations improvements or for highway functional systems not reported in the Highway Performance Monitoring System ($12.1 billion), including roads functionally classified as rural minor collector, rural local, or urban local.

Each of the investment scenarios assume that the share of average annual investment directed towards non-modeled capital improvements will remain at the 2006 level of 25.9 percent. Consequently, the amounts identified as estimated non-modeled spending in *Exhibits 8-11* and *8-12* are proportionally larger or smaller than the 2006 spending level of $20.3 billion, based on the change in modeled spending relative to the 2006 baseline.

Exhibit 8-11

Definitions of Selected Systemwide Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Fixed Rate User Financing

Scenario Name and Description	Scenario Component (and Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars) Modeled Spending	Estimated Non-Modeled	Total	Share of Average Annual Investment
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS (0.00%)	61.3%	$48.2		$48.2	61.3%
	NBIAS (0.00%)	12.9%	$10.1		$10.1	12.9%
	Non-Modeled	25.9%		$20.3	$20.3	25.9%
	Total	100.0%	$58.3	$20.3	**$78.7**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at 2006 levels)	HERS (3.07%)	61.3%	$67.2		$67.2	63.7%
	NBIAS (0.83%)	12.9%	$11.1		$11.1	10.5%
	Non-Modeled	25.9%		$27.3	$27.3	25.9%
	Total	100.0%	$78.3	$27.3	**$105.6**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCRs as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (5.03%)	61.3%	$84.0		$84.0	61.1%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	13.0%
	Non-Modeled	25.9%		$35.5	$35.5	25.9%
	Total	100.0%	$101.9	$35.5	**$137.4**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCRs as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (6.41%)	61.3%	$98.6		$98.6	62.8%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	11.4%
	Non-Modeled	25.9%		$40.6	$40.6	25.9%
	Total	100.0%	$116.5	$40.6	**$157.1**	100.0%
MinBCR=1.0 scenario (Invest in projects with BCRs as low as 1.0 and eliminate economic backlog for bridge rehabilitation)	HERS (7.45%)	61.3%	$111.5		$111.5	63.9%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	10.2%
	Non-Modeled	25.9%		$45.1	$45.1	25.9%
	Total	100.0%	$129.4	$45.1	**$174.6**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-21 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-5 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

The average annual investment level for the **Sustain Conditions and Performance scenario** for 2007 to 2026 assuming fixed rate user financing is $105.6 billion, as shown in *Exhibit 8-11*, while *Exhibit 8-12* identifies the comparable annual figure assuming the widespread adoption of variable rate user charges (i.e., congestion pricing) as $71.3 billion in constant 2006 dollars. The HERS-modeled components of these totals are $67.2 billion and $41.8 billion, respectively. The NBIAS modeled component is identical in both exhibits, totaling $11.1 billion, as NBIAS does not consider alternative financing mechanisms. The estimated non-modeled portion of the scenario differs proportionally in response to the differences between the HERS-derived figures.

As shown in *Exhibit 8-11*, the average annual investment level for the period 2007 to 2026 for the **MinBCR=1.5 scenario** assuming financing from fixed rate user charges is $137.4 billion, including a HERS-derived component of $84.0 billion, stated in constant 2006 dollars. *Exhibit 8-12* identifies an average annual investment for the **MinBCR=1.5 scenario** of $101.8 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $57.6 billion. The $17.9 billion NBIAS-derived component shown in both *Exhibits 8-11* and *8-12* represents the average annual level of investment to eliminate the economic bridge investment backlog.

Exhibit 8-12

Definitions of Selected Systemwide Highway Capital Investment Scenarios for 2007 to 2026 and Estimation of Non-Modeled Components, Assuming Variable Rate User Financing

Scenario Name and Description	Scenario Component (and Associated Systemwide Growth Rate) *	Share of 2006 Total Capital Outlay	Average Annual Investment (Billions of 2006 Dollars) Modeled Spending	Estimated Non-Modeled	Total	Share of Average Annual Investment
Sustain Current Spending scenario (Maintain spending at base year levels in constant dollar terms)	HERS (0.00%)	61.3%	$48.2		$48.2	61.3%
	NBIAS (0.00%)	12.9%	$10.1		$10.1	12.9%
	Non-Modeled	25.9%		$20.3	$20.3	25.9%
	Total	100.0%	$58.3	$20.3	**$78.7**	100.0%
Sustain Conditions and Performance scenario (Maintain adjusted average highway user costs and economic bridge backlog at base year levels)	HERS (-1.37%)	61.3%	$41.8		$41.8	58.6%
	NBIAS (0.83%)	12.9%	$11.1		$11.1	15.5%
	Non-Modeled	25.9%		$18.4	$18.4	25.9%
	Total	100.0%	$52.9	$18.4	**$71.3**	100.0%
MinBCR=1.5 scenario (Invest in projects with BCRs as low as 1.5 and eliminate economic backlog for bridge rehabilitation)	HERS (1.67%)	61.3%	$57.6		$57.6	56.6%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	17.6%
	Non-Modeled	25.9%		$26.3	$26.3	25.9%
	Total	100.0%	$75.5	$26.3	**$101.8**	100.0%
MinBCR=1.2 scenario (Invest in projects with BCRs as low as 1.2 and eliminate economic backlog for bridge rehabilitation)	HERS (3.30%)	61.3%	$69.0		$69.0	58.9%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	15.3%
	Non-Modeled	25.9%		$30.3	$30.3	25.9%
	Total	100.0%	$86.9	$30.3	**$117.2**	100.0%
Maximum Economic Investment (MinBCR=1.0) scenario (Invest in projects with BCRs as low as 1.0 and eliminate economic bridge backlog)	HERS (4.45%)	61.3%	$79.5		$79.5	60.5%
	NBIAS (5.15%)	12.9%	$17.9		$17.9	13.6%
	Non-Modeled	25.9%		$34.0	$34.0	25.9%
	Total	100.0%	$97.4	$34.0	**$131.3**	100.0%

* *Each scenario component is linked to the analyses presented in Chapter 7. See Exhibit 7-21 for the systemwide growth rates associated with the NBIAS components, and Exhibits 7-5 and 7-14 for the comparable growth rates for the HERS components.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

The average annual investment level over 20 years for the **MinBCR=1.2 scenario** assuming financing from fixed rate user charges is $157.1 billion stated in constant 2006 dollars, including a HERS-derived component of $98.6 billion, as shown in *Exhibit 8-11*. *Exhibit 8-12* identifies an average annual investment for the **MinBCR=1.2 scenario** of $117.2 billion stated in constant 2006 dollars assuming financing from variable rate user charges, including a HERS-derived component of $69.0 billion. The $17.9 billion NBIAS-derived component shown in both *Exhibits 8-11* and *8-12* represents the average annual level of investment to eliminate the economic bridge investment backlog.

The average annual investment level over 20 years for the **MinBCR=1.0 scenario** assuming financing from fixed rate user charges is $174.6 billion stated in constant 2006 dollars, including a HERS-derived component of $111.5 billion, as shown in *Exhibit 8-11*. *Exhibit 8-12* identifies an average annual investment for the **Maximum Economic Investment (MinBCR=1.0) scenario** of $131.3 billion stated in constant 2006 dollars assuming the widespread adoption of variable user charges such as congestion pricing, including a HERS-derived component of $79.5 billion. The $17.9 billion NBIAS-derived component shown in both *Exhibits 8-11* and *8-12* represents the average annual level of investment to eliminate the economic bridge investment backlog.

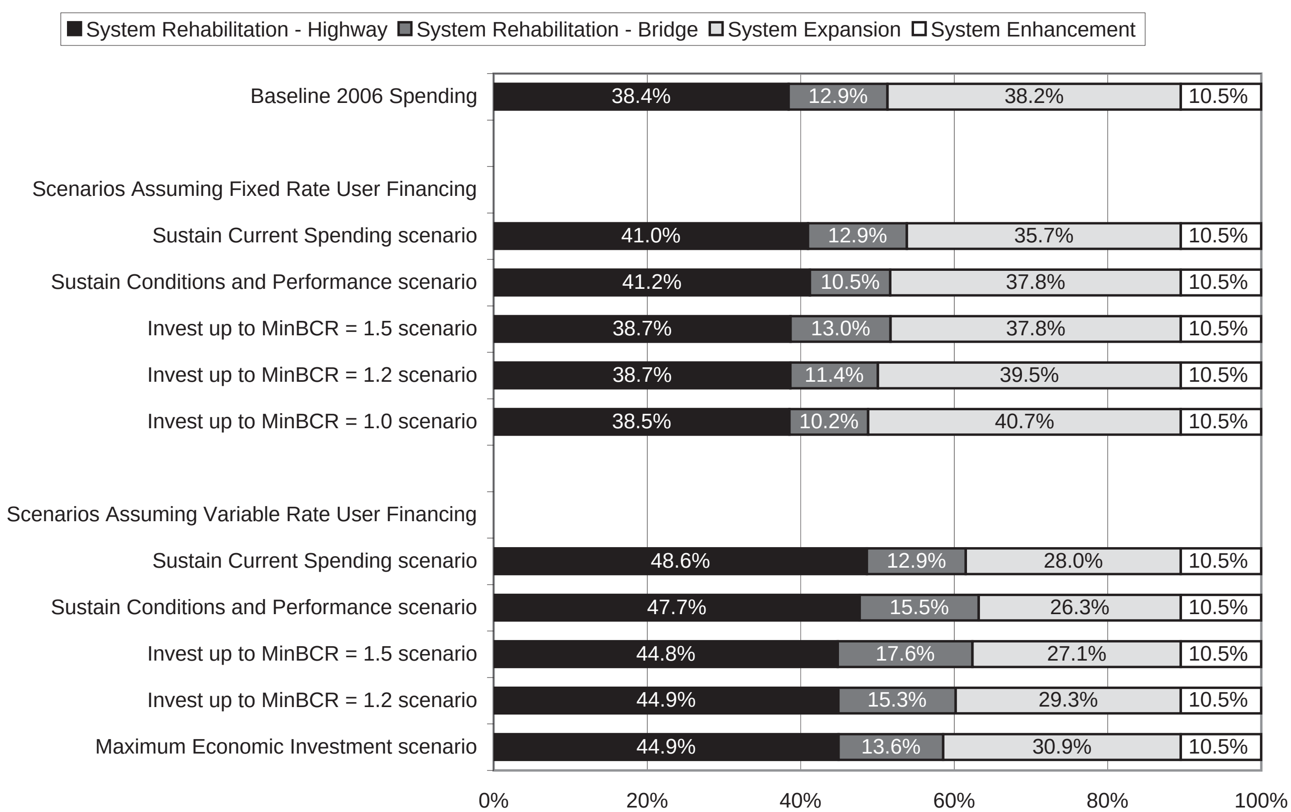
Investment Scenario Estimates by Improvement Type

Exhibit 8-13 compares the distribution of highway and bridge capital spending by type of improvement among the 20-year capital investment scenarios defined in *Exhibits 8-11* and *8-12*. The amounts identified as the bridge portion of the System Rehabilitation category correspond to the NBIAS-modeled portion of each scenario. Amounts identified as System Enhancement spending represent a subset of the non-modeled portion of each scenario as estimated in *Exhibits 8-11* and *8-12;* the remaining non-modeled spending and the HERS-modeled portion of each scenario are split between the System Expansion category and the highway portion of the System Rehabilitation category.

For the **versions of the scenarios assuming fixed rate user financing**, the percentage of capital investment devoted to System Expansion generally rises as the average annual investment level rises. While 38.2 percent of combined public and private highway capital investment was devoted to System Expansion in 2006, the **Sustain Current Spending scenario** suggests this percentage be decreased to 35.7 percent, were this level of investment to be sustained over 20 years in constant dollar terms. If investment were to rise to the **MinBCR=1.0** level, the analysis suggests that 40.7 percent of capital investment be directed to System Expansion.

Exhibit 8-13

Distribution of Capital Improvement Types for Selected Systemwide Highway Capital Investment Scenarios for 2007 to 2026



Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

For the **versions of the scenarios assuming variable rate user financing**, the percentage of capital investment devoted to system expansion would be lower than if only fixed rate user financing were utilized, but would still generally rise as the average annual investment level rises. If investment were to decline in constant dollar terms to the **Sustain Conditions and Performance scenario** level, the analysis suggests that 26.3 percent of capital investment be directed to System Expansion; this share would rise to 28.0 percent for the **Sustain Current Spending scenario**, and to 30.9 percent if investment were to rise to the **Maximum Economic Investment scenario** level. These findings suggest that the widespread adoption of congestion pricing strategies would reduce the relative attractiveness of System Expansion relative to System Rehabilitation, though there would still be plentiful opportunities for potentially cost-beneficial investments of all kinds.

Sustain Current Spending Scenario

Exhibits 8-14 and *8-15* identify the distribution of capital investments for the **Sustain Current Spending scenario** (assuming fixed rate financing and variable rate financing, respectively) with the actual distribution of highway capital spending by all levels of government in 2006. In assessing the percentage differences shown in this table, it is important to note that the distribution of expenditures tends to vary from year to year, and that **2006 does not necessarily represent a typical year** in regards to spending for each of the capital improvement types on each functional class identified in the exhibits; in some cases, **this may make the relative differences between the scenario and current spending patterns appear more dramatic than they actually are**. In both exhibits, for all functional classes, the percent differences shown in the "System Enhancement" column are 0.0 percent, as these types of improvements are not modeled and were assumed to remain constant; the same is true for the rural minor collector and local functional class values in the "System Expansion" and "System Rehabilitation: Highway" columns.

The HERS and NBIAS analyses underlying the distribution of capital investments shown in *Exhibit 8-14* suggest that if combined public and private highway capital spending were maintained at base year 2006 levels in constant dollar terms and **fixed rate user financing** mechanisms were utilized, then shifting resources from rural arterials and collectors to urban arterials and collectors would yield a more favorable outcome in terms of total net benefits to users, agencies, and society. The $13.7 billion of combined public and private investment on rural arterials and collectors included as part of this scenario would represent a 43.8 percent decline relative to actual 2006 spending. The scenario does include a 1.8 percent increase in capital spending on rural interstates relative to the 2006 baseline, as HERS and NBIAS identified a relatively large pool of attractive investments in Interstate System Expansion and Interstate Bridge Rehabilitation. The $49.7 billion of combined investment on urban arterials and collectors included as part of this scenario would represent a 30.3 percent increase relative to actual spending.

Exhibit 8-15 shows that assuming the widespread adoption of **variable rate user financing** mechanisms such as congestion pricing would make some potential urban capital investments less economically attractive than those in rural areas. However, the $16.8 billion of capital investment on rural arterials and collectors assumed under this scenario would represent a 30.9 percent decrease relative to the 2006 baseline; the $46.5 billion of capital investment on urban arterials and collectors would represent a 22.1 percent increase. The HERS and NBIAS analyses underlying the distribution of capital investments shown in *Exhibit 8-15* suggest shifting significant resources towards urban system rehabilitation.

Exhibit 8-14

Sustain Current Spending Scenario Assuming Fixed Rate User Financing: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026 Compared to Actual 2006 Spending, by Functional Class and Improvement Type

Average Annual National Investment (Billions of 2006 Dollars)

	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	$1.6	$0.6	$2.1	$1.8	$0.4	$4.3
Other Principal Arterial	$1.2	$0.5	$1.7	$0.8	$0.6	$3.1
Minor Arterial	$1.1	$0.4	$1.5	$0.2	$0.5	$2.2
Major Collector	$1.6	$0.7	$2.3	$0.2	$0.4	$2.9
Minor Collector	$0.6	$0.3	$0.8	$0.2	$0.1	$1.2
Subtotal	**$6.0**	**$2.5**	**$8.5**	**$3.2**	**$2.0**	**$13.7**
Urban Arterials and Collectors						
Interstate	$5.7	$2.3	$8.0	$10.9	$0.9	$19.8
Other Freeway and Expressway	$2.4	$0.9	$3.3	$3.7	$0.4	$7.5
Other Principal Arterial	$4.2	$1.5	$5.8	$2.6	$1.0	$9.4
Minor Arterial	$5.0	$1.2	$6.2	$2.5	$0.7	$9.4
Collector	$1.8	$0.4	$2.2	$0.9	$0.4	$3.6
Subtotal	**$19.1**	**$6.4**	**$25.5**	**$20.6**	**$3.5**	**$49.7**
Rural and Urban Local	**$7.1**	**$1.3**	**$8.4**	**$4.2**	**$2.7**	**$15.4**
Total	**$32.2**	**$10.1**	**$42.4**	**$28.1**	**$8.2**	**$78.7**

Percent Above Actual 2006 Combined Public and Private Capital Spending

	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	-38.8%	71.9%	-25.8%	84.4%	0.0%	1.8%
Other Principal Arterial	-66.9%	-34.9%	-61.5%	-83.3%	0.0%	-68.0%
Minor Arterial	-52.5%	-44.0%	-50.4%	-83.2%	0.0%	-54.7%
Major Collector	-34.8%	-13.4%	-29.4%	-68.7%	0.0%	-33.3%
Minor Collector	0.0%	-18.6%	-6.7%	0.0%	0.0%	-4.9%
Subtotal	**-47.6%**	**-17.7%**	**-41.4%**	**-59.3%**	**0.0%**	**-43.8%**
Urban Arterials and Collectors						
Interstate	77.3%	6.8%	49.0%	79.7%	0.0%	60.6%
Other Freeway and Expressway	71.0%	90.8%	75.9%	17.7%	0.0%	36.3%
Other Principal Arterial	26.4%	66.0%	34.9%	-51.2%	0.0%	-11.5%
Minor Arterial	114.2%	38.7%	93.5%	1.5%	0.0%	47.5%
Collector	27.1%	-14.0%	16.4%	-5.1%	0.0%	7.8%
Subtotal	**63.3%**	**29.5%**	**53.3%**	**15.0%**	**0.0%**	**30.3%**
Rural and Urban Local	**0.0%**	**-41.5%**	**-9.8%**	**0.0%**	**0.0%**	**-5.6%**
Total	**6.5%**	**0.0%**	**4.9%**	**-6.6%**	**0.0%**	**0.0%**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Exhibit 8-15

Sustain Current Spending Scenario Assuming Variable Rate User Financing: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026 Compared to Actual 2006 Spending, by Functional Class and Improvement Type

Average Annual National Investment (Billions of 2006 Dollars)						
	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	$1.9	$0.6	$2.5	$1.7	$0.4	$4.6
Other Principal Arterial	$1.8	$0.5	$2.3	$1.0	$0.6	$3.9
Minor Arterial	$1.8	$0.4	$2.3	$0.3	$0.5	$3.0
Major Collector	$2.7	$0.7	$3.4	$0.3	$0.4	$4.1
Minor Collector	$0.6	$0.3	$0.8	$0.2	$0.1	$1.2
Subtotal	**$8.9**	**$2.5**	**$11.3**	**$3.5**	**$2.0**	**$16.8**
Urban Arterials and Collectors						
Interstate	$5.2	$2.3	$7.5	$6.1	$0.9	$14.4
Other Freeway and Expressway	$2.4	$0.9	$3.3	$2.1	$0.4	$5.8
Other Principal Arterial	$5.5	$1.5	$7.0	$2.4	$1.0	$10.5
Minor Arterial	$6.5	$1.2	$7.7	$2.7	$0.7	$11.1
Collector	$2.8	$0.4	$3.2	$1.0	$0.4	$4.7
Subtotal	**$22.3**	**$6.4**	**$28.7**	**$14.3**	**$3.5**	**$46.5**
Rural and Urban Local	**$7.1**	**$1.3**	**$8.4**	**$4.2**	**$2.7**	**$15.4**
Total	**$38.3**	**$10.1**	**$48.4**	**$22.0**	**$8.2**	**$78.7**

Percent Above Actual 2006 Combined Public and Private Capital Spending						
	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	-24.4%	71.9%	-13.1%	77.5%	0.0%	8.8%
Other Principal Arterial	-49.0%	-34.9%	-46.6%	-79.0%	0.0%	-59.1%
Minor Arterial	-20.4%	-44.0%	-26.4%	-79.7%	0.0%	-38.6%
Major Collector	11.8%	-13.4%	5.4%	-56.8%	0.0%	-5.7%
Minor Collector	0.0%	-18.6%	-6.7%	0.0%	0.0%	-4.9%
Subtotal	**-22.5%**	**-17.7%**	**-21.5%**	**-55.9%**	**0.0%**	**-30.9%**
Urban Arterials and Collectors						
Interstate	60.0%	6.8%	38.6%	-0.1%	0.0%	16.8%
Other Freeway and Expressway	67.2%	90.8%	73.1%	-33.7%	0.0%	5.7%
Other Principal Arterial	63.9%	66.0%	64.3%	-54.7%	0.0%	-1.4%
Minor Arterial	178.5%	38.7%	140.2%	12.2%	0.0%	75.1%
Collector	100.5%	-14.0%	70.6%	5.6%	0.0%	42.2%
Subtotal	**90.3%**	**29.5%**	**72.3%**	**-20.1%**	**0.0%**	**22.1%**
Rural and Urban Local	**0.0%**	**-41.5%**	**-9.8%**	**0.0%**	**0.0%**	**-5.6%**
Total	**26.5%**	**0.0%**	**19.8%**	**-26.6%**	**0.0%**	**0.0%**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Sustain Conditions and Performance Scenario

Exhibit 8-16 identifies the distribution of capital investments by improvement type and functional class for the **Sustain Conditions and Performance scenario**. Assuming fixed rate user financing, the $67.2 billion of capital investment on urban arterials and collectors under this scenario would represent 63.7 percent of the $105.6 billion total public and private average annual capital spending under this scenario. Investment

Exhibit 8-16

Sustain Condition and Performance Scenarios: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026

Average Annual National Investment (Billions of 2006 Dollars)

Assuming Fixed Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.0	$0.6	$2.6	$2.1	$0.5	$5.2
Other Principal Arterial	$1.8	$0.5	$2.3	$1.0	$0.8	$4.1
Minor Arterial	$1.7	$0.5	$2.2	$0.3	$0.6	$3.1
Major Collector	$2.5	$0.7	$3.2	$0.3	$0.6	$4.1
Minor Collector	$0.8	$0.3	$1.1	$0.2	$0.2	$1.5
Subtotal	**$8.7**	**$2.6**	**$11.4**	**$4.0**	**$2.7**	**$18.1**
Urban Arterials and Collectors						
Interstate	$7.1	$2.5	$9.5	$15.0	$1.2	$25.7
Other Freeway and Expressway	$3.0	$1.0	$4.0	$5.7	$0.6	$10.3
Other Principal Arterial	$5.8	$1.7	$7.5	$4.3	$1.4	$13.2
Minor Arterial	$6.6	$1.4	$8.0	$3.7	$1.0	$12.6
Collector	$2.8	$0.5	$3.3	$1.7	$0.6	$5.5
Subtotal	**$25.3**	**$7.0**	**$32.3**	**$30.3**	**$4.7**	**$67.2**
Rural and Urban Local	**$9.5**	**$1.4**	**$10.9**	**$5.7**	**$3.7**	**$20.3**
Total	**$43.5**	**$11.1**	**$54.6**	**$40.0**	**$11.1**	**$105.6**

Assuming Variable Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$1.7	$0.6	$2.4	$1.5	$0.3	$4.2
Other Principal Arterial	$1.5	$0.5	$2.0	$0.9	$0.6	$3.5
Minor Arterial	$1.5	$0.5	$2.0	$0.2	$0.4	$2.7
Major Collector	$2.2	$0.7	$2.9	$0.2	$0.4	$3.6
Minor Collector	$0.5	$0.3	$0.8	$0.2	$0.1	$1.1
Subtotal	**$7.5**	**$2.6**	**$10.1**	**$3.1**	**$1.8**	**$15.0**
Urban Arterials and Collectors						
Interstate	$4.8	$2.5	$7.2	$5.1	$0.8	$13.1
Other Freeway and Expressway	$2.2	$1.0	$3.2	$1.8	$0.4	$5.3
Other Principal Arterial	$5.0	$1.7	$6.6	$2.1	$0.9	$9.6
Minor Arterial	$5.8	$1.4	$7.2	$2.2	$0.7	$10.0
Collector	$2.4	$0.5	$2.9	$0.8	$0.4	$4.1
Subtotal	**$20.1**	**$7.0**	**$27.1**	**$11.9**	**$3.2**	**$42.1**
Rural and Urban Local	**$6.4**	**$1.4**	**$7.9**	**$3.8**	**$2.5**	**$14.2**
Total	**$34.0**	**$11.1**	**$45.1**	**$18.8**	**$7.5**	**$71.3**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

on rural arterials collectors under this scenario totals $18.1 billion (17.1 percent), while the rural and urban local roads and streets component totals $20.3 billion (19.2 percent).

Assuming variable rate user financing, the relative share of capital investment devoted to urban arterials and collectors would be lower. The $42.1 billion directed toward urban arterials and collectors under this scenario would represent 59.1 percent of the $71.3 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $15.0 billion (21.0 percent), while the rural and urban local roads and streets component totals $14.2 billion (19.9 percent).

> **Q&A**
>
> **Do the amounts identified for each functional class in *Exhibit 8-16* represent the costs associated with maintaining the conditions and performance of that functional class?**
>
> No. It is important to note that the goal of the Sustain Conditions and Performance scenario is to maintain average conditions and performance on a systemwide basis; the conditions and performance of individual functional classes may vary. Consequently, the dollar amount shown for each functional class does not represent the cost of maintaining the condition or performance of that functional class in isolation.
>
> A supplemental scenario is presented later in this chapter that identifies the costs associated with maintaining the conditions and performance of individual system components.

MinBCR=1.5 Scenario

Exhibit 8-17 identifies the distribution of capital investments by improvement type and functional class for the **MinBCR=1.5 scenario**, in which the investment level is determined as the amount that would support potential investments with a benefit-cost ratio of 1.5 or higher. Assuming fixed rate user financing, the $87.5 billion of capital investment on urban arterials and collectors under the **MinBCR=1.5 scenario** would represent 63.7 percent of the $137.4 billion total public and private average annual capital spending under this scenario. Investment on rural arterials collectors under this scenario totals $23.0 billion (16.7 percent), while the rural and urban local roads and streets component totals $26.9 billion (19.6 percent).

Assuming variable rate user financing, the relative share of capital investment devoted to urban arterials and collectors would be lower. The $60.1 billion directed toward urban arterials and collectors under this scenario would represent 59.0 percent of the $101.8 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $21.3 billion (20.9 percent), while the rural and urban local roads and streets component totals $20.5 billion (20.2 percent).

MinBCR=1.2 Scenario

Exhibit 8-18 identifies the distribution of capital investments by improvement type and functional class for the **MinBCR=1.2 scenario**, in which the investment level is determined as the amount that would support potential investments with a benefit-cost ratio of 1.2 or higher. Assuming fixed rate user financing, the $100.4 billion of capital investment on urban arterials and collectors under the **MinBCR=1.2 scenario** would represent 63.9 percent of the $157.1 billion total public and private average annual capital spending under this scenario. Investment on rural arterials collectors under this scenario totals $26.3 billion (16.8 percent), while the rural and urban local roads and streets component totals $30.4 billion (19.4 percent).

Assuming variable rate user financing, the relative share of capital investment devoted to urban arterials and collectors would be lower. The $69.3 billion directed toward urban arterials and collectors under this scenario would represent 59.1 percent of the $117.2 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $24.6 billion (21.0 percent), while the rural and urban local roads and streets component totals $23.3 billion (19.9 percent).

Exhibit 8-17

MinBCR=1.5 Scenarios: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026

Average Annual National Investment (Billions of 2006 Dollars)

Assuming Fixed Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.2	$0.9	$3.2	$2.3	$0.6	$6.0
Other Principal Arterial	$2.3	$0.7	$3.0	$1.2	$1.1	$5.3
Minor Arterial	$2.2	$0.7	$2.9	$0.4	$0.8	$4.1
Major Collector	$3.3	$1.1	$4.4	$0.4	$0.7	$5.5
Minor Collector	$1.0	$0.4	$1.4	$0.3	$0.2	$2.0
Subtotal	**$11.1**	**$3.7**	**$14.8**	**$4.7**	**$3.5**	**$23.0**
Urban Arterials and Collectors						
Interstate	$8.0	$3.8	$11.7	$18.9	$1.5	$32.2
Other Freeway and Expressway	$3.6	$1.4	$5.0	$7.8	$0.8	$13.5
Other Principal Arterial	$7.1	$2.9	$10.0	$5.9	$1.8	$17.7
Minor Arterial	$7.6	$2.7	$10.3	$5.2	$1.3	$16.8
Collector	$3.4	$1.0	$4.4	$2.1	$0.7	$7.3
Subtotal	**$29.7**	**$11.8**	**$41.5**	**$39.9**	**$6.1**	**$87.5**
Rural and Urban Local	**$12.4**	**$2.3**	**$14.7**	**$7.4**	**$4.8**	**$26.9**
Total	**$53.2**	**$17.9**	**$71.0**	**$51.9**	**$14.4**	**$137.4**

Assuming Variable Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.1	$0.9	$3.1	$2.0	$0.5	$5.5
Other Principal Arterial	$2.3	$0.7	$3.0	$1.1	$0.8	$5.0
Minor Arterial	$2.2	$0.7	$2.9	$0.3	$0.6	$3.9
Major Collector	$3.4	$1.1	$4.4	$0.4	$0.5	$5.4
Minor Collector	$0.7	$0.4	$1.2	$0.2	$0.2	$1.6
Subtotal	**$10.9**	**$3.7**	**$14.6**	**$4.1**	**$2.6**	**$21.3**
Urban Arterials and Collectors						
Interstate	$5.9	$3.8	$9.6	$7.6	$1.1	$18.4
Other Freeway and Expressway	$2.7	$1.4	$4.1	$2.7	$0.6	$7.4
Other Principal Arterial	$6.4	$2.9	$9.4	$3.1	$1.3	$13.8
Minor Arterial	$7.2	$2.7	$9.9	$3.3	$1.0	$14.2
Collector	$3.4	$1.0	$4.4	$1.3	$0.5	$6.2
Subtotal	**$25.6**	**$11.8**	**$37.4**	**$18.1**	**$4.5**	**$60.1**
Rural and Urban Local	**$9.2**	**$2.3**	**$11.5**	**$5.5**	**$3.5**	**$20.5**
Total	**$45.7**	**$17.9**	**$63.5**	**$27.6**	**$10.7**	**$101.8**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Exhibit 8-18

MinBCR=1.2 Scenarios: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026

Average Annual National Investment (Billions of 2006 Dollars)

Assuming Fixed Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.5	$0.9	$3.4	$2.5	$0.7	$6.6
Other Principal Arterial	$2.8	$0.7	$3.5	$1.5	$1.2	$6.2
Minor Arterial	$2.7	$0.7	$3.4	$0.5	$0.9	$4.8
Major Collector	$4.1	$1.1	$5.1	$0.5	$0.8	$6.5
Minor Collector	$1.2	$0.4	$1.6	$0.4	$0.3	$2.2
Subtotal	**$13.3**	**$3.7**	**$17.0**	**$5.3**	**$4.0**	**$26.3**
Urban Arterials and Collectors						
Interstate	$8.6	$3.8	$12.4	$22.1	$1.7	$36.2
Other Freeway and Expressway	$3.9	$1.4	$5.4	$9.7	$0.9	$15.9
Other Principal Arterial	$8.4	$2.9	$11.3	$7.7	$2.1	$21.1
Minor Arterial	$8.4	$2.7	$11.1	$6.0	$1.5	$18.6
Collector	$4.0	$1.0	$5.0	$2.7	$0.8	$8.6
Subtotal	**$33.3**	**$11.8**	**$45.1**	**$48.2**	**$7.0**	**$100.4**
Rural and Urban Local	**$14.2**	**$2.3**	**$16.5**	**$8.4**	**$5.5**	**$30.4**
Total	**$60.8**	**$17.9**	**$78.7**	**$62.0**	**$16.5**	**$157.1**

Assuming Variable Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.4	$0.9	$3.3	$2.2	$0.5	$6.0
Other Principal Arterial	$2.8	$0.7	$3.5	$1.4	$0.9	$5.8
Minor Arterial	$2.8	$0.7	$3.5	$0.5	$0.7	$4.6
Major Collector	$4.2	$1.1	$5.3	$0.5	$0.6	$6.4
Minor Collector	$0.9	$0.4	$1.3	$0.3	$0.2	$1.8
Subtotal	**$13.1**	**$3.7**	**$16.8**	**$4.8**	**$3.0**	**$24.6**
Urban Arterials and Collectors						
Interstate	$6.6	$3.8	$10.4	$9.6	$1.3	$21.3
Other Freeway and Expressway	$3.0	$1.4	$4.5	$3.4	$0.7	$8.5
Other Principal Arterial	$7.6	$2.9	$10.5	$4.3	$1.5	$16.3
Minor Arterial	$7.9	$2.7	$10.6	$4.3	$1.1	$16.0
Collector	$3.9	$1.0	$4.9	$1.7	$0.6	$7.2
Subtotal	**$29.0**	**$11.8**	**$40.8**	**$23.2**	**$5.2**	**$69.3**
Rural and Urban Local	**$10.6**	**$2.3**	**$12.9**	**$6.3**	**$4.1**	**$23.3**
Total	**$52.6**	**$17.9**	**$70.5**	**$34.4**	**$12.3**	**$117.2**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

MinBCR=1.0 Scenario

Exhibit 8-19 and *8-20* identify the distribution of capital investments for the **MinBCR=1.0 scenario**, in which the investment level is determined as the amount that would support potential investments with a benefit-cost ratio of 1.0 or higher assuming fixed rate financing and variable rate financing, respectively. The version of this scenario described in *Exhibit 8-20* which assumes the widespread adoption of variable-rate

Exhibit 8-19

MinBCR=1.0 Scenario Assuming Fixed Rate User Financing: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026 Compared to Actual 2006 Spending, by Functional Class and Improvement Type

Average Annual National Investment (Billions of 2006 Dollars)

	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	$2.7	$0.9	$3.6	$2.6	$0.8	$7.0
Other Principal Arterial	$3.2	$0.7	$3.9	$1.6	$1.4	$6.8
Minor Arterial	$3.3	$0.7	$4.0	$0.6	$1.1	$5.6
Major Collector	$4.9	$1.1	$6.0	$0.6	$0.9	$7.5
Minor Collector	$1.3	$0.4	$1.7	$0.4	$0.3	$2.4
Subtotal	**$15.4**	**$3.7**	**$19.1**	**$5.8**	**$4.5**	**$29.4**
Urban Arterials and Collectors						
Interstate	$9.0	$3.8	$12.7	$24.5	$1.9	$39.2
Other Freeway and Expressway	$4.4	$1.4	$5.8	$11.4	$1.0	$18.2
Other Principal Arterial	$9.4	$2.9	$12.4	$9.5	$2.3	$24.2
Minor Arterial	$9.0	$2.7	$11.7	$7.4	$1.6	$20.7
Collector	$4.4	$1.0	$5.3	$3.0	$0.9	$9.3
Subtotal	**$36.1**	**$11.8**	**$48.0**	**$55.9**	**$7.8**	**$111.6**
Rural and Urban Local	**$15.8**	**$2.3**	**$18.1**	**$9.4**	**$6.1**	**$33.5**
Total	**$67.3**	**$17.9**	**$85.2**	**$71.1**	**$18.3**	**$174.6**

Percent Above Actual 2006 Combined Public and Private Capital Spending

	System Rehabilitation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancement**	**Total**
Rural Arterials and Collectors						
Interstate	5.5%	172.1%	25.0%	171.6%	121.9%	67.0%
Other Principal Arterial	-10.8%	-8.9%	-10.5%	-66.0%	121.9%	-28.6%
Minor Arterial	43.0%	-15.3%	28.1%	-55.2%	121.9%	14.0%
Major Collector	104.8%	30.0%	85.9%	-19.7%	121.9%	71.3%
Minor Collector	121.9%	30.5%	88.8%	121.9%	121.9%	97.5%
Subtotal	**34.7%**	**24.5%**	**32.6%**	**-26.1%**	**121.9%**	**21.0%**
Urban Arterials and Collectors						
Interstate	178.5%	73.7%	136.4%	303.0%	121.9%	217.5%
Other Freeway and Expressway	208.5%	200.4%	206.5%	260.5%	121.9%	230.9%
Other Principal Arterial	181.0%	222.1%	189.8%	80.3%	121.9%	128.5%
Minor Arterial	287.1%	212.9%	266.8%	203.2%	121.9%	225.7%
Collector	212.1%	98.5%	182.4%	208.3%	121.9%	182.5%
Subtotal	**208.3%**	**140.7%**	**188.4%**	**211.2%**	**121.9%**	**193.0%**
Rural and Urban Local	**121.9%**	**4.7%**	**94.1%**	**121.9%**	**121.9%**	**106.0%**
Total	**122.4%**	**76.6%**	**110.9%**	**136.5%**	**121.9%**	**121.9%**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Exhibit 8-20

Maximum Economic Investment Scenario (MinBCR=1.0 Scenario Assuming Variable Rate User Financing): Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026 Compared to Actual 2006 Spending, by Functional Class and Improvement Type

Average Annual National Investment (Billions of 2006 Dollars)

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$2.6	$0.9	$3.5	$2.4	$0.6	$6.5
Other Principal Arterial	$3.2	$0.7	$3.9	$1.5	$1.0	$6.4
Minor Arterial	$3.3	$0.7	$4.0	$0.6	$0.8	$5.4
Major Collector	$5.1	$1.1	$6.2	$0.6	$0.7	$7.5
Minor Collector	$1.0	$0.4	$1.4	$0.3	$0.2	$1.9
Subtotal	**$15.2**	**$3.7**	**$19.0**	**$5.4**	**$3.4**	**$27.7**
Urban Arterials and Collectors						
Interstate	$7.2	$3.8	$10.9	$11.4	$1.5	$23.7
Other Freeway and Expressway	$3.4	$1.4	$4.8	$4.1	$0.7	$9.7
Other Principal Arterial	$8.6	$2.9	$11.6	$5.5	$1.7	$18.8
Minor Arterial	$8.5	$2.7	$11.3	$5.2	$1.2	$17.7
Collector	$4.2	$1.0	$5.2	$2.0	$0.7	$7.9
Subtotal	**$31.9**	**$11.8**	**$43.8**	**$28.2**	**$5.8**	**$77.8**
Rural and Urban Local	**$11.9**	**$2.3**	**$14.2**	**$7.1**	**$4.6**	**$25.8**
Total	**$59.0**	**$17.9**	**$76.9**	**$40.6**	**$13.8**	**$131.3**

Percent Above Actual 2006 Combined Public and Private Capital Spending

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	0.8%	172.1%	20.9%	148.1%	66.9%	54.0%
Other Principal Arterial	-10.5%	-8.9%	-10.3%	-66.8%	66.9%	-32.5%
Minor Arterial	44.1%	-15.3%	29.0%	-57.2%	66.9%	8.7%
Major Collector	114.5%	30.0%	93.2%	-23.9%	66.9%	70.7%
Minor Collector	66.9%	30.5%	53.7%	66.9%	66.9%	57.2%
Subtotal	**33.2%**	**24.5%**	**31.4%**	**-31.5%**	**66.9%**	**14.0%**
Urban Arterials and Collectors						
Interstate	121.9%	73.7%	102.6%	86.7%	66.9%	92.2%
Other Freeway and Expressway	140.7%	200.4%	155.6%	29.9%	66.9%	76.1%
Other Principal Arterial	156.4%	222.1%	170.5%	3.9%	66.9%	77.2%
Minor Arterial	267.2%	212.9%	252.4%	115.6%	66.9%	178.6%
Collector	203.5%	98.5%	176.1%	100.3%	66.9%	139.6%
Subtotal	**172.6%**	**140.7%**	**163.2%**	**57.0%**	**66.9%**	**104.3%**
Rural and Urban Local	**66.9%**	**4.7%**	**52.1%**	**66.9%**	**66.9%**	**58.5%**
Total	**95.1%**	**76.6%**	**90.5%**	**35.2%**	**66.9%**	**66.9%**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

user charges is also described as the **"Maximum Economic Investment"** level, as it reflects conditions under which users would be charged an economically rational price to travel on facilities that would be improved only to the extent that such investment was cost-beneficial.

Exhibits 8-19 and *8-20* both include comparisons between the scenario and the actual distribution of highway capital spending by all levels of government in 2006. In each exhibit, the percentage difference for non-modeled items matches the overall total, as such items were increased proportionally. These include all values shown in the "System Enhancement" column, as well as the rural minor collector and local functional class values in the "System Expansion" and "System Rehabilitation: Highway" columns.

The $111.6 billion of capital investment on urban arterials and collectors under the **MinBCR=1.0 scenario** assuming **fixed rate user financing** shown in *Exhibit 8-19* would represent 64.0 percent of the $157.1 billion total public and private average annual capital spending under this scenario. Investment on rural arterials collectors under this scenario totals $29.4 billion (16.8 percent), while the rural and urban local roads and streets component totals $33.5 billion (19.2 percent). The scenario reflects a 21.0 percent increase in average annual investment on rural arterials and collectors relative to the 2006 year baseline, compared to a 193 percent increase for capital spending on urban arterials and collectors. The largest increases under this version of the scenario would be concentrated in urban system expansion.

Assuming **variable rate user financing** as in the **Maximum Economic Investment (MinBCR=1.0) scenario** shown in *Exhibit 8-20*, the relative share of capital investment devoted to urban arterials and collectors would be lower. The $77.8 billion directed toward urban arterials and collectors under this scenario would represent 59.3 percent of the $131.3 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $27.7 billion (21.1 percent), while the rural and urban local roads and streets component totals $25.8 billion (19.6 percent). The scenario reflects a 14.0 percent increase in average annual investment on rural arterials and collectors relative to the 2006 year baseline, compared to a 104.3 percent increase for capital spending on urban arterials and collectors. The largest increases under this version of the scenario would be concentrated on highway system rehabilitation in urban areas, as the widespread adoption of strategies such as congestion pricing would eliminate the need for capacity expansion in some locations. However, urban system expansion would still increase significantly under this scenario.

Investment Scenario Impacts

Exhibit 8-21 summarizes the potential impacts of the 20-year Interstate capital investment scenarios defined in *Exhibits 8-11* and *8-12* on selected measures of system conditions and performance. The **Sustain Conditions and Performance scenario** would by definition be associated with a 0.0 percent change in adjusted average user costs and the bridge investment backlog, as the scenario is designed to represent a level of investment that could allow the 2026 values for these indicators to match their base year 2006 values. For the version of this scenario that **assumes fixed rate user financing**, average delay per VMT is projected to increase by 3.6 percent, while average pavement roughness (as measured by IRI as defined in Chapter 3) would decline by 1.0 percent. This suggests a tradeoff between improved physical conditions and a worsening of operational performance. The opposite is true for the version of this scenario **assuming variable rate user financing**, under which average delay per VMT is projected to decrease by 3.7 percent while average IRI increases by 8.4 percent. This suggests that the operational performance improvements associated with the widespread adoption of congestion pricing would be sufficient to allow a significant reduction in capital spending while still having the same net impact on the costs experienced by highway users.

Relative to the scenario focusing on sustaining current conditions and performance, those scenarios with higher average annual levels of investment would be expected to result in overall improvements to the system, as measured by their impacts on adjusted average user costs and other performance indicators. As noted earlier, five of the six scenarios are associated with annual HERS and NBIAS spending growth rates

Exhibit 8-21

Projected Changes in 2026 System Performance Indicators Compared With 2006 for Selected Systemwide Highway Capital Investment Scenarios

Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)	Percent Change in: Adjusted Average User Costs [1]	Average Delay Per VMT [2]	Average IRI [3]	Bridge Investment Backlog [4]
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$78.7	2.1%	11.1%	17.1%	12.8%
Sustain Conditions and Performance scenario	$105.6	**0.0%**	3.6%	-1.0%	**0.0%**
Invest up to MinBCR=1.5 scenario	$137.4	-1.4%	-2.7%	-11.2%	-100.0%
Invest up to MinBCR=1.2 scenario	$157.1	-2.3%	-6.9%	-18.1%	-100.0%
Invest up to MinBCR=1.0 scenario	$174.6	-2.9%	-10.2%	-23.1%	-100.0%
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$78.7	-0.6%	-5.3%	1.8%	12.8%
Sustain Conditions and Performance scenario	$71.3	**0.0%**	-3.7%	8.4%	**0.0%**
Invest up to MinBCR=1.5 scenario	$101.8	-1.4%	-7.7%	-6.7%	-100.0%
Invest up to MinBCR=1.2 scenario	$117.2	-2.1%	-10.3%	-14.0%	-100.0%
Maximum Economic Investment scenario (MinBCR=1.0)	$131.3	-2.7%	-12.3%	-19.3%	-100.0%

[1] *Values shown correspond to amounts in Exhibit 7-5 for types of roads modeled in HERS.*

[2] *Values shown correspond to amounts in Exhibit 7-8 for types of roads modeled in HERS.*

[3] *Values shown correspond to amounts in Exhibit 7-12 for types of roads modeled in HERS.*

[4] *Values shown correspond to amounts in Exhibit 7-21.*

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

that are identified in *Exhibits 8-11* and *8-12*. Chapter 7 includes a series of exhibits that show the potential impacts on investments at these levels on a variety of other measures of system conditions and performance.

Comparison of Scenario Investment Levels With Base Year Spending

Exhibit 8-22 compares the combined public and private capital investment levels associated with each of the selected scenarios with actual capital spending in 2006. By definition, the **Sustain Current Spending scenario** matches base year spending in constant dollar terms.

Among the **versions of the scenarios assuming fixed rate user financing**, the difference in average annual investment levels relative to the 2006 baseline ranges from 34.2 percent for the **Sustain Conditions and Performance scenario** up to 121.9 percent for the **MinBCR=1.0 scenario**. *Exhibit 8-22* also identifies the annual increase in combined public and private capital investment that would be sufficient to produce the average annual investment levels identified for each scenario. A constant dollar spending growth rate of 2.72 percent would be sufficient to support the **Sustain Conditions and Performance scenario**; the equivalent growth rate associated with the **MinBCR=1.0 scenario** would be 7.10 percent.

Among the **versions of the scenarios assuming variable rate user financing**, the average annual investment level for the **Sustain Conditions and Performance scenario** is 9.3 percent lower than actual capital spending in 2006; *Exhibit 8-22* indicates that spending could decline by 0.94 percent annually in constant dollar terms and still generate sufficient funding to support this scenario. The average annual investment level for the **Maximum Economic Investment scenario** exceeds base year 2006 highway capital spending by 66.9 percent. Achieving this average annual investment level could be accomplished by increasing combined public and private capital spending by 4.66 percent per year.

Exhibit 8-22 also includes the estimated annual revenues that might be generated from the widespread adoption of congestion pricing, as identified in *Exhibit 7-4*. (See the discussion in Chapter 7 for additional details.) Based on the assumptions underlying the analyses presented in these scenarios, the additional revenues generated from congestion charges on the Interstate system would be more than adequate to support an increase in capital spending up to the level of the **MinBCR=1.2 scenario** if all of these revenues were used for this purpose, but would not be sufficient to support investment at the **Maximum Economic Investment** level.

Exhibit 8-22

Comparison of Selected Systemwide Highway Capital Investment Scenarios for 2007 to 2026 With Base Year 2006 Capital Spending

Scenario Name and Description	Average Annual Investment (Billions of 2006 Dollars)	Difference Relative to 2006 Highway Capital Spending (Billions of 2006 Dollars)	Difference Relative to 2006 Highway Capital Spending: Percent	Annual Percent Increase to Support Scenario Investment [1]	Annual Revenues Generated From Variable Rate User Charges [2]
Scenarios Assuming Fixed Rate User Financing					
Sustain Current Spending scenario	$78.7	$0.0	0.0%	0.00%	$0.0
Sustain Conditions and Performance scenario	$105.6	$26.9	34.2%	2.72%	$0.0
Invest up to MinBCR=1.5 scenario	$137.4	$58.7	74.6%	5.05%	$0.0
Invest up to MinBCR=1.2 scenario	$157.1	$78.5	99.7%	6.21%	$0.0
Invest up to MinBCR=1.0 scenario	$174.6	$95.9	121.9%	7.10%	$0.0
Scenarios Assuming Variable Rate User Financing					
Sustain Current Spending scenario	$78.7	$0.0	0.0%	0.00%	$47.0
Sustain Conditions and Performance scenario	$71.3	-$7.3	-9.3%	-0.94%	$49.1
Invest up to MinBCR=1.5 scenario	$101.8	$23.2	29.5%	2.40%	$44.1
Invest up to MinBCR=1.2 scenario	$117.2	$38.5	48.9%	3.65%	$40.7
Maximum Economic Investment scenario (MinBCR=1.0)	$131.3	$52.6	66.9%	4.66%	$38.1

[1] This percentage represents the annual percent changes relative to 2006 that would be required to achieve the average annual funding level specified for the scenario.

[2] Amounts shown represent the revenues from variable rate user charges identified in Exhibit 7-4 as computed in the HERS run used to develop the scenario.

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Supplemental Scenarios

As noted earlier, the five primary systemwide scenarios presented above are each associated with a single HERS run which is linked to a minimum benefit-cost ratio. While it is desirable from an economic perspective for investment decisions among competing potential projects to be driven primarily by an evaluation of their relative benefits and costs, it is also appropriate to take other considerations into account. This edition of the C&P Report introduces two supplemental scenarios that are tied to systemwide performance targets that cannot be analyzed with a single HERS or NBIAS run; the **Sustain Conditions and Performance of System Components** scenario and the **Sustain Conditions and Improve Performance scenario** each represents a compilation of several HERS and NBIAS runs for different individual functional classes and performance indicators.

Sustain Conditions and Performance of System Components Scenario

The goal of the **Sustain Conditions and Performance scenario** presented earlier in this section is to maintain a systemwide average measure of conditions and performance (adjusted average user costs) for the lowest cost possible. The conditions and performance of individual functional systems are allowed to vary under this scenario, and tend to improve for higher-ordered functional systems with high traffic volumes, and deteriorate for lower-ordered systems.

In contrast, the **Sustain Conditions and Performance of System Components scenario** is designed to maintain specific indicators of the conditions and performance (average IRI, average delay, and the economic bridge investment backlog) for individual functional systems at base year levels, to the extent that it would be cost-beneficial to do so. This represents a more aggressive performance target than the **Sustain Conditions and Performance scenario which** translates into higher costs.

Q&A

Why are the costs associated with the Sustain Conditions and Performance of System Components scenario higher than those associated with the Sustain Conditions and Performance scenario?

The goal of the **Sustain Conditions and Performance** scenario is to maintain adjusted average highway user costs and the economic backlog of bridge investments at their base year levels on a systemwide basis. This scenario would allow the conditions and performance of some functional systems to decline, as long as other functional systems improved sufficiently to bring the 2026 average back up to the 2006 baseline. The scenario would also allow physical conditions to deteriorate if this was offset by improvements to operational performance, or vice versa.

The **Sustain Current Conditions and Performance of System Components** scenario has a more aggressive goal of sustaining each functional class individually at base year levels, rather than the overall system. As additional constraints are added to a scenario goal, the level of investment required to attain that goal will tend to rise.

While the NBIAS performance indicator used in both of these scenarios (economic backlog of bridge investments) is the same, the HERS-derived component of the Sustain Current Conditions and Performance of System Components scenario targets average IRI and average delay per VMT rather than adjusted average user costs. Maintaining both physical conditions and operational performance individually (rather than maintaining a composite index of both) represents an additional constraint, which adds costs to the mathematical solution that would achieve the scenario goal.

The average annual investments level for the version of the **Sustain Conditions and Performance of System Components scenario** assuming fixed rate user financing is $119.5 billion, which is 51.9 percent higher than actual highway capital spending in 2006. Achieving this average annual investment level could be accomplished by increasing combined public and private capital spending by 3.83 percent per year above the 2006 level of $78.7 billion. The comparable average annual figure assuming the widespread adoption of variable rate user charges (i.e., congestion pricing) is $83.4 billion in constant 2006 dollars, which is 6.0 percent higher than 2006 highway capital spending. An annual spending increase of 0.55 percent in constant dollar terms would be sufficient to support the variable rate user financing version of this scenario.

Exhibit 8-23 identifies the distribution of capital investments by improvement type and functional class for both the fixed rate user financing and variable rate user financing versions of the **Sustain Conditions and Performance of System Components scenario**. Assuming fixed rate user financing, the $74.0 billion of capital investment on urban arterials and collectors under this scenario would represent 61.9 percent of the $119.5 billion total public and private average annual capital spending under this scenario. Investment on rural arterials collectors under this scenario totals $22.4 billion (18.8 percent), while the rural and urban local roads and streets component totals $23.1 billion (19.3 percent).

Exhibit 8-23

Sustain Condition and Performance of System Components Scenarios: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026

Average Annual National Investment (Billions of 2006 Dollars)

Assuming Fixed Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$1.1	$0.6	$1.8	$2.1	$0.5	$4.4
Other Principal Arterial	$1.4	$0.5	$1.9	$1.3	$0.9	$4.1
Minor Arterial	$3.3	$0.4	$3.7	$0.6	$0.7	$5.1
Major Collector	$4.9	$0.9	$5.8	$0.6	$0.6	$7.0
Minor Collector	$0.9	$0.4	$1.2	$0.3	$0.2	$1.7
Subtotal	**$11.6**	**$2.9**	**$14.4**	**$4.9**	**$3.1**	**$22.4**
Urban Arterials and Collectors						
Interstate	$5.9	$2.2	$8.1	$12.1	$1.3	$21.5
Other Freeway and Expressway	$2.6	$0.8	$3.4	$5.5	$0.7	$9.6
Other Principal Arterial	$5.2	$1.5	$6.6	$9.5	$1.6	$17.7
Minor Arterial	$6.6	$1.4	$8.0	$7.4	$1.1	$16.5
Collector	$4.4	$0.6	$5.0	$3.0	$0.6	$8.7
Subtotal	**$24.6**	**$6.5**	**$31.2**	**$37.5**	**$5.3**	**$74.0**
Rural and Urban Local	**$10.8**	**$1.7**	**$12.5**	**$6.4**	**$4.2**	**$23.1**
Total	**$47.0**	**$11.1**	**$58.1**	**$48.9**	**$12.5**	**$119.5**

Assuming Variable Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$1.1	$0.6	$1.8	$2.1	$0.4	$4.3
Other Principal Arterial	$1.4	$0.5	$1.9	$1.3	$0.7	$3.9
Minor Arterial	$3.3	$0.4	$3.8	$0.6	$0.5	$4.9
Major Collector	$5.1	$0.9	$6.0	$0.6	$0.4	$7.0
Minor Collector	$0.6	$0.4	$1.0	$0.2	$0.1	$1.3
Subtotal	**$11.7**	**$2.9**	**$14.5**	**$4.7**	**$2.1**	**$21.4**
Urban Arterials and Collectors						
Interstate	$4.8	$2.2	$6.9	$0.0	$0.9	$7.9
Other Freeway and Expressway	$2.2	$0.8	$3.1	$0.0	$0.5	$3.5
Other Principal Arterial	$4.9	$1.5	$6.3	$5.5	$1.1	$12.9
Minor Arterial	$6.3	$1.4	$7.7	$5.2	$0.8	$13.7
Collector	$4.2	$0.6	$4.9	$2.0	$0.4	$7.3
Subtotal	**$22.4**	**$6.5**	**$28.9**	**$12.7**	**$3.7**	**$45.4**
Rural and Urban Local	**$7.5**	**$1.7**	**$9.2**	**$4.5**	**$2.9**	**$16.6**
Total	**$41.6**	**$11.1**	**$52.7**	**$21.9**	**$8.7**	**$83.4**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Assuming variable rate user financing, the relative share of capital investment devoted to urban arterials and collectors would be lower. This is because congestion pricing, by inducing some traffic to leave peak congested roads, reduces the need for new capacity investment in urban areas. The $45.4 billion directed toward urban arterials and collectors under this scenario would represent 54.4 percent of the $83.4 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $21.4 billion (25.6 percent), while the rural and urban local roads and streets component totals $16.6 billion (19.9 percent).

Sustain Conditions and Improve Performance Scenario

The **Sustain Conditions and Improve Performance scenario** is designed to maintain specific indicators of the physical conditions of highways (average IRI) and bridges (economic bridge investment backlog) for each individual functional system and to improve the operational performance (measured by average user delay) of the system where it is cost-beneficial to do so. This scenario represents a combination of parts of two of the scenarios presented earlier. As noted earlier, the system rehabilitation expenditures reflected in the scenario are drawn from the **Sustain Conditions and Performance scenario**, while the system expansion expenditures are drawn from the **MinBCR=1.0 scenario**. The impact of this scenario on average delay per VMT should be similar to that projected for the **MinBCR=1.0** scenario in *Exhibit 8-21*.

The average annual investments level for the version of the **Sustain Conditions and Improve Performance scenario** assuming fixed rate user financing is $143.5 billion, which is 84.7 percent higher than actual highway capital spending in 2006. Achieving this average annual investment level could be accomplished by increasing combined public and private capital spending by 5.54 percent per year above the 2006 level of $78.7 billion. The comparable average annual figure assuming the widespread adoption of variable rate user charges (i.e., congestion pricing) is $104.9 billion in constant 2006 dollars, which is 33.4 percent higher than 2006 highway capital spending. An annual spending increase of 2.67 percent in constant dollar terms would be sufficient to support the variable rate user financing version of this scenario.

Exhibit 8-24 identifies the distribution of capital investments by improvement type and functional class for both the fixed rate user financing and variable rate user financing versions of the **Sustain Conditions and Improve Performance scenario**. Assuming fixed rate user financing, the $93.5 billion of capital investment on urban arterials and collectors under this scenario would represent 64.4 percent of the $145.3 billion total public and private average annual capital spending under this scenario. Investment on rural arterials collectors under this scenario totals $24.1 billion (16.6 percent), while the rural and urban local roads and streets component totals $27.7 billion (19.1 percent).

Assuming variable rate user financing, the relative share of capital investment devoted to urban arterials and collectors would be lower. This is because congestion pricing, by inducing some traffic to leave peak congested roads, reduces the need for new capacity investment in urban areas. The $61.8 billion directed toward urban arterials and collectors under this scenario would represent 58.9 percent of the $104.9 billion average annual capital spending under this scenario, stated in 2006 dollars. Investment on rural arterials and collectors under this scenario totals $22.7 billion (21.6 percent), while the rural and urban local roads and streets component totals $20.5 billion (19.5 percent).

Exhibit 8-24

Sustain Conditions and Improve Performance Scenarios: Distribution of Average Annual Combined Public and Private Capital Spending for 2007 to 2026

Average Annual National Investment (Billions of 2006 Dollars)

Assuming Fixed Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$1.1	$0.6	$1.8	$2.6	$0.7	$5.0
Other Principal Arterial	$1.4	$0.5	$1.9	$1.6	$1.1	$4.6
Minor Arterial	$3.3	$0.4	$3.7	$0.6	$0.9	$5.2
Major Collector	$4.9	$0.9	$5.8	$0.6	$0.8	$7.1
Minor Collector	$1.1	$0.4	$1.4	$0.3	$0.3	$2.0
Subtotal	**$11.8**	**$2.9**	**$14.6**	**$5.7**	**$3.7**	**$24.1**
Urban Arterials and Collectors						
Interstate	$5.9	$2.2	$8.1	$24.5	$1.6	$34.2
Other Freeway and Expressway	$2.6	$0.8	$3.4	$11.4	$0.8	$15.7
Other Principal Arterial	$5.2	$1.5	$6.6	$9.5	$1.9	$18.1
Minor Arterial	$6.6	$1.4	$8.0	$7.4	$1.4	$16.8
Collector	$4.4	$0.6	$5.0	$3.0	$0.8	$8.8
Subtotal	**$24.6**	**$6.5**	**$31.2**	**$55.9**	**$6.5**	**$93.5**
Rural and Urban Local	**$13.1**	**$1.7**	**$14.8**	**$7.8**	**$5.1**	**$27.7**
Total	**$49.5**	**$11.1**	**$60.6**	**$69.4**	**$15.2**	**$145.3**

Assuming Variable Rate User Financing

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials and Collectors						
Interstate	$1.1	$0.6	$1.8	$2.4	$0.5	$4.7
Other Principal Arterial	$1.4	$0.5	$1.9	$1.5	$0.8	$4.3
Minor Arterial	$3.3	$0.4	$3.8	$0.6	$0.6	$5.0
Major Collector	$5.1	$0.9	$6.0	$0.6	$0.6	$7.1
Minor Collector	$0.8	$0.4	$1.1	$0.2	$0.2	$1.6
Subtotal	**$11.8**	**$2.9**	**$14.7**	**$5.3**	**$2.7**	**$22.7**
Urban Arterials and Collectors						
Interstate	$4.8	$2.2	$6.9	$11.4	$1.2	$19.5
Other Freeway and Expressway	$2.2	$0.8	$3.1	$4.1	$0.6	$7.8
Other Principal Arterial	$4.9	$1.5	$6.3	$5.5	$1.4	$13.2
Minor Arterial	$6.3	$1.4	$7.7	$5.2	$1.0	$13.9
Collector	$4.2	$0.6	$4.9	$2.0	$0.6	$7.4
Subtotal	**$22.4**	**$6.5**	**$28.9**	**$28.2**	**$4.7**	**$61.8**
Rural and Urban Local	**$9.5**	**$1.7**	**$11.2**	**$5.6**	**$3.7**	**$20.5**
Total	**$43.7**	**$11.1**	**$54.8**	**$39.2**	**$11.0**	**$104.9**

Sources: Highway Economic Requirements System and National Bridge Investment Analysis System.

Selected Transit Capital Investment Scenarios

While Chapter 7 considered the impacts of varying levels of capital investment on various measures of conditions and performance, this section will provide a more in-depth analysis of specific investment scenarios. In addition to consideration of the "Maintain" and "Improve" scenarios for transit asset conditions and service performance as considered in reports for prior years, the following analysis also considers the level of transit investment required to serve ridership that could be diverted from automobile usage due to the influence of congestion pricing (as described in the highway section of this chapter). This section also considers the impacts that variations in the pass-fail threshold for the Transit Economic Requirements Model's (TERM's) benefit-cost test have upon investment forecasts. To help place each of these scenarios in context, this section begins with an assessment of the expected ways in which maintaining current transit capital expenditure levels will impact future transit asset conditions and service performance. Each of the analyses considered in this chapter are summarized in *Exhibit 8-25*.

Exhibit 8-25

Transit Capital Investment Scenarios

Scenario Name	Description / Analysis
Maintain Current Funding	Examines the expected impact on conditions and performance if current (2006) transit investment levels for rehabilitation, replacement and expansion are maintained over the next 20-year period.
TERM Scenarios From Prior Year C&P Reports	Estimates the level of investment required to: Maintain transit asset physical conditions and service performance at current levels. Improve transit asset physical conditions and service performance to specific condition and performance targets.
Increase Passing Benefit-Cost Ratio to 1.2	Examines how transit investment needs are impacted by increasing the passing benefit-cost ratio from 1.0 to 1.2.
Congestion Pricing	Examines the level of transit expansion investment required to serve highway users diverted to transit as a result of congestion pricing (see Chapter 7 "Potential Highway Capital Investment Impacts" section) while maintaining current transit performance.

Maintain Current Funding Scenario

In 2006 transit agencies spent a total of $12.8 billion on capital projects. Of this amount, $9.3 billion was dedicated to the rehabilitation and replacement of existing assets while the remaining $3.5 billion was dedicated to either expanding existing services to support ongoing ridership growth (roughly $2.4 billion) or to investments that added new services or otherwise improved transit performance and attracted new ridership ($1.1 billion); these data are presented in *Exhibit 8-26*. This **Maintain**

Exhibit 8-26

2006 Annual Transit Investment Summary by Type of Improvement (Billions of 2006 Dollars)

Type of Improvement	Maintain Current Funding
Replacement and Rehabilitation	$9.3
Asset Expansion	$2.4
Performance Improvements	$1.1
Total	**$12.8**

Source: Transit Economic Requirements Model and FTA staff estimates.

Current Funding scenario considers the expected impact on the long-term physical conditions and service performance of the Nation's transit infrastructure if these 2006 expenditure levels are maintained through 2026 in constant dollar terms. This analysis builds off of analysis first introduced in Chapter 7. Similar to the discussion in Chapter 7, the analysis first considers the impacts of rehabilitation and replacement investments separately from those of asset expansion and performance improving investments.

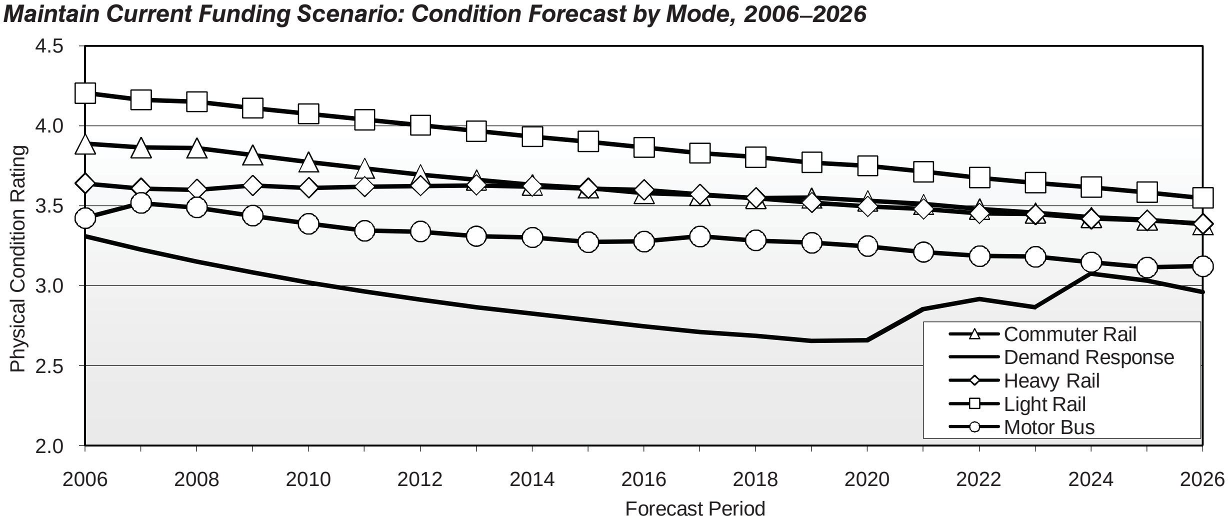
Rehabilitation and Replacement

As noted above, the Nation's transit operators spent an estimated $9.3 billion in 2006 on the rehabilitation and replacement of existing transit infrastructure. Based on current TERM analysis, this level of reinvestment is less than the level required to meet the anticipated reinvestment needs of the Nation's existing transit infrastructure, and, if maintained over the forecasted 20-year period, would result in a steady decline in overall asset conditions.

For example, *Exhibit 8-27* presents the forecasted change in average condition level, by mode, assuming that the level of investment funding is maintained at 2006 levels through the year 2026, and that each investment is prioritized based on TERM's estimated benefit-cost ratio for that investment. With the exception of demand response, all modes are projected to undergo continuous decay throughout this period as the rate of asset decay exceeds the rate of reinvestment. Different types of assets decay at different rates, based on numerous factors. For instance, heavy rail systems have significant levels of investment in complex assets with expected lives of up to 100 years or more (e.g., tunnels and bridges). In contrast, demand response systems are dominated by investments in vehicles with an expected life of 4 to 5 years. From 2006 to 2019, demand response investments tend to have low benefit-cost ratios relative to other modes; thus, TERM tends to invest in these other modes leading to a decline in demand response investments and conditions. After 2019, the demand response investments tend to have a higher benefit-cost ratio leading to a higher rate of investment relative to other modes. The improvement in demand response conditions over the period 2019 to 2024 reflects this heightened investment. In contrast, the average condition rating of the heavy rail mode declined only from 3.64 to 3.39, in part because it contains a large proportion of assets with very long life expectancies (e.g., tunnels and bridges) as compared to other asset types. When measured across all modes, average condition ratings are estimated to fall from a high of 3.72 in 2006 to 3.36 by 2026 if current reinvestment is maintained at an annual rate of $9.3 billion.

Exhibit 8-27

Maintain Current Funding Scenario: Condition Forecast by Mode, 2006–2026

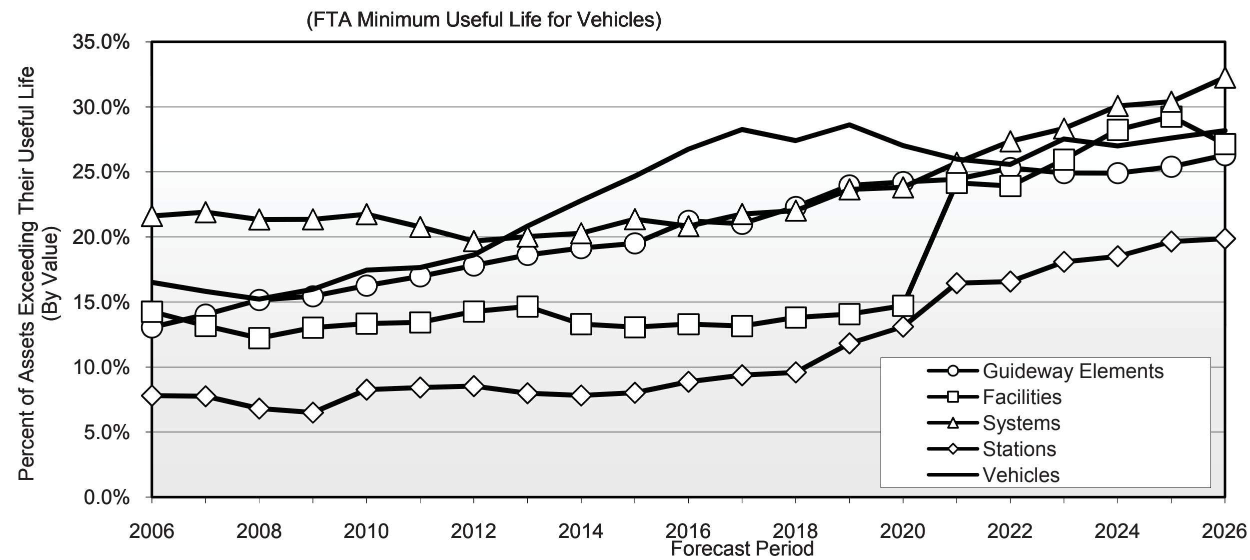


Source: Transit Economic Requirements Model.

In contrast to *Exhibit 8-27*, which presented the projected decline in asset conditions if current reinvestment expenditures are maintained through 2026, *Exhibit 8-28* presents the projected increase in the proportion of assets exceeding their useful life, by asset category, over this same time period. (Note that the proportion of assets exceeding their useful life is measured based on asset replacement values, not asset quantities). Given a level of asset reinvestment less than is required to address current reinvestment needs, the projection shows a steady increase in the proportion of assets exceeding their useful life over the 20-year projection. As in the prior exhibit, throughout this time period, systems start and end with the highest proportion of assets that exceed their useful life (using the Federal Transit Administration's useful life minimums), with the estimated proportion of over-age systems increasing from 21.6 percent in 2006 to 32.3 percent in 2026. In contrast, stations and facilities start the 20-year period with among the lowest proportion of over-age assets (roughly 7.8 and 14.3 percent, respectively) but conclude the period with roughly 19.9 and 27.1 percent or more of these assets, respectively, projected to be over-age. As with the conditions projections provided above, differences in the rate of change in the proportion of over-age assets by type reflect differences in TERM's internal prioritization of these reinvestments (based on TERM's assigned benefit-cost ratios).

Exhibit 8-28

Maintain Current Funding Scenario: Age Forecast by Asset Category, 2006–2026



Source: Transit Economic Requirements Model.

Finally, *Exhibit 8-29* presents the average asset condition of all transit assets as compared to the percent of those assets that are in operation past their useful life, again assuming that rehabilitation and replacement expenditures are maintained at current levels. It is estimated that, while condition ratings decline at an average annual rate of 0.5 percent, the proportion of assets in operation in excess of their useful life continues to increase at an average rate of 3.1 percent each year from 2006 through 2026, or from 14.6 percent in 2006 to 26.9 percent by 2026.

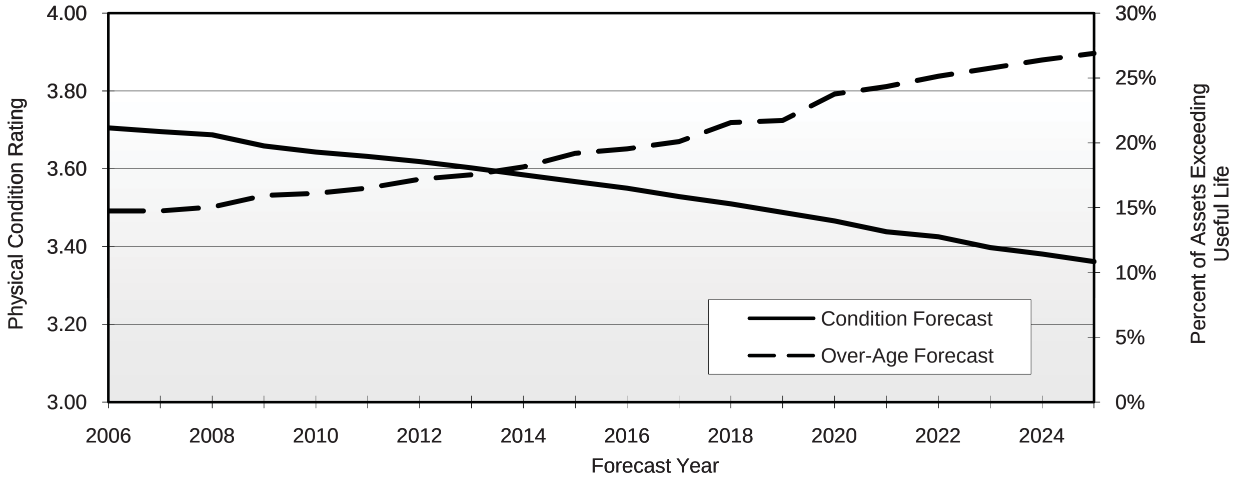
Expansion and Performance Improvement Investments

In addition to the $9.3 billion spent on transit asset rehabilitation and replacement in 2006, transit agencies spent an additional $3.5 billion on expansions to existing services to support ongoing ridership growth (roughly $2.4 billion) and on investments in new services or transit capacity to improve transit performance and attract new ridership ($1.1 billion). This section presents analysis considering how the continuation of 2006 levels of investment in expansion and performance improvement projects can be expected to impact transit service performance over the next 20 years. Specifically, the analysis compares the projected growth in

Exhibit 8-29

Maintain Current Funding Scenario: Conditions Versus Over-Age Forecast, 2006–2026

(All Transit Assets; FTA Minimum Useful Life for Vehicles)



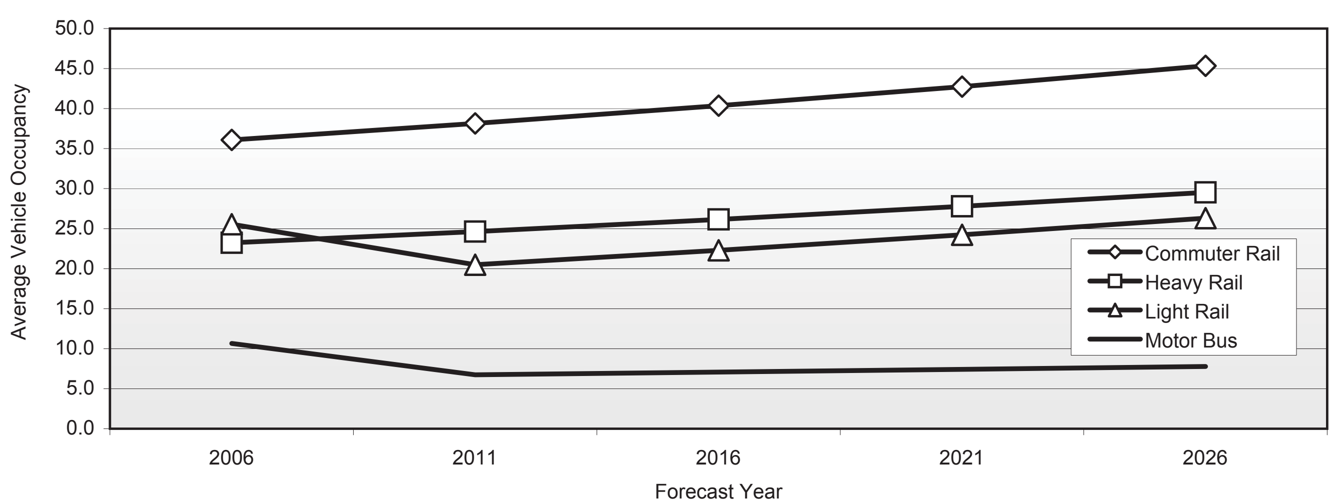
Source: Transit Economic Requirements Model.

transit capacity anticipated at current investment rates with projected growth in total ridership to assess the long-term impact on transit capacity utilization (i.e., average number of riders per vehicle). Once again, this analysis builds off of that already presented in Chapter 7.

Exhibit 8-30 presents the projected average vehicle occupancy by mode over the period from 2006 through 2026. These projections assume that (1) transit agencies continue to invest roughly $3.5 billion per year on expansion and capacity-related improvements and (2) that ridership will grow at rates consistent with those projected by the Nation's metropolitan planning organizations (MPOs). Despite some reductions in capacity utilization for light rail during the early years of the projection, capacity utilization for all rail modes is projected to increase over the forecast period if expansion investments maintain their current pace. Thus, recent spending levels do not appear sufficient to maintain performance in aggregate across the rail transit modes, potentially compounding existing overcrowding problems for some high demand operators. In contrast, capacity utilization for motorbus is projected to decline from 10.7 to 7.8 passengers per vehicle

Exhibit 8-30

Maintain Current Funding Scenario: Capacity Utilization by Mode Forecast, 2006 –2026



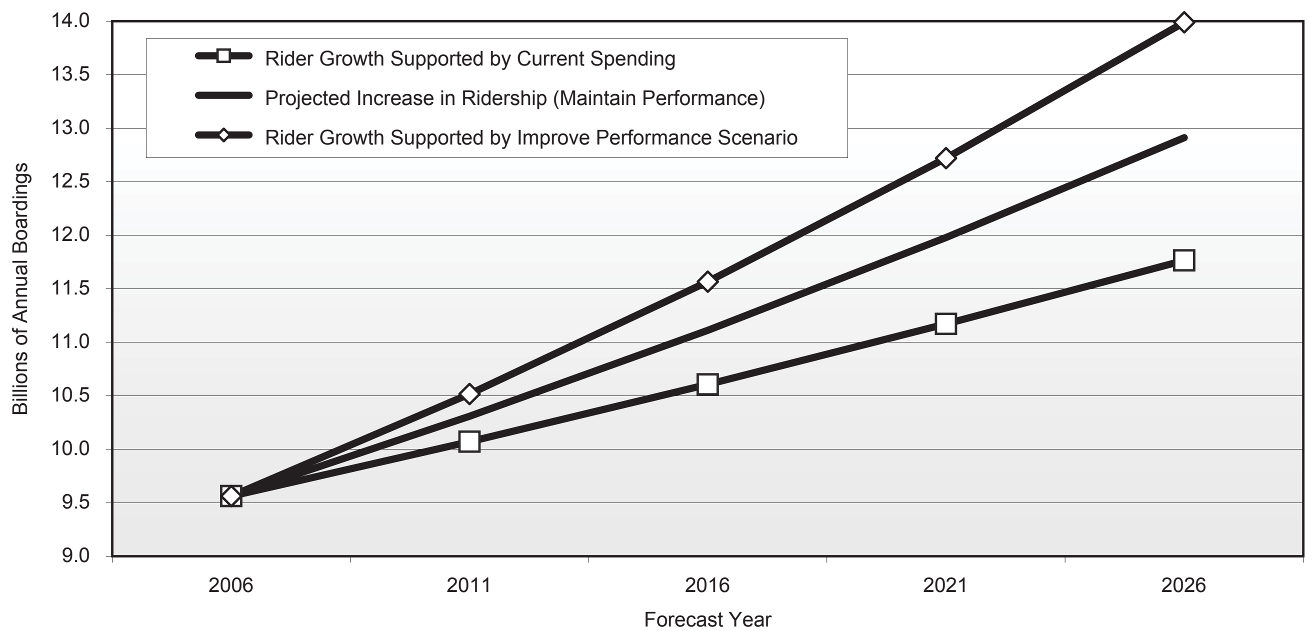
Source: Transit Economic Requirements Model.

over this period. This projected decline for bus and the increase for rail systems results from the generally higher benefit-cost ratios generated by TERM for bus versus rail investments; hence, bus investments generally receive a higher investment priority in this budget constrained analysis. By comparison, light rail incurs a 3.0 percent increase in occupancy, while commuter rail and heavy rail average vehicle occupancy both increase by more than 25 percent between 2006 and 2026.

Exhibit 8-31 presents the total number of transit riders that are supported by differing levels of investment, while maintaining performance (i.e., capacity utilization) at current levels. This exhibit clearly indicates that, while continuation of the 2006 level of investment could support a significant number of new riders—more than 2 billion in additional annual boardings—this level of investment is not sufficient to support the number of new riders projected by the Nation's MPOs (almost 3.5 billion additional annual riders). Finally, investment consistent with TERM's **Improve Performance scenario** (as described in the next section) could support an additional 5.5 billion annual boardings over 2006 levels.

Exhibit 8-31

Projected Versus Currently Supported Ridership Growth



Source: Transit Economic Requirements Model.

Maintain and Improve Conditions and Performance Scenarios

Since 1997, the C&P report has included a consistent set of TERM investment scenarios that assess the level of investment required to attain specific asset conditions and performance targets. The levels of investment required to attain these targets have also been combined to construct a range of investment scenarios. The specific investment targets include the following:

- **Maintain Conditions scenario**

  Transit assets are replaced and rehabilitated over the 20-year period such that the overall average condition at the beginning of the period is identical to that at the end of the forecast period.

- **Maintain Performance scenario**

  New transit vehicles and infrastructure investments are undertaken to accommodate projected increases in transit ridership so that the vehicle utilization rate existing at the beginning of the period remains the same at the end of the period. Ridership growth estimates are obtained from MPOs.

- **Improve Conditions scenario**

  Transit asset rehabilitation and replacement is accelerated to improve the average condition of all transit assets to a "Good" level at the end of the 20-year period (2026 for purposes of this report). If an average condition of good can be reached only by replacing assets that are still in operationally acceptable condition, then this scenario will target a lower condition level; this will be equal to the highest condition that can be achieved without replacing assets that are still in operationally acceptable condition.

> Q&A
>
> **Is the average asset condition to Maintain Conditions reached after 20 years always the same as in the base year? Does the average asset condition to Improve Conditions absolutely reach an average condition rating of 4 at the end of the 20-year period?**
>
> The Maintain Conditions scenario tries to match the average asset condition in the projected year (2026) with the average asset condition in the base year (2006). In this report, the investment needs to Maintain Conditions assume that the average condition rating will be 3.55 in 2026, compared with an average condition rating of 3.71 in 2006. To reach an average condition rating of 3.82 in 2026 would require TERM to replace some asset types at an unreasonably high condition replacement threshold (i.e., while those assets were still in an operationally acceptable condition). The Improve Conditions scenario assumes that an average asset condition rating of 3.67 will be reached in 2026. To reach a condition rating of 4.0 in 2026 would again require TERM to replace many asset types while still in an operationally acceptable condition even more (see Appendix C).

- **Improve Performance scenario**

  The performance of the Nation's transit system is improved overall as additional investments in bus rapid transit (BRT), light rail, or heavy rail are introduced in urbanized areas with the most crowded vehicles and the slowest system speeds in order to reduce vehicle utilization rates (and crowding) and increase average transit operating speeds.

Scenario Investment Needs: Benefit-Cost Ratio of 1.0

Exhibit 8-32 presents estimates of the total annual capital investment required to attain combinations of the four investment scenarios presented above. Moreover, these needs are segmented by improvement type, including needs for rehabilitation and replacement (to maintain conditions), for asset expansion (to maintain performance), and those for performance improvement. The analysis presented in this section only includes investments with benefit-cost ratios of 1.0 or higher.

Maintain Conditions

Replacement and rehabilitation needs to maintain asset conditions through 2026 are estimated to be $10.7 billion annually. This includes $6.0 billion for rail and $4.5 billion for nonrail modes, respectively. The $4.7 billion investment requirement for nonrail includes $0.2 billion for Special Services (Section 5310) operators.

Maintain Performance

Over the period from 2006 through 2026, the Nation's MPOs project an estimated 1.5 percent (weighted) average annual increase in boardings. The annual investment in asset expansion required to serve this projected increase while maintaining current service performance is $4.3 billion. Annual rail investment requirements are estimated at $2.9 billion, with an additional $1.5 billion for nonrail assets.

Exhibit 8-32

Annual Transit Investment Requirements by Type of Improvement (Billions of 2006 Dollars)

Type of Improvement	Maintain Conditions & Performance	Improve Conditions & Maintain Performance	Maintain Conditions & Improve Performance	Improve Conditions & Performance
Replacement and Rehabilitation	$10.7	$12.2	$10.7	$12.2
Asset Expansion	$4.3	$2.9	$4.3	$2.9
Performance Improvements			$5.9	$5.9
Total	**$15.1**	**$15.2**	**$21.0**	**$21.1**

Note: Figures presented in Exhibit 8-32 and other tables in Chapter 8 are not strictly comparable with those presented in Chapter 7. This is for two reasons. First, the tables in this chapter include investment needs for Special Services (Section 5310) operators. Because of this, the investment needs estimates in Chapter 8 are $0.2 billion higher for the Maintain Conditions scenarios and $0.3 billion higher for the Improve Conditions scenarios. Second, the needs estimates in Chapter 7 also include investments in betterments, safety, and other improvements not considered by TERM. Finally, the tables in Chapter 8 are constructed using the same needs estimates as used to construct similar tables in prior C&P reports and hence are comparable with those documents.

Source: Transit Economic Requirements Model and FTA staff estimates.

Improve Conditions

The incremental $1.5 billion for asset rehabilitation and replacement represents the additional investment required to rehabilitate and replace assets to attain an overall physical condition level of good. The average annual estimate of $1.5 billion comprises $0.6 billion for rail assets and $0.9 billion for nonrail assets.

Improve Performance

Investments to improve performance (increasing passenger speeds and reducing crowding in systems not operating at a condition of good performance threshold levels) are estimated to be $5.9 billion annually. Note that this scenario defines an upper limit above which additional investment in transit is unlikely to be economically justifiable.

Investment Estimates by Population Area Size

Exhibit 8-33 provides a detailed view of transit investments by TERM scenario, area population size, and asset type. Urban areas with populations of more than 1 million make up 88.6 percent of transit investment estimates for the **Maintain Conditions and Performance scenario**, reflecting the fact that, in 2006, 92 percent of the Nation's transit passenger miles were in these areas.

The **Maintain Conditions and Performance scenario** estimates an average annual investment of $13.3 billion to maintain the conditions and performance of transit assets in large urban areas; the **Improve Conditions and Performance scenario** estimates an average annual investment of $18.4 billion annually to improve the conditions and performance of transit assets in large urban areas. The investment in less-populated areas (i.e., those urban areas with populations of less than 1 million) is estimated to be considerably lower than the investment in more populous areas because the former have fewer transit assets. The **Maintain Conditions and Performance scenario** estimates an average investment of $1.7 billion annually in the transit infrastructure in these less-populated areas, and the **Improve Conditions and Performance scenario** estimates an average investment of $2.7 billion annually in transit infrastructure in these less-populated areas.

Exhibit 8-33

Annual Average Cost to Maintain and Improve Transit Conditions and Performance, 2007–2026

Mode, Purpose, & Asset Type		Cost to Maintain Conditions & Performance	Incremental Cost to Improve Conditions	Incremental Cost to Improve Performance	Cost to Improve Conditions & Performance
		(Billions of 2006 Dollars)			
Areas More Than 1 Million in Population					
Nonrail [1]					
Replacement & Rehabilitation	(Vehicles)	$2.0	$0.5	$0.0	$2.5
	(Nonvehicles) [2]	$1.3	$0.1	$0.0	$1.4
Asset Expansion	(Vehicles)	$0.7	$0.0	$0.0	$0.8
	(Nonvehicles)	$0.4	$0.0	$0.0	$0.4
Improve Performance	(Vehicles)	$0.0	$0.0	$0.4	$0.4
	(Nonvehicles) [2]	$0.0	$0.0	$0.2	$0.2
Special Service [3]	(Vehicles)	$0.0	$0.0	$0.0	$0.0
Subtotal Nonrail[4]		**$4.5**	**$0.6**	**$0.6**	**$5.7**
Rail					
Replacement & Rehabilitation	(Vehicles)	$0.8	$0.4	$0.0	$1.2
	(Nonvehicles) [2]	$5.2	$0.2	$0.0	$5.4
Asset Expansion	(Vehicles)	$0.7	-$0.3	$0.0	$0.4
	(Nonvehicles) [2]	$2.1	-$1.1	$0.0	$1.1
Improve Performance	(Vehicles)	$0.0	$0.0	$0.6	$0.6
	(Nonvehicles) [2]	$0.0	$0.0	$4.0	$4.0
Subtotal Rail[4]		**$8.8**	**-$0.8**	**$4.6**	**$12.7**
Total Areas More Than 1 Million[4]		**$13.3**	**-$0.2**	**$5.2**	**$18.4**
Areas Less Than 1 Million in Population					
Nonrail [1]					
Replacement & Rehabilitation	(Vehicles)	$0.7	$0.2	$0.0	$0.9
	(Nonvehicles) [2]	$0.5	$0.1	$0.0	$0.5
Fleet Expansion	(Vehicles)	$0.2	$0.0	$0.0	$0.2
	(Nonvehicles) [2]	$0.1	$0.0	$0.0	$0.1
Improve Performance	(Vehicles)	$0.0	$0.0	$0.2	$0.2
	(Nonvehicles) [2]	$0.0	$0.0	$0.5	$0.5
Special Service [3]	(Vehicles)	$0.2	$0.1	$0.0	$0.3
Subtotal Nonrail[4]		**$1.7**	**$0.3**	**$0.7**	**$2.7**
Rail					
Replacement & Rehabilitation	(Vehicles)	$0.0	$0.0	$0.0	$0.0
	(Nonvehicles) [2]	$0.0	$0.0	$0.0	$0.0
Fleet Expansion	(Vehicles)	$0.0	$0.0	$0.0	$0.0
	(Nonvehicles) [2]	$0.0	$0.0	$0.0	$0.0
Improve Performance	(Vehicles)	$0.0	$0.0	$0.0	$0.0
	(Nonvehicles) [2]	$0.0	$0.0	$0.0	$0.0
Subtotal Rail[4]		**$0.0**	**$0.0**	**$0.0**	**$0.0**
Total Areas Less Than 1 Million[4]		**$1.7**	**$0.3**	**$0.7**	**$2.7**
Total[4]		**$15.1**	**$0.1**	**$5.9**	**$21.1**

[1] Buses, vans and other (including ferryboats).

[2] Nonvehicles comprise guideway elements, facilities, systems, and stations.

[3] Vehicles to serve the elderly and disabled.

[4] Note that totals may not sum due to rounding.

Source: Transit Economic Requirements Model and FTA staff estimates.

Nonrail Needs in Areas With Populations of More Than 1 Million

The nonrail infrastructure component (buses, vans, and ferryboats) of the **Maintain Conditions and Performance scenario** in urban areas with populations over 1 million is considerably smaller than the rail component. The **Maintain Conditions and Performance scenario** estimates that 33.8 percent of the investment in larger urban areas, or about $4.5 billion annually, is for nonrail infrastructure. Of this $4.5 billion, 74.3 percent, or $3.3 billion annually, is estimated for the rehabilitation and replacement of assets, and 25.0 percent, or $1.1 billion, is estimated for the purchase of new assets to maintain performance. It is estimated that 60.4 percent of rehabilitation and replacement expenditures and 66.3 percent of asset expansion expenditures would be for vehicles. The incremental costs to improve nonrail conditions are estimated to be $580 million annually, of which 78.4 percent ($455 million) would be for vehicle rehabilitation and replacement. The incremental costs to improve performance are estimated to be $619 million annually, of which 65.0 percent ($402 million) would be spent on new vehicles (principally buses) and 35.0 percent ($217 million) on new nonvehicle assets. Expenditures on nonvehicle assets include investments for the purchase or construction of dedicated highway lanes for BRT. The **Improve Conditions and Performance scenario** estimates that, in total, $5.7 billion is needed for investment in these more heavily populated areas.

Rail Needs in Areas With Populations of More Than 1 Million

The **Maintain Conditions and Performance scenario** estimates that 66.2 percent of the total transit investment in large urban areas, or $8.8 billion annually, is for rail infrastructure. Of this $8.8 billion, 67.7 percent, or $6.0 billion annually, is for the rehabilitation and replacement of rail assets to maintain conditions, and 32.3 percent, or $2.8 billion, is for the purchase of new assets to expand rail systems as ridership increases. The **Improve Performance scenario** estimates an additional amount of $4.6 billion annually for rail assets, including the cost of purchasing rights-of-way. Eighty-seven percent of the $4.6 billion performance investments for rail, or $4.0 billion, is for nonvehicle rail infrastructure. The split between vehicle and nonvehicle investment for performance improvement is within the range of what is typical for new heavy and light rail infrastructure development projects. A total of $12.7 billion annually is estimated by the **Improve Conditions and Performance scenario** for rail in these more heavily populated, urbanized areas.

Nonrail Needs in Areas With Populations of Less Than 1 Million

Based on the **Maintain Conditions and Performance scenario**, 99.1 percent of transit investment in areas with populations under 1 million is estimated for nonrail transit. The **Maintain Conditions and Performance scenario** estimates an investment of $1.7 billion annually in the nonrail transit infrastructure in these less-populated areas; and the **Improve Conditions and Performance scenario** estimates it to be $2.7 billion annually. The incremental investment estimated to improve conditions in these areas is $0.3 billion annually, and the incremental investment to improve performance is $0.7 billion. Of the $0.7 billion incremental annual investment to improve performance, 29.8 percent, or $0.2 billion, would be needed to acquire new vehicles, and 70.2 percent, or $0.5 billion, would be needed for investment in the new nonvehicle infrastructure. This edition of the C&P report assumes that investment required to improve speed will be in the form of BRT rather than light rail, except in systems where rail already exists. This assumption was also made for the 2006 Report. The 2002 C&P Report and earlier editions assumed that all investment to increase speeds in these less populous areas would be in light rail.

Rail Needs in Areas With Populations of Less Than 1 Million

The investment scenarios find that rail needs in areas with populations of less than 1 million are minimal. Six light rail systems currently operate in these less-populated areas. The **Maintain Conditions and Performance scenario** estimates investment in rail for these areas to be $15.3 million annually.

Eighty-eight percent of the $15.3 million, or $13.1 million annually, is for investment in nonvehicle rail infrastructure. For the **Improve Conditions and Performance scenario,** an additional $2.7 million would be required to support vehicle rehabilitation and replacement.

Investment Estimates by Asset Type

Exhibit 8-34 provides disaggregated annual investment by scenario for rail and nonrail transportation modes by asset type for asset replacement and rehabilitation, asset expansion, and performance improvement.

Assets are disaggregated into five categories—guideway elements, facilities, systems, stations, and vehicles. The estimates of annual funding for services to support investment in new transit capacity are provided under "Other Project Costs." These costs include expenditures for project design, project management and oversight, right-of-way acquisition, and site preparation.

Rail Infrastructure

Fifty-nine percent of the total amount estimated by the **Maintain Conditions and Performance scenario** ($8.9 billion dollars annually) and 60.1 percent of the total amount estimated by the **Improve Conditions and Performance scenario** ($12.7 billion annually) are for rail infrastructure. Guideway elements and systems are estimated to have the largest amounts of the total capital investment of all rail assets between 2007 and 2026, followed by vehicles, stations, and facilities in descending order of investment.

Guideways are estimated to account for 44.3 percent of the total value of the Nation's rail infrastructure. [See the "Value of U.S. Transit Assets" section in Chapter 3.] Twenty-eight percent of the total amount of the investment in the Nation's transit rail assets estimated by the **Maintain Conditions and Performance and Improve Conditions and Performance scenarios** is for guideway elements, comprising elevated structures, systems structures, and track—assets with long, useful lives relative to most other transit assets. The **Maintain Conditions and Performance scenario** estimates annual rail guideway investment to be $2.5 billion, and the **Improve Conditions and Performance scenario** estimates annual guideway investment to be $3.5 billion. For guideway elements, the **Maintain Conditions scenario** estimates annual rehabilitation and replacement to be $1.8 billion, the **Maintain Performance scenario** estimates annual asset expansions to cost $0.7 billion, and the **Improve Performance scenario** estimates no investments annually. The amount estimated by the **Improve Conditions scenario,** for guideway elements, annual rehabilitation and replacement to be $1.9 billion, the **Improve Conditions scenario** estimates annual asset expansions to cost $0.4 billion, and the **Improve Performance scenario** estimates investments of $1.2 billion annually.

Vehicles are estimated to account for 11.6 percent of the total value of the Nation's rail infrastructure. Eighteen percent of the amount estimated to maintain rail asset conditions and performance, or $1.6 billion annually, and 17.5 percent of the amount estimated to improve rail asset conditions and performance, or $2.2 billion annually, are for vehicles. Annual vehicle rehabilitation and replacement costs are estimated to be $0.8 billion to maintain conditions and $1.2 billion to improve conditions. Annual asset expansion costs are estimated to be $0.7 billion to maintain performance and $0.4 billion to improve performance.

Rail systems, comprising train control, traction power, and communications, are estimated to account for 22.0 percent of the total value of the Nation's rail asset base. Twenty-four percent of the amount estimated to maintain the conditions and performance of rail assets, or $2.1 billion annually, and 20.0 percent of the amount estimated to improve the conditions and performance of rail assets, or $2.5 billion annually,

Exhibit 8-34

Transit Infrastructure: Average Annual Investment by Scenario and by Asset Type, 2007–2026 (Billions of 2006 Dollars)

Asset Type	Rehabilitation and Replacement	Asset Expansion	Improve Performance	Total
Maintain Conditions and Performance				
Rail				
Guideway Elements	$1.8	$0.7	$0.0	$2.5
Facilities	$0.5	$0.1	$0.0	$0.6
Systems	$1.9	$0.2	$0.0	$2.1
Stations	$0.9	$0.4	$0.0	$1.3
Vehicles	$0.8	$0.7	$0.0	$1.6
Other Project Costs		$0.7	$0.0	$0.7
Subtotal Rail[1]	**$6.0**	**$2.9**	**$0.0**	**$8.9**
Nonrail				
Guideway Elements	$0.3	$0.1	$0.0	$0.3
Facilities	$1.4	$0.3	$0.0	$1.8
Systems	$0.1	$0.0	$0.0	$0.1
Stations	$0.0	$0.0	$0.0	$0.1
Vehicles	$2.9	$1.0	$0.0	$3.9
Other Project Costs		$0.0	$0.0	$0.0
Subtotal Nonrail[1]	**$4.7**	**$1.5**	**$0.0**	**$6.2**
Total Maintain Conditions[1]	**$10.7**	**$4.3**	**$0.0**	**$15.1**
Improve Conditions and Performance				
Asset Type	**Rehabilitation and Replacement**	**Asset Expansion**	**Improve Performance**	**Total**
Rail				
Guideway Elements	$1.9	$0.4	$1.2	$3.5
Facilities	$0.5	$0.0	$0.1	$0.7
Systems	$2.1	$0.1	$0.3	$2.5
Stations	$0.9	$0.2	$0.8	$1.9
Vehicles	$1.2	$0.4	$0.6	$2.2
Other Project Costs		$0.3	$1.5	$1.9
Subtotal Rail[1]	**$6.6**	**$1.5**	**$4.6**	**$12.7**
Nonrail				
Guideway Elements	$0.3	$0.1	$0.2	$0.5
Facilities	$1.6	$0.3	$0.3	$2.2
Systems	$0.1	$0.0	$0.0	$0.1
Stations	$0.0	$0.0	$0.1	$0.1
Vehicles	$3.7	$1.0	$0.6	$5.3
Other Project Costs		$0.0	$0.1	$0.1
Subtotal Nonrail[1]	**$5.6**	**$1.5**	**$1.3**	**$8.4**
Total Improve Conditions[1]	**$12.2**	**$2.9**	**$5.9**	**$21.1**

[1] *Note that totals may not sum due to rounding.*

Note: Figures presented in Chapter 8 analysis are not comparable to analyses presented in Chapter 7 as noted in Exhibit 8-32.

Source: Transit Economic Requirements Model and FTA staff estimates.

are for rail systems. Annual rehabilitation and replacement costs are estimated to be $1.9 billion to maintain conditions and $2.1 billion to improve conditions. Annual asset expansion costs are estimated to be $0.2 billion to maintain rail power system performance and an additional $0.1 billion to improve performance.

Stations are estimated to account for 16.0 percent of the total value of the Nation's rail infrastructure. Fifteen percent of the amount estimated to maintain the conditions and performance of rail assets, or $1.3 billion annually, and 15.1 percent of the annual amount estimated to improve the conditions and performance of rail assets, or $1.9 billion annually, are estimated to be for stations. The amount estimated for rehabilitation and replacement both to maintain rail station conditions and to improve rail station conditions is estimated to be $0.9 billion. The annual amount of station expansion to maintain performance is estimated to be $0.4 billion. To improve performance, the annual amount of station expansion investment required is estimated to be $0.2 billion.

Facilities for rail vehicles (maintenance facilities and yards) are estimated to account for 6.1 percent of the total value of the Nation's rail transit asset base. Seven percent of the amount to maintain conditions, $0.6 billion annually, and 5.3 percent of the amount to improve conditions and performance, $0.7 billion annually, are estimated to be for facilities. Annual rehabilitation and replacement costs are estimated to be $0.5 billion both to maintain and to improve conditions. Asset expansion costs are estimated to be $0.1 billion annually for maintain performance and $42 million annually to improve performance.

Nonrail Assets

Forty-one percent of the total amount to maintain conditions and performance, or $6.2 billion dollars annually, and 39.9 percent of the total amount estimated to improve conditions and performance, or $8.4 billion annually, are for nonrail infrastructure. Vehicles are estimated to require the largest amount of the total capital investment in nonrail assets between 2007 and 2026, followed in descending order of estimated investment by facilities, guideway elements (dedicated lanes for buses), stations, and systems.

Vehicles are estimated to account for 31.7 percent of the total value of the Nation's nonrail assets, excluding vehicles in rural areas. (Note that asset value is estimated by TERM, which does not include rural operators.) However, they account for substantially more of estimated nonrail investment because they depreciate much more quickly than nonvehicle assets. The investment in nonrail vehicles estimated by the **Maintain Conditions and Performance scenario** is $3.9 billion annually, and the investment in nonrail estimated by the **Improve Conditions and Performance scenario** is $5.3 billion annually. Sixty-two percent of estimated nonrail rehabilitation and replacement expenditures by the **Maintain Performance scenario** is for vehicles, while 65.1 percent of estimated nonrail rehabilitation and replacement expenditures by the **Improve Performance scenario** is for vehicles. Vehicles are also estimated to account for the largest proportion, about 67.7 percent, of nonrail asset expansion investments by the **Maintain Performance scenario** and 68.3 percent of the amount estimated by the **Improve Performance scenario**.

Facilities are estimated to account for 52.3 percent of the total value of the Nation's nonrail assets, excluding facilities in rural areas. Although facilities account for more than half of the nonrail assets, it is estimated that they will account for over 28.6 percent of future nonrail investment in the **Maintain Conditions and Performance scenario** because external structures and many of the facility components depreciate slowly. The **Maintain Conditions and Performance scenario** estimates investment in facilities to be $1.8 billion, and the **Improve Conditions and Performance scenario** estimates investment in facilities to be $2.2 billion.

Guideway elements account for 10.3 percent of the Nation's nonrail assets, stations account for 3 percent, and power systems account for 1.8 percent. The **Maintain Conditions and Performance scenario** estimates investment of $0.3 billion annually for nonrail guideway, and the **Improve Conditions and**

Performance scenario estimates investment of $0.5 billion for nonrail guideway. These amounts decreased principally due to revisions in the benefit-cost analysis and updated NTD data. The **Maintain Conditions and Performance scenario** estimates investment of $0.1 billion annually for nonrail stations, and the **Improve Conditions and Performance scenario** estimates investment of $0.1 billion for nonrail stations. The **Maintain Conditions and Performance scenario** estimates investment of $0.1 billion annually in nonrail systems; and the **Improve Conditions and Performance scenario** estimates investment of $0.1 billion in nonrail systems.

Scenario Investment Needs: Benefit-Cost Ratio of 1.2

The analysis presented in the previous section included all investments with a benefit-cost ratio of 1.0 or higher. In contrast, this section reproduces each of the scenarios considered above, but this time only including those investments with a benefit-cost ratio of 1.2 or higher. By assessing the sensitivity of the estimated investment needs to changes in the underlying benefit-cost ratio, this analysis provides an indication of the proportion of investments expected to provide high returns versus those expected to provide more marginal investment returns. To facilitate this comparison, *Exhibit 8-35* below presents a summary of the annual transit investment requirements by TERM investment scenario and type of improvement where the benefit-cost ratio is greater than or equal to 1.0 and 1.2, and the variance between the two scenarios.

Exhibit 8-35

Cost to Maintain and Improve Conditions and Performance Scenarios With Benefit-Cost Ratios of 1.0 and 1.2 (Billions of 2006 Dollars)*

TERM Investment Scenario	Maintain Conditions & Performance			Improve Conditions & Performance		
	BCR 1.0	**BCR 1.2**	**Difference**	**BCR 1.0**	**BCR 1.2**	**Difference**
Type of Improvement						
Replacement and Rehabilitation						
Rail	$6.0	$0.7	-$5.3	$6.6	$0.4	-$6.2
Nonrail	$4.7	$3.2	-$1.5	$5.6	$3.7	-$1.9
Total	**$10.7**	**$3.9**	**-$6.8**	**$12.2**	**$4.1**	**-$8.1**
Asset Expansion						
Rail	$2.9	$0.6	-$2.3	$1.5	$0.4	-$1.0
Nonrail	$1.5	$1.1	-$0.3	$1.5	$1.1	-$0.4
Total	**$4.3**	**$1.7**	**-$2.6**	**$2.9**	**$1.5**	**-$1.4**
Performance Improvements						
Rail	$0.0	$0.0	$0.0	$4.6	$3.2	-$1.4
Nonrail	$0.0	$0.0	$0.0	$1.3	$1.3	$0.0
Total	**$0.0**	**$0.0**	**$0.0**	**$5.9**	**$4.5**	**-$1.4**
Total						
Rail	$8.9	$1.3	-$7.5	$12.7	$4.0	-$8.7
Nonrail	$6.2	$4.3	-$1.9	$8.4	$6.1	-$2.3
Total	**$15.1**	**$5.6**	**-$9.4**	**$21.1**	**$10.2**	**-$11.0**

* *Numbers may not sum due to rounding.*

Source: Transit Economic Requirements Model.

Based on the analysis below, TERM estimates show some sensitivity to changes in the benefit-cost ratio. Moreover, this sensitivity is apparent for all investment types, including those to maintain or improve conditions and those to maintain or improve performance.

Maintain Conditions

The annual amount estimated by TERM under the **Maintain Conditions and Performance scenario** baseline at a benefit-cost ratio of 1.0 for the Nation's rail and nonrail transit infrastructure is $10.7 billion annually. By increasing the benefit-cost ratio from 1.0 to 1.2, a decrease of 63.4 percent in investment requirements is realized on the annual cost to maintain conditions and performance, yielding an average annual investment requirement of $3.9 billion. For the baseline scenario with a benefit-cost ratio of 1.2, the average annual amount estimated by TERM for replacement and rehabilitation of the Nation's transit assets between 2007 and 2026 is $0.7 billion for rail and $3.2 billion for nonrail, compared with rail investment requirements of $6.0 billion and nonrail investment requirements of $4.7 billion annually with a benefit-cost ratio of 1.0.

> Q&A
>
> **How does TERM screen proposed investments?**
>
> All investments identified by TERM's capital investment needs estimates must successfully pass the model's benefit-cost test. If an investment fails that test, it is rejected and the cost of that investment is not added to the model's tally of national transit investment needs. If the investment passes the benefit-cost test, the investment needs tally is updated to include that investment's costs. All of TERM's benefit-cost tests evaluate the benefits and costs of each proposed investment over a 20-year time period. For most analyses, the ratio of benefits to costs must equal or exceed a value of 1.0 to pass the benefit-cost test. This subsection only considers investments with benefit-cost ratios greater than or equal to 1.2.

Maintain Performance

To accommodate asset expansion, an additional $0.6 billion annually is required for rail assets and an additional $1.1 billion is required for nonrail assets under the 1.2 benefit-cost ratio scenario, compared with $2.9 billion for rail assets and $1.5 billion for nonrail assets under the 1.0 scenario.

Improve Conditions

The average annual amount estimated by TERM to improve conditions decreases from $12.2 billion in the 1.0 benefit-cost ratio scenario to $4.1 billion in the 1.2 benefit-cost ratio scenario, with $0.4 billion required for rail and $3.7 billion for nonrail. It is interesting to note that rail investment requirements decreased more significantly than nonrail requirements due to a higher benefit-cost ratio on average for bus than rail. Most bus benefit-cost ratios are significantly further from 1.2, while rail aligns closer to 1.0.

Improve Performance

The investment to improve service performance for rail assets over the period 2007 to 2026 declined from the $4.6 billion under the benefit-cost ratio of 1.0 scenario to $3.2 billion annually under the benefit-cost ratio of 1.2. For nonrail assets, annual investments required to improve performance are the same for both benefit-cost ratio scenarios with an estimate of $1.3 billion per year.

Maintain and Improve Conditions and Performance Scenarios Assuming Highway Congestion Pricing

The highway congestion pricing scenarios examined in this and other chapters of this edition of the C&P report assume that a portion of the reduction in vehicle miles traveled (VMT) resulting from the imposition of highway congestion pricing is diverted to transit (see "Projected VMT in 2026" section in Chapter 7). This section considers the level of expansion investment required to support this increase in transit ridership while maintaining current transit performance (measured as vehicle capacity utilization) at today's levels. To do so, the analysis assumes that between 25 percent and 50 percent of diverted automobile users shift to transit as their preferred modal choice. The remaining diverted highway users are assumed to telecommute, defer their trip, or identify other alternative modes of transportation.

> **How did TERM analyze the effects of congestion pricing on transit?** Q&A
>
> Chapter 7 analyzed the potential effects of congestion pricing as an alternative funding mechanism for highway capital investments. The results of the analysis demonstrate that as highway user costs rise, vehicle miles traveled fall as travelers move to less expensive forms of transportation.
>
> In analyzing the effects of congestion pricing on transit, TERM treated the assumed diversion of highway travelers to transit as a one-time increase in the number of transit passenger miles. The model then estimated the level of expansion investment in rail and bus vehicles, stations, guideways, and other asset types as required to support the increase in travel demand while maintaining existing vehicle occupancy rates.

This analysis leverages both the transit and highways investment scenarios. As referenced earlier in this chapter, the **Sustain Current Spending** (SCS) **scenario** for highways assumes that highway capital spending is maintained in constant dollar terms at base year 2006 levels over the 20-year period from 2007 through 2026. The **Maximum Economic Investment** (MEI) **scenario** for highways assumes that combined public and private highway capital investment gradually increases in constant dollar terms over 20 years up to the point at which all potentially cost-beneficial investments (i.e., those with a benefit-cost ratio of 1.0 or higher) are funded by 2026. Each highway scenario is projected to result in different levels of congestion, average highway user costs, and future highway VMT. As future highway congestion is projected to be worse under the SCS scenario than the MEI scenario, the average highway congestion charges imposed under the SCS scenario are higher, resulting in more potential diversion of highway VMT to transit. This results in an increase in passenger miles traveled (PMT) ranging from 2.3 percent and 4.3 percent depending on the highways investment scenario, as presented in *Exhibit 8-36*.

Exhibit 8-36

Percent Increase in Transit Passenger Miles of Travel Due to Congestion Pricing

	25% Diversion	50% Diversion
Maximum Economic Investment	2.3%	2.9%
Sustain Current Spending	3.1%	4.3%

Source: Transit Economic Requirements Model.

The analysis below presents the total level of transit expansion investment required to support each of these projected increases in transit ridership. As with the scenario analysis discussed above, this analysis is presented first for all those projects with a passing benefit-cost ratio of 1.0 or higher. The analysis is then repeated for projects with a benefit-cost ratio of 1.2 or higher. Once again, this approach suggests significant variation in the relative investment returns of these investment scenarios.

Benefit-Cost Ratio of 1.0

Exhibit 8-37 presents the annual level of transit investment required to support VMT diverted from highways to transit over the time period from 2007 through 2026 for projects with a benefit-cost ratio of 1.0 or higher. In comparison with the investment scenarios discussed in the prior section of this report (i.e., the scenarios for maintaining or improving conditions and performance), a significant amount of the increased

Exhibit 8-37

Maintain and Improve Transit Conditions Scenarios, Adjusted by Highway Congestion Pricing Scenarios (Benefit-Cost Ratio≥1.0) (Billions of 2006 Dollars)

Highway Investment Scenario	Sustain Current Spending		Maximum Economic Investment	
Percent of Reduced Highway VMT Diverted to Transit	**25%**	**50%**	**25%**	**50%**
Type of Improvement				
Replacement and Rehabilitation (Maintain Conditions)				
Rail	$6.1	$6.8	$6.1	$6.8
Nonrail	$4.8	$5.0	$4.7	$5.0
Total	**$10.9**	**$11.8**	**$10.8**	**$11.8**
Replacement and Rehabilitation (Improve Conditions)				
Rail	$6.2	$7.0	$6.2	$7.0
Nonrail	$5.1	$5.3	$5.0	$5.3
Total	**$11.3**	**$12.3**	**$11.3**	**$12.3**
Asset Expansion (Maintain Performance)				
Rail	$4.7	$5.3	$4.7	$6.2
Nonrail	$3.1	$5.0	$2.7	$4.3
Total	**$7.8**	**$10.3**	**$7.4**	**$10.6**
Performance Improvements				
Rail	$4.6	$4.6	$4.6	$4.6
Nonrail	$1.3	$1.3	$1.3	$1.3
Total	**$5.9**	**$5.9**	**$5.9**	**$5.9**
Total				
Rail	$15.5	$16.8	$15.4	$17.7
Nonrail	$9.1	$11.3	$8.7	$10.6
Total	**$24.6**	**$28.0**	**$24.1**	**$28.3**
TERM Scenario Totals				
Maintain Conditions and Performance	$18.7	$22.1	$18.2	$22.4
Improve Conditions and Performance	$25.0	$28.5	$24.6	$28.8

Source: Transit Economic Requirements Model.

need is reflected in the "Asset Expansion" category. There is also a modest increase in the level of investment needed for rehabilitation and replacement required to maintain the expanded asset base.

Maintain Conditions

The average annual amount estimated by TERM for replacement and rehabilitation of the Nation's transit assets between 2007 and 2026, assuming that 25 percent of highway VMT is diverted to transit, is $6.1 billion for rail and $4.8 billion for nonrail. The diversion of highway VMT to transit yields an increase of only 1.9 percent in the **Maintain Conditions scenario** on annual transit investment requirements. However, if 50 percent of reduced VMT resulting from highway congestion pricing was diverted to transit, the **Maintain Conditions scenario** investment requirements would increase 10.3 percent on an annual basis, to $11.8 billion. Estimates for the highway MEI scenario under the **Maintain Conditions scenario** are relatively consistent with the estimated annual investment requirements for both the 25- and 50-percent scenarios. Nonrail investment requirements show a slight decline in the 25-percent scenario, from $4.8 billion to $4.7 billion.

Maintain Performance

Given the projected increase in demand for transit services from 2007 through 2026 in terms of PMT, coupled with the transition of 25 percent of reduced highway VMT to transit, TERM estimates that

$7.8 billion will be required on an annual basis for investments to maintain performance at current service levels. This represents an increase from $2.9 billion for rail in the baseline to $4.7 billion under the congestion pricing scenario, and from $1.5 billion to $3.1 billion for nonrail assets to accommodate the asset expansion. To support 50 percent of highway VMT diverting to transit, an estimated $10.3 billion would be required on an annual basis in the highway SCS scenario and $10.6 billion under the MEI scenario.

The annual amount estimated by TERM under the **Maintain Conditions and Performance scenario** within the highway SCS investment scenario for the Nation's rail and nonrail transit infrastructure is $18.7 billion for a 25-percent diversion of reduced highway VMT to transit and $22.1 billion for a 50-percent diversion. Similarly, the annual amount estimated by TERM to maintain current conditions and performance under the highway MEI investment scenario is $18.2 billion for a 25-percent diversion of reduced highway VMT to transit and $22.4 billion for a 50-percent diversion.

Improve Conditions

The average annual amount estimated by TERM to improve conditions of the Nation's transit assets between 2007 and 2026, assuming that 25 percent of highway VMT is diverted to transit, is $6.2 billion for rail and $5.1 billion for nonrail under the Highway Congestion Pricing SCS scenario. Under the MEI scenario, nonrail requirements decline to $5.0 billion. However, if 50 percent of reduced VMT resulting from highway congestion pricing was diverted to transit, the **Improve Conditions scenario** investment requirements would increase 8.8 percent on an annual basis, to $7.0 billion for rail, and $5.3 billion for nonrail. Estimates for the highway MEI and SCS scenarios under the **Improve Conditions scenario** are relatively consistent with the estimated annual investment requirements for both the 25- and 50-percent scenarios.

Improve Performance

The average annual amount estimated by TERM to improve performance assuming highway congestion pricing is consistent with the baseline requirements, at $4.6 billion for rail and $1.3 billion for nonrail, to support the additional riders resulting from the VMT shift. Further, the investment required to improve performance is consistent between the two VMT scenarios at a total of $5.9 billion annually. Estimates for the **Performance Improvement scenario** are consistent per the MEI for both the 25-percent and 50-percent scenarios. The congestion pricing scenarios only have a direct impact on **Maintain Performance scenario** investments, which are modeled by increasing PMT growth rates. The **Maintain Conditions scenario** may also be impacted because the benefit-cost tests are tied together for the Maintain Performance and Maintain and Improve Condition investments (on an agency-mode basis). In contrast, there is no link between the Maintain Performance and Improve Performance modules for this analysis.

Benefit-Cost Ratio of 1.2

Exhibit 8-38 presents the annual level of transit investment required to support VMT diverted from highways to transit over the 2007 to 2026 time period for projects with a benefit-cost ratio of 1.2 or higher.

Maintain Conditions

With a benefit-cost ratio of 1.2, the average annual amount estimated by TERM for replacement and rehabilitation of the Nation's transit assets between 2007 and 2026, assuming that 25 percent of reduced highway VMT were diverted to transit under the SCS scenario, increases from $3.9 billion in the baseline analysis to $4.9 billion for rail and nonrail assets. If 50 percent of VMT were diverted to transit, the **Maintain Conditions scenario** investment requirements increase to an estimated $8.6 billion again, compared with $3.9 billion in the baseline **Maintain Conditions and Performance** scenario with a benefit-cost ratio of 1.2.

Exhibit 8-38

Maintain and Improve Transit Conditions Scenarios, Adjusted by Highway Congestion Pricing Scenarios (Benefit-Cost Ratio≥1.2) (Billions of 2006 Dollars)

Highway Investment Scenario	Sustain Current Spending		Maximum Economic Investment	
Percent of Reduced Highway VMT Diverted to Transit	**25%**	**50%**	**25%**	**50%**
Type of Improvement				
Replacement and Rehabilitation (Maintain Conditions)				
Rail	$1.4	$5.1	$1.4	$4.8
Nonrail	$3.5	$3.5	$3.4	$3.5
Total	**$4.9**	**$8.6**	**$4.8**	**$8.3**
Replacement and Rehabilitation (Improve Conditions)				
Rail	$0.9	$5.3	$1.6	$5.0
Nonrail	$3.0	$3.9	$3.7	$3.8
Total	**$4.0**	**$9.2**	**$5.3**	**$8.8**
Asset Expansion (Maintain Performance)				
Rail	$0.8	$3.4	$0.8	$3.4
Nonrail	$2.7	$4.3	$2.4	$3.8
Total	**$3.5**	**$7.8**	**$3.2**	**$7.2**
Performance Improvements				
Rail	$3.2	$3.2	$3.2	$3.2
Nonrail	$1.3	$1.3	$1.3	$1.3
Total	**$4.5**	**$4.5**	**$4.5**	**$4.5**
Total				
Rail	$5.5	$11.8	$5.4	$11.5
Nonrail	$7.4	$9.0	$7.0	$8.6
Total	**$12.8**	**$20.9**	**$12.5**	**$20.1**
TERM Scenario Totals				
Maintain Conditions and Performance	$8.3	$16.4	$8.0	$15.6
Improve Conditions and Performance	$11.9	$21.4	$13.0	$20.5

Source: Transit Economic Requirements Model.

For the MEI scenarios, average annual investment requirement for the **Maintain Conditions scenario** increases in both the 25- and 50-percent scenarios in comparison to the baseline analysis, with a benefit-cost ratio of 1.2, from $3.9 billion to $4.8 billion at the 25-percent scenario and $8.3 billion for the 50-percent scenario.

Maintain Performance

Given the projected increase in demand for transit services from 2007 through 2026 in PMT, coupled with the transition of 25 percent of reduced highway VMT to transit, TERM estimates that $3.5 billion will be required on an annual basis for investments to maintain performance at current service levels for both rail and nonrail assets in the SCS scenario; under the MEI scenario, this decreases to $3.2 billion. This is in comparison to $1.7 billion in annual investment requirements in the baseline with a benefit-cost ratio of 1.2. To support 50 percent of reduced highway VMT diverting to transit, an estimated $7.8 billion would be required on an annual basis under SCS, with $3.4 billion required for rail and $4.3 billion for nonrail assets. Under the constraints of the MEI scenario, the annual investment requirement declines to $7.2 billion, resulting from a decline in nonrail requirements.

The annual amount estimated by TERM under the **Maintain Conditions and Performance scenario** for the Nation's rail and nonrail transit infrastructure is $8.3 billion for a 25-percent diversion of highway VMT to transit and $16.4 billion for a 50-percent diversion under the highway SCS scenario. The baseline analysis with a benefit-cost ratio of 1.2 shows $5.6 billion in annual investment requirements.

Under the highway MEI scenario, the annual amount estimated by TERM under the **Maintain Conditions and Performance scenario** for the Nation's rail and nonrail transit infrastructure is $8.0 billion for a 25- percent diversion of highway VMT to transit and $15.6 billion for a 50-percent diversion. Again, the baseline analysis with a benefit-cost ratio of 1.2 shows $5.6 billion in annual investment requirements.

Improve Conditions

With a benefit-cost ratio of 1.2, the average annual amount estimated by TERM to improve conditions of the Nation's transit assets between 2007 and 2026, assuming that 25 percent of reduced highway VMT were diverted to transit under the SCS scenario, is estimated at $0.9 billion for rail and $3.0 billion for nonrail assets. If 50 percent of VMT were diverted to transit, the **Improve Conditions scenario** investment requirements increase to an estimated $5.3 billion for rail, and $3.9 billion for nonrail assets. For the MEI scenario, average annual investment requirement for the **Improve Conditions scenario** is estimated at $5.3 billion at the 25-percent scenario and $8.8 billion for the 50-percent scenario.

Improve Performance

The average annual amount estimated by TERM to improve performance is consistent with the baseline requirements with a benefit-cost ratio of 1.2 at $3.2 billion for rail and $1.3 billion for nonrail to support the additional riders resulting from the VMT shift. Further, the investment required to improve performance is consistent between the two VMT scenarios with a benefit-cost ratio of 1.2, at a total of $4.5 billion annually. Estimates for the **Performance Improvement scenario** are also consistent between the SCS and MEI scenarios for both the 25-percent and 50-percent scenarios.

The annual amount estimated by TERM under the **Improve Conditions and Performance scenario** for the Nation's rail and nonrail transit infrastructure is $11.9 billion for a 25-percent diversion of highway VMT to transit and $21.4 billion for a 50-percent diversion under the highway SCS scenario. This is in comparison to the baseline analysis with a benefit-cost ratio of 1.2 that results in $10.2 billion in annual investment requirements for the **Improve Conditions and Performance scenario**.

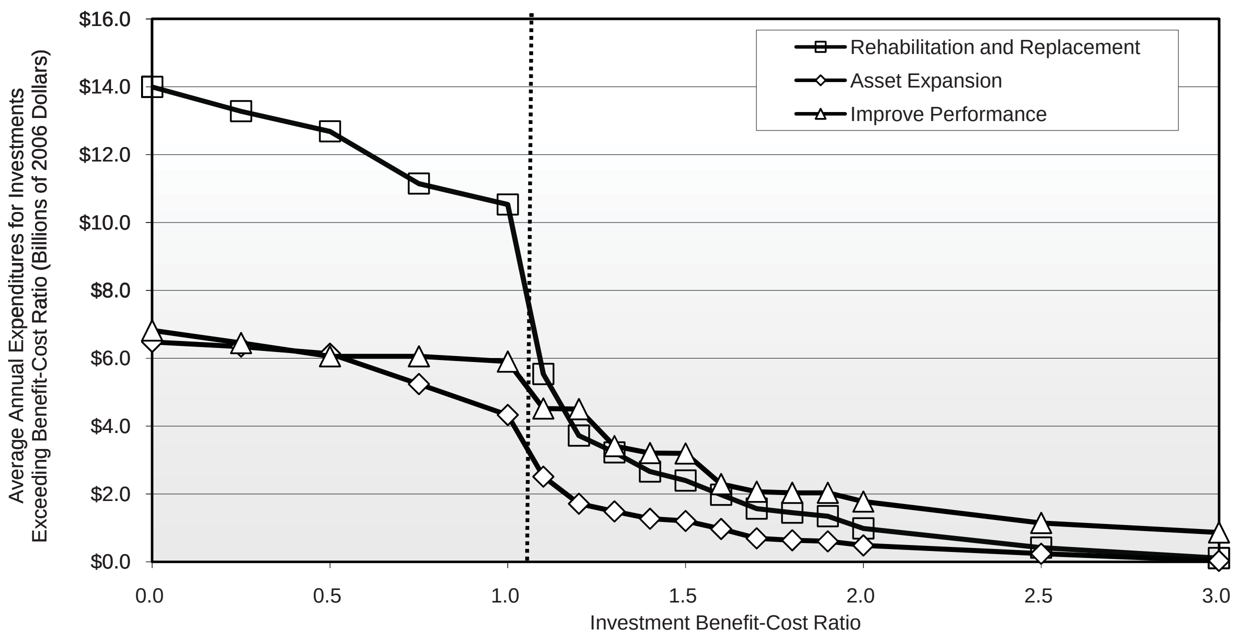
Under the highway MEI scenario, the annual amount estimated by TERM under the **Improve Conditions and Performance scenario** for the Nation's rail and nonrail transit infrastructure is $13.0 billion for a 25- percent diversion of highway VMT to transit and $20.5 billion for a 50-percent diversion. Again, the baseline analysis with a benefit-cost ratio of 1.2 shows $10.2 billion in annual investment requirements.

Alternative Benefit-Cost Ratio Thresholds

The transit analysis presented in this chapter has considered the impact of increasing the benefit-cost ratio from 1.0 to 1.2 on TERM's total needs assessments. In general, this increase resulted in a significant decline in estimated needs, suggesting that there is a broad range of investment returns for those investments considered by the model. *Exhibit 8-39* below helps place this sensitivity of TERM estimates to changes in the benefit-cost ratio in broader perspective. Specifically, this exhibit shows the total level of investments passing TERM's benefit-cost test at various benefit-cost ratio values. It is interesting to note that the slope at which projects fail the benefit-cost test increases dramatically as the benefit-cost ratio approaches and passes 1.0, and then declines again after a ratio of roughly 1.5. This phenomenon is driven primarily by the high costs and frequently low benefit-cost ratios of many rail investments (resulting in a steep drop-off as these higher cost investments are eliminated from the analysis). In contrast, nonrail investments (primarily bus) tend to have significantly higher benefit-cost ratios and lower costs.

Exhibit 8-39

Benefit-Cost Ratios Versus Expenditures: All Modes



Source: Transit Economic Requirements Model.

Comparison

The layout and content of Part II of this edition of the C&P report, including Chapters 7 through 10, has been restructured significantly relative to that of recent editions. Much of the material presented in this chapter represents extensions to more limited analyses presented in Chapters 7, 8, 11, and 12 of the 2006 C&P Report. This discussion of selected capital investment scenarios was moved to Chapter 8 in this report to allow it to follow the more detailed technical analysis presented in Chapter 7, and to emphasize the fact that these scenarios represent only selected points on a broad continuum of possible future investment levels.

Q&A

What is the Federal share of the highway and transit investment scenario estimates presented in this report?

The investment scenario estimates presented in this report represent the projected levels of total capital investment that would be necessary to obtain certain outcomes. **The question of what portion should be funded by the Federal government, State governments, local governments, or the private sector is outside the scope of this report.**

Chapter 6 includes information on historic trends in public funding for highways and transit by different levels of government.

Exhibits 8-40 and *8-41* summarize the average annual investment levels associate with each of the highway and transit investment scenarios presented in the highway and transit sections of this chapter, respectively. These exhibits also compare these investment levels with actual combined public and private highway capital investment in 2006. The scenarios can mainly be classified into two broad categories, those focused on maintaining selected indicators of system conditions and performance, and those focused on improving the overall conditions and performance of the system.

For highways and bridges, the **Sustain Conditions and Performance scenario** focuses on maintaining the system at base year performance levels. The **MinBCR=1.5**, **MinBCR=1.2**, and **MinBCR=1.0** scenarios represent three alternative levels of investment that would each improve the performance of the overall system by varying degrees. A **Sustain Current Spending** scenario was included to project the impact that maintaining combined public and private highway capital spending at base year levels would be expected to have on system conditions and performance. Separate versions of each scenario were developed assuming either fixed rate user financing or variable rate user financing would be utilized to support the overall level of investment associated with that scenario. Each scenario was also computed separately for the Interstate system and the National Highway System, as well as for the overall network of highways and bridges as a whole. Two supplemental highway and bridge scenarios were presented at the systemwide level only. The **Sustain Conditions and Performance of System Components scenario** represents an alternative approach to maintaining the system; the **Sustain Conditions and Improve Performance scenario** focuses on maintaining physical conditions while improving operational performance.

For transit the **Maintain Current Funding** scenario considers the expected impact on the long-term physical condition and service performance of the Nation's transit infrastructure if current (2006) transit investment levels for rehabilitation, replacement, and expansion are maintained through the year 2026. The traditional TERM scenarios are consistent with the 2006 C&P Report. These scenarios estimate the level of investment required to: (1) **Maintain** transit asset physical conditions and service performance at current levels, or (2) **Improve** transit asset physical conditions and service performance to specific condition and performance

Exhibit 8-40

Summary of Selected Highway Capital Investment Scenarios for 2007 to 2026 and Comparison With Base Year 2006 Capital Spending

	Average Annual Investment (Billions of 2006 Dollars)			Percent Difference Relative to 2006 Spending			Annual Percent Increase to Support Scenario Investment [1]		
Scenario Description	**Interstate**	**NHS**	**All Roads**	**Interstate**	**NHS**	**All Roads**	**Interstate**	**NHS**	**All Roads**
Scenarios Assuming Fixed Rate User Financing									
Sustain Current Spending	$16.5	$37.1	$78.7	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%
Sustain Conditions and Performance	$24.8	$38.7	$105.6	49.8%	4.4%	34.2%	3.71%	0.41%	2.72%
Invest up to MinBCR=1.5	$39.0	$60.7	$137.4	135.7%	63.7%	74.6%	7.61%	4.49%	5.05%
Invest up to MinBCR=1.2	$43.5	$69.2	$157.1	163.1%	86.5%	99.7%	8.52%	5.62%	6.21%
Invest up to MinBCR=1.0	$47.0	$76.1	$174.6	183.9%	105.1%	121.9%	9.15%	6.43%	7.10%
Sustain Conditions and Performance of System Components	N/A	N/A	$119.5	N/A	N/A	51.9%	N/A	N/A	3.83%
Sustain Conditions and Improve Performance	N/A	N/A	$143.5	N/A	N/A	84.7%	N/A	N/A	5.54%
Scenarios Assuming Variable Rate User Financing									
Sustain Current Spending	$16.5	$37.1	$78.7	0.0%	0.0%	0.0%	0.00%	0.00%	0.00%
Sustain Conditions and Performance	$11.6	$19.6	$71.3	-29.7%	-47.0%	-9.3%	-3.49%	-6.54%	-0.94%
Invest up to MinBCR=1.5	$24.0	$38.9	$101.8	45.3%	4.9%	29.5%	3.43%	0.46%	2.40%
Invest up to MinBCR=1.2	$27.5	$44.9	$117.2	66.5%	21.2%	48.9%	4.64%	1.80%	3.65%
Maximum Economic Investment (MinBCR=1.0)	$30.4	$50.1	$131.3	83.8%	35.3%	66.9%	5.49%	2.79%	4.66%
Sustain Conditions and Performance of System Components	N/A	N/A	$83.4	N/A	N/A	6.0%	N/A	N/A	0.55%
Sustain Conditions and Improve Performance	N/A	N/A	$104.9	N/A	N/A	33.4%	N/A	N/A	2.67%

[1] *This percentage represents the annual percent change in constant dollar terms relative to 2006 that would be required to achieve the average annual funding level specified for the scenario.*

targets. These scenarios represent all investments that pass the benefit-cost ratio at greater than or equal to 1.0. For the 2008 C&P Report, additional scenarios were included to demonstrate the effect on investments of shifting the **benefit-cost ratio from 1.0 to 1.2**. **Congestion pricing** scenarios were also included that examine the level of transit expansion investment required to serve highway users diverted to transit as a result of highway congestion pricing while maintaining current transit performance. Each of these scenarios was assessed with a benefit-cost ratio of 1.0, and then examined as the ratio shifts to 1.2.

Exhibit 8-42 compares selected 20-year average annual investment scenario estimates in this report with those presented in the 2004 C&P Report. The first column shows the projection for 2005 to 2024, based on 2004 data shown in the 2006 C&P Report and stated in 2004 dollars. The second column restates these highway and transit values in 2006 dollars, to account for the effect of inflation. The third column shows new average annual investment scenario projections for 2007 to 2026 based on 2006 data.

Exhibit 8-41

Summary of Selected Transit Capital Investment Scenarios for 2007 to 2026, Annual Investment Requirements (Billions of 2006 Dollars)

	Rehabilitation and Replacement		Asset	Performance	
	Maintain	Improve	Expansion	Improvement	Total
Maintain Current Funding					
2006 Funding Levels	$9.3	$9.3	$2.4	$1.1	$12.8
Traditional TERM Scenarios					
Maintain Conditions and Performance BCR=1.0	$10.7	N/A	$4.3	N/A	$15.1
Improve Conditions and Performance BCR=1.0	N/A	$12.2	$2.9	$5.9	$21.1
Benefit-Cost Ratio Increased to 1.2					
Maintain Conditions and Performance BCR=1.2	$3.9	N/A	$1.7	N/A	$5.6
Improve Conditions and Performance BCR=1.2	N/A	$4.1	$1.5	$4.5	$10.2
Congestion Pricing Scenarios					
Maintain Conditions and Performance BCR=1.0, SCS 25%	$10.9	N/A	$7.8	N/A	$18.7
Improve Conditions and Performance BCR=1.0, SCS 25%	N/A	$11.3	$7.8	$5.9	$25.0
Maintain Conditions and Performance BCR=1.2, SCS 25%	$4.9	N/A	$4.0	N/A	$8.3
Improve Conditions and Performance BCR=1.2, SCS 25%	N/A	$4.0	$3.5	$4.5	$11.9
Maintain Conditions and Performance BCR=1.0, MEI 25%	$10.8	N/A	$7.4	N/A	$18.2
Improve Conditions and Performance BCR=1.0, MEI 25%	N/A	$11.3	$7.4	$5.9	$24.6
Maintain Conditions and Performance BCR=1.2, MEI 25%	$4.8	N/A	$3.2	N/A	$8.0
Improve Conditions and Performance BCR=1.2, MEI 25%	N/A	$5.3	$3.2	$4.5	$13.0
Maintain Conditions and Performance BCR=1.0, SCS 50%	$11.8	N/A	$10.3	N/A	$22.1
Improve Conditions and Performance BCR=1.0, SCS 50%	N/A	$12.3	$10.3	$5.9	$28.5
Maintain Conditions and Performance BCR=1.2, SCS 50%	$8.6	N/A	$7.8	N/A	$16.4
Improve Conditions and Performance BCR=1.2, SCS 50%	N/A	$9.2	$7.8	$4.5	$21.4
Maintain Conditions and Performance BCR=1.0, MEI 50%	$11.8	N/A	$10.6	N/A	$22.4
Improve Conditions and Performance BCR=1.0, MEI 50%	N/A	$12.3	$10.6	$5.9	$28.8
Maintain Conditions and Performance BCR=1.2, MEI 50%	$8.3	N/A	$7.2	N/A	$15.6
Improve Conditions and Performance BCR=1.2, MEI 50%	N/A	$8.0	$7.2	$4.5	$20.5

Highways and Bridges

As discussed in Chapter 6, highway construction costs as measured by the Federal Highway Administration Composite Bid Price Index (BPI) increased by 43.3 percent from 2004 to 2006. This increase had a significant impact on the capital investment scenarios presented in this report.

As shown in *Exhibit 8-42*, the $105.6 billion average annual investment level in constant 2006 dollars for the version of the **Sustain Conditions and Performance scenario** assuming fixed rate user financing is significantly higher than the amount shown for the comparable "Cost to Maintain" scenario in the 2006 C&P Report, which was stated in constant 2004 dollars; however, accounting for inflation this new estimate is actually 6.5 percent lower in constant dollar terms. Similarly, assuming fixed rate user financing, the $174.6 billion average annual investment level under the **MinBCR=1.0 scenario** stated in constant 2006 dollars is significantly higher than the amount shown in 2004 dollars for the "Cost to Improve" scenario in the 2006 C&P Report. However, accounting for inflation, this new estimate for the 2007 to 2026 period is actually 7.5 percent lower in constant dollar terms than the projection for the 2005 to 2024 period reflected in the 2006 C&P Report. Due to the increase in construction costs, some potential projects that might have been considered cost-beneficial in the previous 2006 C&P Report would not longer meet that standard; however, those projects that would be implemented under this scenario would each be more expensive than was assumed in the 2006 C&P Report, adding to the costs associated with this scenario.

Exhibit 8-42 also shows the variable rate user financing versions of these two scenarios with values presented in sensitivity analyses shown in Chapter 10 of the 2006 C&P Report, that were generally comparable to the scenarios presented in this chapter. The $71.3 billion average annual investment level in constant 2006 dollars for the version of the **Sustain Conditions and Performance scenario** assuming variable rate user financing is significantly higher than the amount shown for the comparable 2004 dollar "Cost to Maintain" value shown in the 2006 C&P Report; however, accounting for inflation this new estimate is actually

Exhibit 8-42

Selected Highway, Bridge, and Transit Investment Scenario Projections Compared With Comparable Data From the 2006 C&P Report (Billions of Dollars)

Scenario	2005–2024 Projection (Based on 2004 Data) 2006 Report (Billions of 2004 $)	2005–2024 Projection (Based on 2004 Data) Adjusted for Inflation* (Billions of 2006 $)	2007–2026 Projection (Based on 2006 Data) (Billions of 2006 $)
Highway and Bridge Scenarios—All Roads			
Sustain Conditions and Performance Scenario Assuming Fixed Rate User Financing	$78.8	$112.9	$105.6
MinBCR=1.0 Scenario Assuming Fixed Rate User Financing	$131.7	$188.8	$174.6
Sustain Conditions and Performance Scenario Assuming Variable Rate User Financing	$57.2	$82.0	$71.3
Maximum Economic Investment Scenario (MinBCR=1.0 Assuming Variable Rate User Financing)	$110.8	$158.8	$131.3
Transit Scenarios (BCR=1.0)			
Maintain Conditions and Performance	$15.8	$17.3	$15.1
Improve Conditions and Maintain Performance	$16.4	$18.0	$15.2
Maintain Conditions and Improve Performance	$21.2	$23.2	$21.0
Improve Conditions and Performance	$21.8	$23.9	$21.1

* *The investment levels for the highway and bridge scenarios were adjusted for inflation using the FHWA Composite Bid Price Index. For transit, the ENR Building Construction Index, 2000 to 2008, was utilized.*

13.0 percent lower in constant dollar terms. Assuming variable rate user financing, the $131.3 billion average annual investment level under the **Maximum Economic Investment (MinBCR=1.0) scenario** stated in constant 2006 dollars is significantly higher than the comparable "Cost to Improve" figure presented in the 2006 C&P Report, stated in 2004 dollars. However, accounting for inflation, this new estimate for the 2007 to 2026 period is actually 17.3 percent lower in constant dollar terms than the projection for the 2005 to 2024 period reflected in the 2006 C&P Report.

The changes in the projected investment scenario levels from the 2006 C&P Report are also partially attributable both to changes in the underlying characteristics, conditions, and performance of the highway system as reported in the available data sources, and to changes in the methodology and models used to generate the estimates. In addition to the inflation adjustments noted above, the highway improvement costs estimates in HERS were updated to reflect better information regarding costs associated with projects in large urbanized areas. These new estimates, which are generally higher than those used previously, reflect the increasing complexity of implementing highway projects in large cities, which often require additional costs aimed at mitigating the impacts of improvements on the environment, communities, and current users of the roadways. Appendix A discusses other recently methodological improvements to HERS.

Exhibit 8-43 compares the estimated percentage differences between current spending and the average annual investment scenario estimates for the fixed rate user financing versions of **Sustain Conditions and Performance scenario** and the **MinBCR=1.0 scenario** and with the values reported for the primary "Maintain" and "Improve" scenarios identified in the 1997, 1999, 2002, 2004, and 2006 C&P Reports.

The recent increases in highway construction costs have caused the percentage difference between current capital spending and the fixed rate user financing versions of **Sustain Conditions and Performance scenario** to grow to 34.2 percent, which is the higher the comparable figures identified in recent editions, though it is lower than the 57.5 percent gap identified for the comparable "Maintain" scenario in the

Exhibit 8-43

Average Annual Highway and Bridge Investment Scenario Estimates vs. Current Spending, 1997 to 2008 C&P Reports

Report Year	Relevant Comparison	Percent Above Current Spending: Primary "Maintain" Scenario*	Percent Above Current Spending: Primary "Improve" Scenario*
1995	Average annual investment scenario estimates for 1994–2013 compared with 1997 spending	57.5%	112.6%
1997	Average annual investment scenario estimates for 1996–2015 compared with 1995 spending	21.0%	108.9%
1999	Average annual investment scenario estimates for 1998–2017 compared with 1997 spending	16.3%	92.9%
2002	Average annual investment scenario estimates for 2001–2020 compared with 2000 spending	17.5%	65.3%
2004	Average annual investment scenario estimates for 2003–2022 compared with 2002 spending	8.3%	74.3%
2006	Average annual investment scenario estimates for 2005–2024 compared with 2004 spending	12.2%	87.4%
2008	Average annual investment scenario estimates for 2007–2026 compared with 2006 spending	34.2%	121.9%

** Amounts shown correspond to the primary investment scenario associated with maintaining or improving the overall highway system in each C&P report; the definitions of these scenarios are not fully consistent between reports. The values shown for this report reflect the fixed rate user financing versions of the* ***Sustain Conditions and Performance*** *and the* ***Min BCR=1.0*** *scenarios.*

1995 C&P Report. The 121.9 percent difference between the current spending and the **MinBCR=1.0 scenario** has also increased sharply from the comparable figures presented in recent reports. Note that the variable rate financing versions of these two scenarios show much smaller gaps; as shown in *Exhibit 8-40* the difference between current spending and the **Maximum Economic Investment (Min BCR=1.0) scenario** is only 66.9 percent, while average annual investment for the **Sustain Conditions and Performance scenario** is actually 9.3 percent lower than base year spending.

Transit

As shown in *Exhibit 8-42,* for Maintain Conditions and Performance, the updated annual investment requirement projection for 2007 to 2026 of $15.1 billion per year is significantly less than the inflation adjusted amount of $17.3 billion from the 2006 C&P Report for 2005 to 2024. This trend continues with the Improve Conditions and Maintain Performance scenario, which compares a current estimate of a $15.2 billion per year investment requirement to an estimate of $18.0 billion per year in the 2006 C&P Report (both reported in 2006 dollars). Maintain Conditions and Improve Performance and Improve Conditions and Performance are more consistent with the estimates provided in the 2006 Report. However, when adjusted for inflation, the analyses presented in this report are again less than the estimates in 2006 dollars. These downward trending changes to projected annual investment requirements as compared to the 2006 C&P Report were driven primarily by updates to the available data through the National Transit Database as well as changes in the methodology used by the Transit Economic Requirements Model.

Exhibit 8-44 compares the percentage difference between current capital spending levels and the level of transit investment estimated by TERM in 2006 with the percentage difference between capital spending levels and the projected investment estimates from TERM provided in previous years C&P reports. As a result of methodological improvements, the TERM projections are not directly comparable from year to year. The annual amount of investment estimated by TERM to maintain conditions and performance between 2007 and 2026 is 28.2 percent higher than actual capital expenditures in 2006. In the 2006 C&P Report, the amount of annual investment estimated by TERM to maintain conditions and performance from 2005 to 2024 was 25.4 percent higher than actual capital expenditures in 2004. This comparison between actual spending and TERM projections had historically presented the TERM projections declining as a percentage difference to actual spend. This edition shows a larger gap between investment levels and current spending than was indicated in previous reports.

Exhibit 8-44

Average Annual Transit Investment by Scenario vs. Current Spending, 1995 to 2008 Conditions and Performance Reports

			Percent Above Current Spending	
Report Year	**Spending Year**	**Investment Forecast Years**	**Cost to Maintain Conditions and Performance**	**Cost to Improve Conditions and Performance**
1995	1993	1994–2013	37.6%	124.4%
1997	1995	1996–2015	38.3%	102.9%
1999	1997	1998–2017	41.0%	110.2%
2002	2000	2001–2020	63.8%	127.7%
2004	2002	2003–2022	26.8%	95.1%
2006	2004	2005–2024	25.4%	73.0%
2008	**2006**	**2007–2026**	**28.2%**	**64.1%**

Source: Transit Economic Requirements Model and FTA staff estimates.

Chapter 9

Scenario Implications

Highway Scenario Implications

This section provides additional discussion on key issues relating to the relationship between highway capital investment and the conditions and performance of the system to assist in the interpretation of the future capital investment scenarios for highways and bridges presented in Chapter 8. This includes an analysis of the impacts that recent and historic funding patterns identified in Chapter 6 have had on the highway conditions and performance trends reported in Chapters 3 and 4, particularly in light of the levels and composition of capital investment associated with the future capital investment scenarios presented in Chapter 8. This section also compares historic growth in vehicle miles traveled (VMT) with the State-generated travel forecasts that underlie the investment/performance analyses presented in this report and illustrates the potential impacts of alternative rates of future construction cost inflation. This section also analyzes the potential impacts of alternative assumptions regarding the timing of investments and the implementation of congestion pricing.

Linkage Between Recent Conditions and Performance and Spending Trends and Selected Capital Investment Scenarios

As discussed in Chapter 6, capital spending by all levels of government increased by 62.7 percent between 1997 and 2006, from $48.4 billion to $78.7 billion, but did not keep pace with the 69.4 percent increase in the Federal Highway Administration Composite Bid Price Index (BPI) over this period. This was primarily due to a sharp increase in the cost of construction materials between 2004 and 2006. In constant dollar terms, combined public and private highway capital spending fell by 4.0 percent between 1997 and 2006. Investment in system expansion (such as the widening of roads and the construction of new facilities) decreased by 14.2 percent in constant dollar terms over this period, while funding for system rehabilitation and system enhancement grew in constant dollar terms by 0.4 percent and 22.7 percent, respectively.

It is important to note that the overall decline in constant dollar capital spending for the period identified above is largely the result of the 40.3 percent increase in the BPI between 2004 and 2006. As indicated in the 2004 C&P Report, capital spending grew 22.9 percent in constant dollar terms between 1997 and 2004. There is a sometimes a delay between the point at which outlays are made and the point at which their impacts are quantifiable (i.e., partial payments on a complex project may have no impact until the project is completed and the road or bridge lane is opened or reopened to traffic). For this reason, the effect of these recent price increases on system conditions and performance may not yet be fully discernable.

Operational Performance

The analyses presented in Chapter 8 suggest that current highway investment levels would not be sufficient to sustain the operational performance of the highway system unless congestion pricing were broadly adopted. The $30.0 billion identified in Chapter 6 as capital spending by all levels of government for system expansion in 2006 is well below the $40.0 billion system expansion component of the fixed rate user financing version of the **Sustain Conditions and Performance scenario**, having fallen significantly in constant dollar terms as noted above. This finding is consistent with the recent declines in operational performance noted in Chapter 4 based on statistics computed using the methodology from the Texas

Transportation Institute's 2005 Urban Mobility Study. The Average Daily Percentage of VMT Under Congested Conditions in urbanized areas increased from 27.4 percent in 1997 to 31.6 percent in 2006. For the period from 1997 to 2005, the Average Length of Congested Conditions in urbanized areas increased from 6.2 hours to 6.6 hours, while the estimated Annual Person-Hours of Delay in those areas rose from 3.3 billion hours in 1997 to 5.1 billion hours in 2005.

Q&A

Why do the comparisons of recent conditions and performance trends and recent spending trends focus on the fixed rate user financing versions of the Chapter 8 scenarios?

Congestion pricing has not been adopted on the widespread basis assumed for the variable rate user financing versions of the Chapter 8 scenarios. The fixed rate user financing versions are more consistent with how highway spending is currently financed, and should provide better benchmarks for examining the impacts of recent spending on recent system performance.

Physical Conditions

Although investment in system rehabilitation has increased slightly in constant dollar terms since 1997 despite recent sharp increases in construction costs, the analyses presented in Chapter 8 suggest that current highway investment levels are not sufficient to sustain the physical conditions of all parts of the highway system. The $40.4 billion identified in Chapter 6 as capital spending by all levels of government for system rehabilitation in 2006 is below the $43.5 billion system rehabilitation component of the fixed rate user financing version of the **Sustain Conditions and Performance scenario**, and the $47.0 billion system rehabilitation component of the fixed rate user financing version of the **Sustain Conditions and Performance of System Components scenario**. The funding gaps are most dramatic for lower-ordered urban functional systems, which is consistent with the findings reported in Chapter 3.

The share of urbanized collector VMT on pavements classified as having good ride quality decreased from 39.8 percent in 1997 to 35.6 percent in 2006. The comparable values for urbanized minor arterials fell from 40.8 percent to 33.7 percent over this same period; declines were also observed for rural major collectors, small urban collectors, and small urban minor arterials. The share of urbanized collector VMT on pavements classified as having acceptable ride quality decreased from 84.4 percent in 1997 to 72.9 percent in 2006; the comparable values for urbanized minor arterials fell from 83.3 percent to 74.9 percent over this same period. Declines were also observed for urbanized other principal arterials, small urban collectors, and small urban minor arterials. The overall share of VMT on pavements with acceptable ride quality for all systems for which data were available fell from 86.4 percent in 1997 to 86.0 percent in 2006 because the decreases noted above for lower-ordered systems were largely offset by increases for higher-ordered systems including the Interstate System.

The 2004 C&P Report indicated that spending in 2004 exceeded the estimated investment level for the bridge component of the "Cost to Maintain" scenario, which was consistent with the report's findings regarding reductions over time in the percent of deficient bridges. However, the $11.1 billion bridge component of the system rehabilitation investment levels identified as part of the **Sustain Conditions and Performance scenario** in Chapter 8 is higher than the $10.1 billion of combined public and private capital investment for bridge rehabilitation and replacement in 2006 cited in Chapter 6. Although Chapter 3 showed continued progress over time in the reduction of the percentage of bridges classified as deficient, from 34.2 percent in 1996 to 27.6 percent in 2006, these gains have not been as large in recent years and have not been consistent across all bridge performance measures. Between 2004 and 2006, the percent of deficient bridges on urban collectors rose slightly, as did the percent of travel on deficient National Highway System (NHS) bridges.

Historic and Projected Travel Growth

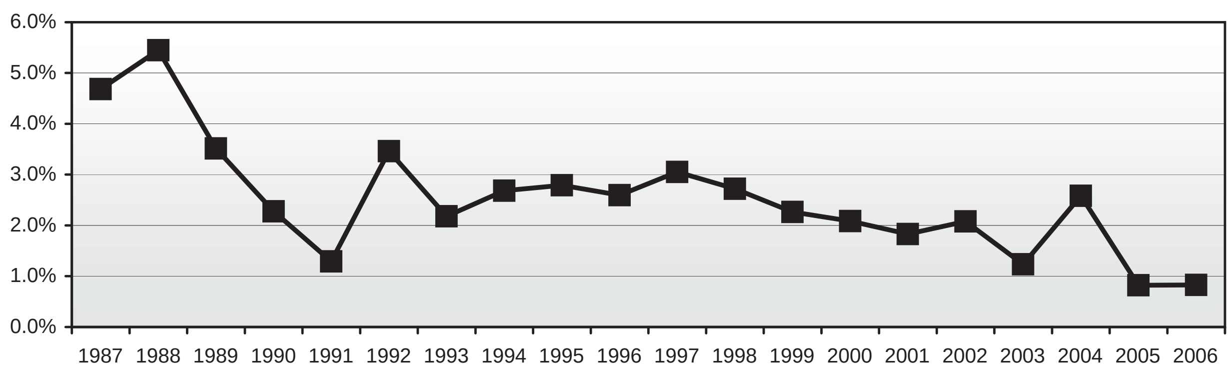
The Highway Performance Monitoring System (HPMS) data supplied by States is the source of the annual VMT statistics presented in this report, as well as the forecasts of future VMT used as input to the Highway Economic Requirements System (HERS) analysis. Separate 20-year forecasts are provided for each of the more than 119,000 HPMS sample sections, based on information that each State has available concerning the particular section and the corridor of which it is a part.

Historic Travel Growth

From 1986 to 2006, annual highway VMT increased from 1.85 trillion to 3.03 trillion, growing at an average annual growth rate of 2.52 percent. As shown in *Exhibit 9-1*, travel growth has varied somewhat from year to year, ranging from a high of 5.45 percent in 1988 to a low of 0.82 percent in 2005, and has generally been trending downward. For 10 out of these 20 years, annual VMT grew at a rate between 2 percent and 3 percent annually. Annual VMT growth exceeded 3 percent in 5 of these 20 years, and slowed to below 2 percent in another 5 of these years. As noted in Chapter 2, preliminary information for 2007 and early 2008 indicate that VMT growth may be negative in one or both of those years. Highway travel growth has typically been lower during periods of slow economic growth and/or higher fuel prices, and higher during periods of economic expansion.

Exhibit 9-1

Annual VMT Growth Rates, 1986 – 2006



Source: Highway Performance Monitoring System.

Travel Growth Forecasts

The composite weighted average annual VMT growth rate based on the 20-year travel forecasts supplied by States with their 2006 HPMS sample section data is 1.84 percent. This is significantly below the average growth rate over the prior 20 years, although it is larger than the growth rates observed since 2004. Projected growth in rural areas (2.07 percent average annual) is somewhat higher than in urban areas (1.72 percent).

Exhibit 9-2 shows projected year-by-year VMT for the period 2006 to 2026 derived from these forecasts under two different assumptions about future growth patterns: geometric growth (growing at a constant annual rate) and linear growth (growing by a constant amount annually, implying that rates would gradually decline over the forecast period). The HERS analyses presented in this report used the linear growth assumption.

The HERS assumes that the HPMS forecasts represent the level of travel that would occur if a constant level of service were maintained and the cost of using the facility remain unchanged. As indicated in Chapter 7,

Do the travel demand elasticity features in HERS differentiate between the components of user costs based on how accurately highway users perceive them?

Q&A

No. The model assumes that comparable reductions or increases in travel time costs, vehicle operating costs, or crash costs would have the same effect on future VMT. The elasticity values in HERS were developed from studies relating actual costs to observed behavior; these studies did not explicitly consider perceived costs of individual user cost components.

Highway users can directly observe some types of user costs such as travel time and fuel costs. Other types of user costs, such as crash costs, can be measured only indirectly. In the short run, directly observed costs may have a greater effect on travel choice than costs that are harder to perceive. However, while highway users may not be able to accurately assess the crash risk for a given facility, they can incorporate their general perceptions of the relative safety of a facility into their decision-making process. The model assumes that the highway users' perceptions of costs are accurate, in the absence of strong empirical evidence that they are biased.

this implies that travel will occur at this level only if pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway user costs at current levels throughout the 20 year period. The travel demand elasticity features in HERS assume that highway users will respond to increases in the cost of traveling a highway facility by shifting to other routes, switching to other modes of transportation, or forgoing some trips entirely. The model also assumes that reducing user costs on a facility will induce additional traffic on that route that would not otherwise have occurred. Future pavement and widening improvements would tend to reduce highway user costs and induce additional travel on the improved sections. If a highway section is not improved, highway user costs on that section would tend to rise over time because of pavement deterioration and/or increased congestion, thereby suppressing some travel on that section. Increases in fuel prices or other costs experienced by drivers would also tend to suppress travel below the HPMS baseline forecast.

Exhibit 9-2

Annual Projected Highway VMT Based on Highway Performance Monitoring System Forecasts

(VMT in Billions)		
Growth Pattern	Linear Growth (Constant Annual Amount)	Geometric Growth (Constant Annual Rate)
2006 (actual)	3,014	3,014
2007	3,080	3,069
2008	3,146	3,126
2009	3,213	3,183
2010	3,279	3,242
2011	3,345	3,301
2012	3,411	3,362
2013	3,477	3,423
2014	3,543	3,486
2015	3,609	3,550
2016	3,676	3,616
2017	3,742	3,682
2018	3,808	3,750
2019	3,874	3,818
2020	3,940	3,888
2021	4,006	3,960
2022	4,072	4,033
2023	4,139	4,107
2024	4,205	4,182
2025	4,271	4,259
2026	4,337	4,337

Source: Highway Performance Monitoring System.

One implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. Since higher investment levels generally result in reduced highway user costs, they also tend to result in higher levels of VMT growth. Another implication is that any external projection of future VMT growth will be valid only for a single level of investment in HERS. Thus, the baseline HPMS forecasts would be valid only under a specific set of conditions. *Exhibit 7-6* in Chapter 7 identifies a range of projected 2026 VMT for different possible funding levels and financing mechanisms ranging from 4.187 trillion to 4.456 trillion; this would equate to average annual VMT growth rates of 1.62 percent to 1.94 percent.

Chapter 10 includes sensitivity analyses identifying the potential impacts of selected alternative travel demand forecasts on future system conditions and performance. The potential impacts of higher fuel prices are also explored.

Accounting for Inflation

The analyses of potential future investment/performance relationships reflected in the C&P report have traditionally been stated in constant dollars, with the base year set according to the year of the conditions and performance data supporting the analysis. As noted frequently in Chapters 7 and 8, all of the analyses in this edition are presented in constant 2006 dollars.

When applying these analytical findings in other contexts, such as comparing a particular scenario with nominal dollar revenue projections, it is sometimes necessary to adjust for inflation to ensure an accurate comparison. Such adjustments could be made by applying an assumption about future inflation to either convert the C&P report's constant dollar numbers to nominal dollars, or to convert the nominal projected revenues to constant 2006 dollars. *Exhibit 9-3* illustrates how the constant dollar figures associated with the **Interstate Sustain Conditions and Performance scenario** presented in Chapter 8 could be converted to nominal dollars, based on three alternative inflation rates selected for their historical significance. The largest 20-year increase in the FHWA Composite BPI since 1956 occurred from 1960 to 1980, while the smallest 20-year increase occurred from 1980 to 2000; the average annual BPI increase for the former period was 7.4 percent, while the comparable annual rate for the latter period was 2.0 percent. From 1986 to 2006, the BPI grew at an average annual rate of 4.0 percent.

The constant dollar figures for the **Interstate Sustain Conditions and Performance scenario** reflect the gradual ramping up of investment levels described in Chapter 7, and illustrated in *Exhibit 7-2*. As described

Q&A

Why are the investment analyses presented in this report expressed in constant base year dollars?

The investment/performance models discussed in this report estimate the future benefits and costs of transportation investments in constant dollar terms. This is standard practice for this type of economic analysis. To convert the model outputs from constant dollars to nominal dollars, it would be necessary to externally adjust them to account for projected future inflation.

Traditionally, this type of adjustment has not been made in the C&P report. As inflation prediction is an inexact science, adjusting the constant dollar figures to nominal dollars would tend to add to the uncertainty of the overall results, and make the report more difficult to use if the inflation assumptions were later proved to be incorrect. Allowing readers to make their own inflation adjustments based on actual trends observed subsequent to the publication of the C&P report and/or their the most recent projections from other sources is expected to yield a better overall result, particularly in light of recent sharp increases in highway construction materials costs that were not fully anticipated.

The use of constant dollar figures is also intended to provide readers with a reasonable frame of reference in terms of an overall cost level that they have recently experienced. When inflation rates are compounded for 20 years, even relatively small growth rates can produce nominal dollar values that appear very large when viewed from the perspective of today's typical costs.

The primary drawback to using constant base year dollar figures in the C&P report is that they are sometimes misapplied by readers, and treated as if they were expressed in current year dollars. However, as the C&P report is produced every two years, the base year costs reflected in the most recent edition are generally close enough to current costs to provide a useful perspective.

Inflation is but one of two separate and distinct factors that account for why the value of a dollar, as seen from the present, diminishes over time. The second factor is the time value of resources, which reflects that there is a cost associated with diverting the resources needed for an investment from other productive uses. The investment/performance models described in this report take the time value of resources into account via a separate mechanism called the discount rate, which is discussed in Chapter 10.

Exhibit 9-3

Illustration of Potential Impact of Alternative Inflation Rates on Interstate Sustain Conditions and Performance Scenario

Year	Interstate Sustain Conditions and Performance Scenario * Highway Capital Investment (Billions of Dollars)							
	Assuming Fixed Rate User Financing (3.71 Percent Annual Constant Dollar Growth)				Assuming Variable Rate User Financing (3.49 Percent Annual Constant Dollar Decline)			
		Nominal Dollars				Nominal Dollars		
	Constant 2006 Dollars	Assuming 2.0 Percent Inflation	Assuming 4.0 Percent Inflation	Assuming 7.4 Percent Inflation	Constant Dollar	Assuming 2.0 Percent Inflation	Assuming 4.0 Percent Inflation	Assuming 7.4 Percent Inflation
2006	$16.5	$16.5	$16.5	$16.5	$16.5	$16.5	$16.5	$16.5
2007	$17.2	$17.5	$17.8	$18.4	$16.0	$16.3	$16.6	$17.1
2008	$17.8	$18.5	$19.2	$20.5	$15.4	$16.0	$16.7	$17.8
2009	$18.5	$19.6	$20.8	$22.9	$14.9	$15.8	$16.7	$18.4
2010	$19.1	$20.7	$22.4	$25.5	$14.4	$15.5	$16.8	$19.1
2011	$19.8	$21.9	$24.1	$28.4	$13.8	$15.3	$16.9	$19.8
2012	$20.6	$23.2	$26.0	$31.6	$13.4	$15.1	$16.9	$20.5
2013	$21.3	$24.5	$28.1	$35.2	$12.9	$14.8	$17.0	$21.3
2014	$22.1	$25.9	$30.3	$39.2	$12.4	$14.6	$17.0	$22.0
2015	$23.0	$27.4	$32.7	$43.6	$12.0	$14.4	$17.1	$22.8
2016	$23.8	$29.0	$35.2	$48.6	$11.6	$14.1	$17.2	$23.7
2017	$24.7	$30.7	$38.0	$54.1	$11.2	$13.9	$17.2	$24.5
2018	$25.6	$32.5	$41.0	$60.3	$10.8	$13.7	$17.3	$25.4
2019	$26.6	$34.4	$44.2	$67.2	$10.4	$13.5	$17.4	$26.4
2020	$27.5	$36.3	$47.7	$74.8	$10.1	$13.3	$17.4	$27.3
2021	$28.6	$38.4	$51.4	$83.3	$9.7	$13.1	$17.5	$28.3
2022	$29.6	$40.7	$55.5	$92.8	$9.4	$12.9	$17.5	$29.4
2023	$30.7	$43.0	$59.8	$103.4	$9.0	$12.7	$17.6	$30.4
2024	$31.9	$45.5	$64.5	$115.1	$8.7	$12.5	$17.7	$31.5
2025	$33.0	$48.1	$69.6	$128.2	$8.4	$12.3	$17.7	$32.7
2026	$34.3	$50.9	$75.1	$142.8	$8.1	$12.1	$17.8	$33.9
Total	**$495.6**	**$628.8**	**$803.6**	**$1,236.1**	**$232.6**	**$281.6**	**$344.0**	**$492.4**
Average Annual	**$24.8**				**$11.6**			

* *Based on average annual investment levels and annual constant dollar growth rates identified in Exhibit 7-5.*

Source: FHWA Staff Analysis.

in *Exhibit 8-5,* combined public and private highway capital investment would rise by 3.71 percent annually in constant dollar terms under the version of this scenario assuming fixed rate user financing, and would decrease by 3.49 percent annually in the variable rate user financing version of the scenario.

Assuming fixed rate user financing, the average annual capital spending level under this scenario of $24.8 billion in constant 2006 dollars corresponds to a 20-year total of $495.6 billion. Assuming a 2.0 percent annual increase in highway construction costs, this would translate into a nominal dollar figure of $628.8 billion; annual inflation of 7.4 percent would yield a nominal dollar figure of over $1.2 trillion.

Assuming variable rate user financing, the average annual capital spending level under this scenario of $11.6 billion in constant 2006 dollars corresponds to a 20-year total of $232.6 billion. Assuming a 2.0 percent annual increase in highway construction costs, this would translate into a nominal dollar figure of $281.6 billion; annual inflation of 7.4 percent would yield a nominal dollar figure of $492.4 billion.

While each project is different, States generally have faced increased prices for roadway construction and maintenance. As noted in Chapter 6, the BPI increased by 43.3 percent between 2004 and 2006, driven by large increases in the prices of steel, asphalt, and concrete. Worldwide demand from China, Europe, India, and the United States has put pressure on the refining and producing capacities for these construction materials. While anecdotal evidence suggests that some of these trends may be abating, it would not be surprising if highway construction costs continue to rise more quickly than consumer prices in the short term. Such increases can have significant impact on the ability of the public and private owners of the various components of the highway system to effectively manage the conditions and performance of these assets.

Timing of Investment

While the investment/performance analyses presented in this report focus mainly on how alternative average annual investment levels over 20 years might impact system performance at the end of that period, it is important to recognize that the timing of investment can have significant performance implications within this time period. As discussed in Chapter 7, the analyses for this report assumed that any increase or decrease in combined public and private investment would occur gradually, at a constant rate relative to 2006.

Although some previous editions of the C&P report included exhibits illustrating a gradual ramping up of spending levels, this was not consistent with the actual modeling assumptions in HERS and the National Bridge Investment Analysis System (NBIAS). The HERS analyses presented in the 2004 C&P Report were tied directly to alternative benefit-cost ratio cutoffs rather than to particular levels of investment in any given year. At higher spending levels, this approach resulted in a significant front-loading of capital investment in the early years of the analysis as the existing backlog of potential cost-beneficial investments was addressed, followed by a sharp decline in later years. The 2006 C&P Report assumed that combined public and private capital investment would immediately jump to the average annual level being analyzed, then remain fixed at that level for 20 years. In contrast, the baseline analyses presented in this report were constructed from HERS and NBIAS analyses that directly assumed a gradually ramping up or down in spending, depending on the investment level being analyzed.

Highway and Bridge Investment Backlog

The highway investment backlog represents all highway improvements that could be economically justified for immediate implementation, based on the current conditions and operational performance of the highway system. The HERS model estimates that a total of $523.5 billion of investment could be justified nationwide based solely on the current conditions and operational performance of the highway system. Approximately 86.1 percent of the backlog is in urban areas, with the remainder in rural areas. Capacity deficiencies on existing highways account for 46.2 percent of the backlog; the remainder results from pavement deficiencies. Approximately 57.6 percent of the backlog is on the NHS, while 34.5 percent of the backlog is on the Interstate highway system (a subset of the NHS).

The $523.5 billion dollar backlog figure noted above does not include the $98.9 billion economic bridge investment backlog figure computed by NBIAS and identified in Chapter 7. Combining these two figures yields a total highway and bridge investment backlog of $622.4 billion.

Note that the HERS-derived figure does not reflect rural minor collectors or rural and urban local roads and streets because HPMS does not contain sample section data for these functional systems; these systems are reflected in the NBIAS estimates. The combined backlog figure does not contain any estimate for system enhancements, which are not currently modeled. The HERS-derived figure assumes funding from non-user sources; the model is not currently equipped to compute a backlog assuming other financing mechanisms.

Alternative Timing of Investment in HERS

Exhibit 9-4 indicates how alternative assumptions regarding the timing of investment would impact the distribution of spending among the four 5-year funding periods considered in HERS. For the baseline

Exhibit 9-4

Distribution of Spending Among 5-Year HERS Analysis Periods, for Alternative Approaches to Investment Timing and Financing Mechanisms

Baseline Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars) [1]	Percentage of HERS-Modeled Spending Occuring in Each 5-Year Period								
		Baseline				Alternatives				
		Ramped Spending				Flat Spending Each Period	BCR-Driven Spending			
		2007 to 2011	2012 to 2016	2017 to 2021	2022 to 2026		2007 to 2011	2012 to 2016	2017 to 2021	2022 to 2026
Assuming Fixed Rate User Financing										
7.45%	$111.5	13.5%	19.3%	27.6%	39.6%	25.0%	36.8%	20.3%	19.2%	23.7%
6.70%	$102.0	14.4%	19.9%	27.6%	38.1%	25.0%	36.0%	20.9%	19.7%	23.4%
6.41%	$98.6	14.8%	20.2%	27.5%	37.5%	25.0%	35.2%	21.3%	19.7%	23.8%
5.25%	$86.1	16.4%	21.1%	27.3%	35.2%	25.0%	34.0%	23.4%	20.8%	21.7%
5.15%	$85.1	16.5%	21.2%	27.3%	35.0%	25.0%	33.9%	23.6%	21.0%	21.4%
5.03%	$84.0	16.7%	21.3%	27.2%	34.8%	25.0%	33.7%	24.1%	20.9%	21.3%
4.55%	$79.5	17.4%	21.7%	27.1%	33.8%	25.0%	32.9%	24.8%	20.5%	21.8%
4.17%	$76.1	17.9%	22.0%	27.0%	33.1%	25.0%	32.4%	25.1%	21.3%	21.2%
3.30%	$69.0	19.3%	22.7%	26.7%	31.4%	25.0%	29.9%	27.7%	21.4%	21.0%
3.07%	$67.2	19.6%	22.9%	26.6%	30.9%	25.0%	29.3%	28.3%	21.6%	20.8%
2.93%	$66.2	19.9%	23.0%	26.5%	30.6%	25.0%	29.0%	28.4%	21.7%	20.9%
1.67%	$57.6	22.0%	23.9%	25.9%	28.2%	25.0%	26.9%	29.0%	22.5%	21.6%
0.83%	$52.6	23.5%	24.5%	25.5%	26.6%	25.0%	24.9%	30.1%	22.9%	22.1%
0.34%	$50.0	24.4%	24.8%	25.2%	25.6%	25.0%	23.9%	30.3%	23.1%	22.7%
0.00%	**$48.2**	**25.0%**	**25.0%**	**25.0%**	**25.0%**	25.0%	23.2%	30.8%	23.3%	22.7%
-0.78%	$44.4	26.5%	25.5%	24.5%	23.6%	25.0%	22.7%	31.0%	24.1%	22.2%
-1.37%	$41.8	27.6%	25.8%	24.1%	22.5%	25.0%	22.0%	31.2%	24.1%	22.8%
-4.95%	$29.5	35.2%	27.3%	21.2%	16.4%	25.0%	19.5%	30.9%	25.6%	23.9%
-7.64%	$23.2	41.2%	27.7%	18.6%	12.5%	25.0%	18.8%	31.3%	25.8%	24.2%
Assuming Variable Rate User Financing										
4.55%	$79.5	17.4%	21.7%	27.1%	33.8%					
4.17%	$76.1	17.9%	22.0%	27.0%	33.1%	25.0%	37.9%	23.1%	19.1%	19.9%
3.30%	$69.0	19.3%	22.7%	26.7%	31.4%	25.0%	36.8%	23.8%	19.9%	19.5%
3.07%	$67.2	19.6%	22.9%	26.6%	30.9%	25.0%	36.2%	24.2%	20.2%	19.3%
2.93%	$66.2	19.9%	23.0%	26.5%	30.6%	25.0%	36.2%	24.6%	20.2%	19.1%
1.67%	$57.6	22.0%	23.9%	25.9%	28.2%	25.0%	34.3%	26.3%	21.4%	18.0%
0.83%	$52.6	23.5%	24.5%	25.5%	26.6%	25.0%	31.7%	27.7%	21.5%	19.2%
0.34%	$50.0	24.4%	24.8%	25.2%	25.6%	25.0%	30.5%	28.4%	21.7%	19.3%
0.00%	**$48.2**	**25.0%**	**25.0%**	**25.0%**	**25.0%**	25.0%	30.2%	29.0%	22.0%	18.9%
-0.78%	$44.4	26.5%	25.5%	24.5%	23.6%	25.0%	27.8%	30.3%	22.1%	19.8%
-1.37%	$41.8	27.6%	25.8%	24.1%	22.5%	25.0%	26.9%	31.1%	22.5%	19.5%
-4.95%	$29.5	35.2%	27.3%	21.2%	16.4%	25.0%	20.4%	35.0%	23.3%	21.3%
-7.64%	$23.2	41.2%	27.7%	18.6%	12.5%	25.0%	18.2%	35.3%	24.8%	21.7%

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] Each percentage distribution shown corresponds to a HERS analysis assuming investment up to a minimum benefit-cost ratio cutoff point. For each row, this cutoff was set at a level such that total spending would be consistent with the average annual spending level shown.

Source: Highway Economic Requirements System.

analyses, the distribution of spending among funding periods is driven by the annual constant dollar spending growth rate assumed; for higher growth rates, a smaller percentage of total 20-year investment would occur in the first 5 years. When a 0-percent growth rate is assumed, one-quarter of total spending would occur in each of the 5-year funding periods.

The "BCR-driven" spending percentages identified in *Exhibit 9-4* represent the distribution of spending that would occur if a uniform minimum benefit-cost ratio were applied in HERS across all four 5-year funding periods. The benefit-cost cutoff points were selected to coordinate with the total 20-year spending for each of the baseline analyses. At higher spending levels, the existence of the backlog of cost-beneficial investments would cause a higher percentage of spending to occur in the first 5-year period through 2011. This effect is less pronounced at lower levels of investment, as some potential projects included in the estimated backlog would have a benefit-cost ratio below the cutoff point associated with that level of spending, and would thus be deferred for consideration in later funding periods. Assuming that any changes in combined public and private highway capital spending were supported by a fixed rate user financing mechanism, the portion of spending occurring in the first 5 years ranged from 18.8 percent for the lowest spending level analyzed up to 36.8 percent for the highest spending level. Assuming that variable rate user charges were imposed, the share of spending for the 2007 to 2011 period ranged from 18.2 percent to 37.9 percent of the 20-year total.

Exhibits 9-5 and *9-6* identify the impacts of alternative investment timing on adjusted average user costs assuming fixed rate user financing and variable rate user financing, respectively. Looking at the 2026 figures, the differences in adjusted average user costs do not vary significantly among the three investment patterns. For example, the amount of investment projected to result in adjusted average user costs in 2026 being maintained at base year 2006 levels is approximately the same in each case. This suggests that the amount of cumulative 20-year constant dollar investment is more critical to system performance than the distribution of that investment within the 20-year period. The potential benefits of front-loading capital spending toward the early part of the analysis period become more apparent when considering the intermediate year user costs shown in *Exhibits 9-5* and *9-6* for 2011, 2016, and 2021, in light of the spending shares by funding period identified in *Exhibit 9-4*.

The fixed rate user financing analyses reflected in *Exhibit 9-5* indicate that, for the highest level of investment shown (consistent with an average annual level of $111.5 billion), adjusted average highway user costs would be expected to increase by 2.1 percent by 2011 assuming a ramped up spending pattern directing 13.5 percent of total 20-year investments to the period from 2007 to 2011. If combined public and private investment were to immediately jump to this average annual investment level, so that 25.0 percent of spending would occur in the first 5 years, then adjusted average user costs would be expected to increase by only 0.5 percent by 2011. Assuming a front-loaded minimum benefit-cost ratio investment approach with 36.8 percent of this level of 20-year spending occurring in the first 5 years, adjusted average user costs would be expected to decrease by 0.6 percent. It should be noted that, based on projected travel volumes for 2026, each 1-percent decrease in user costs would generate savings to system users of approximately $40 billion annually. This suggests that, if resources were available to immediately address a significant portion of the existing backlog of cost-beneficial highway investments, this would produce significant savings to system users, even if annual investment later dropped to lower levels.

Exhibit 9-5												
Projected Changes in Highway User Costs for 2011, 2016, 2021, and 2026 Compared With 2006 Levels for Different Possible Approaches to Investment Timing, Assuming Fixed Rate User Financing												
Average Annual Spending Modeled in HERS (Billions of 2006 Dollars) [1]	**Change in Adjusted Average User Costs Relative to 2006 on Roads Modeled In HERS** [2]											
	Baseline				**Alternatives**							
	Ramped Spending, Percent Change as of:				**Flat Spending, Percent Change as of:**				**BCR-Driven Spending, Percent Change as of:**			
	2011	**2016**	**2021**	**2026**	**2011**	**2016**	**2021**	**2026**	**2011**	**2016**	**2021**	**2026**
$111.5	2.1%	0.7%	-1.0%	-2.9%	0.5%	-1.1%	-2.1%	-2.8%	-0.6%	-1.6%	-2.1%	-2.7%
$102.0	2.1%	0.9%	-0.7%	-2.4%	0.8%	-0.8%	-1.7%	-2.3%	-0.3%	-1.3%	-1.7%	-2.3%
$98.6	2.1%	0.9%	-0.6%	-2.3%	0.9%	-0.6%	-1.5%	-2.1%	-0.1%	-1.1%	-1.6%	-2.1%
$86.1	2.2%	1.2%	-0.1%	-1.5%	1.2%	0.0%	-0.9%	-1.4%	0.4%	-0.6%	-1.1%	-1.4%
$85.1	2.2%	1.2%	0.0%	-1.4%	1.2%	0.0%	-0.8%	-1.4%	0.4%	-0.6%	-1.1%	-1.3%
$84.0	2.2%	1.3%	0.0%	-1.4%	1.3%	0.0%	-0.7%	-1.3%	0.5%	-0.6%	-1.0%	-1.3%
$80.4	2.3%	1.4%	0.2%	-1.1%	1.4%	0.2%	-0.5%	-1.0%	0.7%	-0.4%	-0.7%	-1.0%
$79.5	2.3%	1.4%	0.2%	-1.0%	1.4%	0.3%	-0.4%	-1.0%	0.7%	-0.3%	-0.7%	-1.0%
$76.1	2.3%	1.5%	0.4%	-0.8%	1.5%	0.5%	-0.2%	-0.7%	0.8%	-0.1%	-0.5%	-0.7%
$69.0	2.4%	1.7%	0.8%	-0.2%	1.8%	0.9%	0.3%	-0.1%	1.3%	0.3%	0.0%	-0.1%
$68.3	2.4%	1.7%	0.9%	-0.1%	1.8%	1.0%	0.4%	-0.1%	1.4%	0.3%	0.0%	-0.1%
$67.2	2.4%	1.8%	0.9%	**0.0%**	1.8%	1.0%	0.5%	**0.0%**	1.4%	0.4%	0.1%	**0.0%**
$66.4	2.4%	1.8%	1.0%	0.1%	1.8%	1.1%	0.5%	0.1%	1.5%	0.4%	0.2%	0.1%
$66.2	2.4%	1.8%	1.0%	0.1%	1.8%	1.1%	0.5%	0.1%	1.5%	0.5%	0.2%	0.1%
$57.6	2.5%	2.1%	1.6%	1.0%	2.2%	1.7%	1.3%	1.0%	2.0%	1.2%	1.1%	1.0%
$52.6	2.5%	2.3%	2.0%	1.5%	2.4%	2.1%	1.8%	1.5%	2.4%	1.7%	1.6%	1.5%
$50.0	2.6%	2.4%	2.2%	1.8%	2.5%	2.3%	2.1%	1.8%	2.6%	2.0%	2.0%	1.8%
$48.2	2.6%	2.4%	2.3%	2.1%	2.6%	2.4%	2.3%	2.1%	2.7%	2.2%	2.2%	2.1%
$44.4	2.6%	2.6%	2.7%	2.6%	2.7%	2.8%	2.8%	2.6%	2.9%	2.5%	2.6%	2.6%
$44.1	2.6%	2.6%	2.7%	2.6%	2.8%	2.8%	2.8%	2.6%	3.0%	2.5%	2.6%	2.7%
$41.8	2.7%	2.7%	2.9%	3.0%	2.9%	3.0%	3.1%	3.0%	3.1%	2.8%	3.0%	3.0%
$29.5	2.9%	3.6%	4.4%	5.2%	3.5%	4.5%	5.1%	5.3%	3.8%	4.4%	5.0%	5.3%
$23.2	3.1%	4.2%	5.5%	6.7%	3.8%	5.3%	6.3%	6.7%	4.2%	5.3%	6.3%	6.7%

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The performance impacts identified in this table are driven by spending modeled in HERS, and do not reflect rural minor collectors, rural local, or urban local roads, because these functional systems are not included in the HPMS sample data.

Source: Highway Economic Requirements System.

The variable rate user financing analyses reflected in *Exhibit 9-6* show similar results to the fixed rate user financing analyses presented in *Exhibit 9-5*, except that the relative impacts to highway users were more favorable across the board. It is worth noting, however, that while HERS was able to spend at an average annual rate of $79.5 billion assuming ramped up spending over time, the model was not able to identify sufficient opportunities for cost-beneficial spending at this level if a flat spending approach was utilized, or if investment was driven by minimum benefit-cost ratio cutoffs.

Exhibit 9-6

Projected Changes in Highway User Costs for 2011, 2016, 2021, and 2026 Compared With 2006 Levels for Different Possible Approaches to Investment Timing, Assuming Variable Rate User Financing

Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)[1]	Change in Adjusted Average User Costs Relative to 2006 on Roads Modeled In HERS[2]											
	Baseline				Alternatives							
	Ramped Spending, Percent Change as of:				Flat Spending, Percent Change as of:				BCR-Driven Spending, Percent Change as of:			
	2011	2016	2021	2026	2011	2016	2021	2026	2011	2016	2021	2026
$79.5	1.5%	0.0%	-1.3%	-2.7%								
$76.1	1.6%	0.1%	-1.2%	-2.5%	0.9%	-0.7%	-1.6%	-2.5%	-0.1%	-1.3%	-1.8%	-2.4%
$69.0	1.6%	0.2%	-1.0%	-2.1%	1.1%	-0.3%	-1.3%	-2.1%	0.2%	-1.0%	-1.5%	-2.1%
$68.3	1.6%	0.2%	-0.9%	-2.1%	1.1%	-0.3%	-1.2%	-2.1%	0.3%	-0.9%	-1.5%	-2.0%
$67.2	1.6%	0.3%	-0.9%	-2.0%	1.2%	-0.3%	-1.2%	-2.0%	0.3%	-0.9%	-1.4%	-2.0%
$66.4	1.6%	0.3%	-0.9%	-2.0%	1.2%	-0.2%	-1.1%	-1.9%	0.4%	-0.9%	-1.4%	-1.9%
$66.2	1.6%	0.3%	-0.9%	-2.0%	1.2%	-0.2%	-1.1%	-1.9%	0.4%	-0.8%	-1.4%	-1.9%
$57.6	1.7%	0.5%	-0.4%	-1.4%	1.5%	0.2%	-0.6%	-1.4%	0.8%	-0.4%	-1.0%	-1.4%
$52.6	1.8%	0.7%	-0.2%	-1.0%	1.6%	0.5%	-0.3%	-1.0%	1.2%	0.0%	-0.6%	-1.0%
$50.0	1.8%	0.7%	0.0%	-0.8%	1.7%	0.7%	0.0%	-0.8%	1.4%	0.2%	-0.3%	-0.8%
$48.2	1.8%	0.8%	0.1%	-0.6%	1.8%	0.8%	0.1%	-0.6%	1.5%	0.3%	-0.2%	-0.6%
$44.4	1.8%	1.0%	0.3%	-0.3%	2.0%	1.1%	0.4%	-0.3%	1.8%	0.6%	0.2%	-0.3%
$44.1	1.8%	1.0%	0.4%	-0.2%	2.0%	1.1%	0.5%	-0.2%	1.8%	0.6%	0.2%	-0.2%
$41.8	1.9%	1.1%	0.5%	**0.0%**	2.0%	1.2%	0.7%	**0.0%**	1.9%	0.8%	0.4%	**0.0%**
$29.5	2.1%	1.6%	1.6%	1.6%	2.6%	2.3%	2.1%	1.6%	2.8%	2.0%	1.9%	1.6%
$23.2	2.2%	2.0%	2.4%	2.6%	2.8%	3.0%	3.0%	2.7%	3.2%	2.8%	2.9%	2.7%

[1] *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.*

[2] *The performance impacts identified in this table are driven by spending modeled in HERS, and do not reflect rural minor collectors, rural local, or urban local roads, because these functional systems are not included in the HPMS sample data.*

Source: Highway Economic Requirements System.

Alternative Timing of Investment in NBIAS

Exhibit 9-7 identifies the impacts of alternative investment timing on the backlog of potentially cost-beneficial bridge investments. As discussed in Chapter 7, changes in the economic bridge investment backlog can be viewed as a proxy for changes in overall bridge conditions.

The relative impacts of the alternative bridge investment approaches identified in *Exhibit 9-7* vary by funding level. A flat spending approach would result in a lower economic backlog in 2026 than the ramped approach assumed in the baseline analyses for a range of funding levels stretching from the 2006 spending level of $10.1 billion up to a point consistent with an average annual investment level falling somewhere between $12.1 billion to $13.9 billion, stated in constant 2006 dollars. For investment levels falling above or below this range, the ramped approach would result in a lower economic backlog in 2026. This pattern suggests that, while there are advantages to steering a larger share of investment to the early portion of the 20-year analysis period to address the existing economic backlog, increased spending in the later years would help address new deficiencies in bridge elements that are expected to emerge over time.

Exhibit 9-7 also shows that the BCR-driven spending approach would result in a lower 2026 economic backlog than the baseline ramped approach for a range of funding levels stretching from a point consistent with an average annual investment level between $4.9 billion and $6.2 billion in constant 2006 dollars up

Exhibit 9-7

Projected Changes in 2026 Bridge Investment Backlog Compared With 2006 Levels for Different Possible Funding Levels and Approaches to Investment Timing

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in NBIAS (Billions of 2006 Dollars) [1]	2026 Bridge Economic Investment Backlog for System Rehabilitation (Billions of 2006 Dollars) [2]			Percent Change in 2026 Bridge Economic Backlog for System Rehabilitation Compared to 2006		
		Baseline, Ramped Spending	Alternatives		Baseline, Ramped Spending	Alternatives	
			Flat Spending	BCR-Driven Spending		Flat Spending	BCR-Driven Spending
5.15%	$17.9	$0.0	$19.6	$21.1	**-100.0%**	-80.2%	-78.7%
5.03%	$17.6	$3.5	$21.4	$22.5	-96.5%	-78.4%	-77.2%
4.65%	$16.9	$15.5	$27.1	$27.5	-84.3%	-72.6%	-72.2%
4.55%	$16.7	$18.3	$28.9	$28.8	-81.5%	-70.8%	-70.9%
4.17%	$16.0	$28.5	$35.5	$33.7	-71.2%	-64.1%	-65.9%
3.30%	$14.5	$49.7	$51.6	$51.0	-49.7%	-47.8%	-48.4%
3.21%	$14.4	$51.8	$53.3	$52.7	-47.6%	-46.1%	-46.7%
3.07%	$14.1	$55.0	$55.8	$55.2	-44.4%	-43.6%	-44.2%
2.96%	$14.0	$57.1	$57.8	$57.1	-42.2%	-41.5%	-42.2%
2.93%	$13.9	$57.8	$58.4	$57.7	-41.5%	-40.9%	-41.6%
1.67%	$12.1	$83.4	$81.3	$79.3	-15.6%	-17.8%	-19.8%
0.83%	$11.1	$98.8	$98.0	$93.6	**0.0%**	-0.9%	-5.3%
0.34%	$10.5	$107.0	$106.8	$102.3	8.2%	8.0%	3.5%
0.00%	**$10.1**	$112.6	$112.6	$107.8	13.9%	13.9%	9.0%
-0.78%	$9.3	$125.8	$127.3	$120.1	27.3%	28.8%	21.5%
-0.86%	$9.3	$127.2	$128.7	$121.3	28.6%	30.2%	22.7%
-1.37%	$8.8	$134.8	$137.3	$130.5	36.4%	38.9%	32.0%
-4.95%	$6.2	$180.9	$187.5	$180.7	83.0%	89.7%	82.8%
-7.64%	$4.9	$206.0	$218.0	$208.2	108.3%	120.5%	110.6%
2006 Baseline Value:		**$98.9**					

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $10.1 billion (12.9 percent) was used for types of capital improvements modeled in NBIAS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The amounts shown do not reflect system expansion needs; the bridge component of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

to a point between $14.5 billion and $16.0 billion. The superior performance of the ramped spending approach may be related to "lumpiness" in the future bridge investment needs identified by NBIAS. As discussed in Chapter 3 and Chapter 11, the rate of construction of new bridges has not been uniform over time, so that the age distribution of the bridge inventory includes some peaks. Consequently, the need for certain types of bridge repair and rehabilitation actions tends to be clustered to a certain extent. At the higher funding levels identified in *Exhibit 9-7*, the BCR-driven approach allows investment to be significantly frontloaded and concentrated into a relatively short period of time; although this approach has benefits in terms of reducing ongoing maintenance costs, it also tends to exacerbate the concentration of future bridge needs by putting a larger number of bridges onto the same repair and rehabilitation cycle. The imposition of an annual spending constraint in the baseline analyses tends to stretch out bridge work across a longer period, so that subsequent repair and rehabilitation cycles would be more spread out.

Timing of Congestion Pricing

The variable rate user financing analyses presented in Chapter 7 and the selected scenarios drawing upon those analyses presented in Chapter 8 assume the immediate imposition of some form of congestion pricing on a widespread basis. While such a transition could not occur in all locations overnight, these analyses do serve a useful purpose in identifying the types of system performance gains that could be achieved by applying a more economically rational approach to pricing peak use of transportation assets, and reducing the cross-subsidization of capacity additions by off-peak users who would not directly benefit.

If one believes that a system of variable rate user charges will be widely adopted within the 20-year analysis period covered by this approach, then an argument can be made that current investment decisions should all be made with this future in mind to avoid directing scarce resources to capacity additions that ultimately might not be necessary. This would suggest that the distribution of investments identified in the variable-rate financing analyses could be particularly relevant to decisionmaking, even if the performance impacts projected in that scenario may not be achievable until congestion pricing is implemented more broadly.

Exhibit 9-8 splits the difference between the fixed rate user financing analyses and the variable rate user financing analyses by deferring the implementation of congestion pricing until halfway through the 20-year analysis period. As would be expected, the performance impacts of this alternative approach fall in between those projected for the two sets of baseline analyses. HERS projects that a higher level of investment would be required to maintain adjusted average user costs in 2026 at their 2006 level if pricing were delayed 10 years than if pricing were adopted immediately, but shows that this result could potentially be achieved at the 2006 base year level of combined public and private highway capital spending. In contrast, the baseline analyses assuming fixed rate user financing (and no significant adoption of pricing) projected a significant increase in investment would be required to achieve this target.

Relative to the baseline variable rate user financing analyses assuming immediate pricing, the alternative approach assuming the widespread adoption of congestion pricing by 2016 produces a larger pool of potential investments that are considered to be cost-beneficial by HERS, particularly in the first 10 years of the analysis period. Consequently, the minimum benefit-cost ratios associated with each investment level for this alternative approach fall in between those identified for the baseline fixed rate user financing and variable rate user financing analyses.

Exhibit 9-8

Impact of Alternative Congestion Pricing Assumptions on Projected Changes in 2026 User Costs Compared With 2006 Levels and Projected Minimum Benefit-Cost Ratios, for Different Possible Funding Levels

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars) [1]	Percent Change in Adjusted Average User Cost [2]			Minimum Benefit-Cost Ratio Cutoff [2]		
		Baseline Fixed Rate, No Pricing	Alternative Variable Rate, Delayed Pricing	Baseline Variable Rate, Immediate Pricing	Baseline Fixed Rate, No Pricing	Alternative Variable Rate, Delayed Pricing	Baseline Variable Rate, Immediate Pricing
7.45%	$111.5	-2.9%			**1.00**		
6.70%	$102.0	-2.4%			1.15		
6.41%	$98.6	-2.3%			**1.20**		
5.25%	$86.1	-1.5%			1.45		
5.15%	$85.1	-1.4%	-2.6%		1.46	1.00	
5.03%	$84.0	-1.4%	-2.6%		**1.50**	1.03	
4.65%	$80.4	-1.1%	-2.4%		1.59	1.09	
4.55%	$79.5	-1.0%	-2.4%	-2.7%	1.62	1.11	**1.00**
4.17%	$76.1	-0.8%	-2.2%	-2.5%	1.71	1.18	1.06
3.30%	$69.0	-0.2%	-1.7%	-2.1%	1.93	1.33	**1.20**
3.21%	$68.3	-0.1%	-1.7%	-2.1%	1.96	1.35	1.21
3.07%	$67.2	**0.0%**	-1.6%	-2.0%	1.98	1.37	1.24
2.96%	$66.4	0.1%	-1.6%	-2.0%	2.01	1.40	1.25
2.93%	$66.2	0.1%	-1.6%	-2.0%	2.02	1.40	1.26
1.67%	$57.6	1.0%	-1.0%	-1.4%	2.42	1.67	**1.50**
0.83%	$52.6	1.5%	-0.6%	-1.0%	2.70	1.92	1.71
0.34%	$50.0	1.8%	-0.3%	-0.8%	2.86	2.07	1.82
0.00%	$48.2	2.1%	**-0.2%**	-0.6%	2.89	2.17	1.90
-0.78%	$44.4	2.6%	**0.2%**	-0.3%	2.94	2.42	2.12
-0.86%	$44.1	2.6%	0.2%	-0.2%	2.95	2.44	2.14
-1.37%	$41.8	3.0%	0.5%	**0.0%**	2.99	2.64	2.25
-4.95%	$29.5	5.2%	2.2%	1.6%	3.24	3.24	2.42
-7.64%	$23.2	6.7%	3.3%	2.6%	3.43	3.43	2.55

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The values shown for the "Baseline Fixed Rate" and "Baseline Variable Rate" correspond to the fixed rate user financing and the variable rate user financing mechanism discussed in Chapter 7, and duplicate information presented in Exhibits 7-5 and 7-14 . The "Alternative Variable Rate" alternative assumes that the widespread adoption of congestion pricing would occur halfway through the 20-year analysis period.

Source: Highway Economic Requirements System.

Transit Scenario Implications

This section of Chapter 9 considers a number of potential implications and limitations of the transit scenario analyses presented in Chapters 7 and 8. The intention is to provide a more comprehensive understanding of the assumptions used in scenario development as well as some alternative interpretations of the scenario results. Specifically, this section includes discussion of the following topics:

- Ridership response to Transit Economic Requirements Model (TERM) investments
- The potential impact of highway congestion pricing on CO_2 emissions from both automobiles and transit vehicles
- A comparison of the passenger miles traveled (PMT) growth rates used by TERM's asset expansion module with the recent, actual PMT growth rates
- The potential impact of recent construction commodity price increases on transit investment costs.

Ridership Response to Investment

Each of the three investment types considered by TERM—including the rehabilitation and replacement of existing assets, asset expansion, and performance-improving investments—would be expected to draw varying levels of new transit ridership. First, the rehabilitation and replacement of aging transit assets improves the quality and reliability of transit services, improvements that are believed to attract new transit riders. At present, the responsiveness of ridership to changes in asset conditions is not well understood and for this reason these impacts are not currently modeled within TERM.

> **Q&A**
>
> **How responsive is transit ridership to changes in user costs?**
>
> Transit riders are not highly sensitive to changes in user costs. Research has shown that transit riders' demand for transit services is relatively inelastic and that the relationship between user costs and riders is an inverse one. This means that a 1-percent increase or decrease in transit user costs will lead to a decrease or increase, respectively, of less than 1 percent in the number of transit riders. The percentage change in ridership resulting by a 1-percent change in user costs is known as the elasticity of ridership with respect to user costs. TERM assumes that this elasticity ranges in value from –0.22 to –0.40 depending on the mode (see Appendix C).

Second, TERM's asset expansion investments are, by definition, designed to support the future growth in ridership as projected by the Nation's metropolitan planning organizations (MPOs), while maintaining service performance (in the form of vehicle loads) at today's levels. Given the weighted-average annual national growth rate of 1.5 percent assumed in the analysis, it is estimated that TERM's roughly \$4.7 billion in annual transit expansion investments (i.e., to maintain performance) would support an additional 3.3 billion annual boardings by 2026, roughly 35 percent more than the current 9.5 billion annual boardings.

Finally, the TERM estimate for improving transit performance is \$6.06 billion annually in constant 2006 dollars. Of this amount, \$1.59 billion is for investment in new rail or bus rapid transit capacity to increase speed and \$4.46 billion is for fleet expansion to reduce occupancy levels on crowded transit services. Together, these new investments are estimated to generate 4.4 billion annual transit boardings by 2026, 46 percent over current ridership levels.

Impact of Congestion Pricing on CO_2 Emissions

Analysis in Chapter 8 considered the level of investment in new transit capacity as required to support new ridership diverted from highway travel in response to the imposition of highway congestion pricing. This analysis assumed that between 25 percent and 50 percent of diverted highway users would select transit as their preferred mode and that the new transit capacity would be sufficient to maintain current service performance (i.e., maintain the current average ridership loads on transit vehicles). In addition to reducing highway congestion and generating new transit ridership, this change also offers the opportunity to reduce the level of CO_2 emissions from commuter travel. When converted to a comparable "passenger mile" basis, travel by auto is estimated to result in roughly double the emissions of CO_2 as compared to travel by most transit modes (assuming average auto and transit vehicle occupancy rates, fuel and electricity consumption rates, and national average CO_2 emissions per unit of energy consumed based on energy source). A comparison of these differences by transit mode is provided in *Exhibit 9-9*. Hence, the conversion of highway VMT to transit PMT offers the potential to appreciably reduce commute-related CO_2 emissions.

Exhibit 9-9

Comparison of Green House Gas Emissions: Personal Auto Versus Select Transit Modes

Mode	Metric Tons of CO_2 per VMT	Metric Tons of CO_2 per PMT	CO_2 Output Relative to Auto PMT
Auto	0.0004	0.0004	100%
Motor Bus (diesel and CNG)	0.0022	0.0002	55%
Commuter Rail (mix of diesel and electric)	0.0055	0.0002	38%
Heavy Rail	0.0044	0.0002	45%
Light Rail	0.0063	0.0003	58%

Source: Transit Economic Requirements Model.

Exhibit 9-10 presents the total impact on CO_2 emissions in 2026 from diverting VMT to transit for two highway investment scenarios, "Sustain Current Spending" (SCS) and "Maximum Economic Investment" (MEI). In assessing the impacts of the travel shifts in TERM, it was assumed that auto users diverted to transit due to congestion pricing would select transit modes in roughly the same proportion as the existing transit riders who select these modes (i.e., 53 percent select a rail mode while the remaining 46.7 percent select bus or another nonrail mode). Given these assumptions, the analysis presented suggests the possibility of appreciable reductions in CO_2 emissions resulting from congestion pricing.

Under highway SCS scenario (25 percent diversion), 24.0 billion in VMT are diverted to transit, resulting in a reduction in CO_2 emissions from auto users of roughly 10.7 million metric tons. Translating the 24 billion VMT to transit yields 26.4 billion PMT and a corresponding increase in CO_2 emissions from various transit modes of 5.7 million metric tons. The net reduction in CO_2 emissions for these diverted travelers is 5.0 million metric tons, or 47.1 percent. To maintain conditions and performance for the increased ridership in this scenario, the incremental cost to TERM's transit capital expenditure projections is \$3.98 billion per year, equating to \$0.79 billion per million metric tons of CO_2 reduced. To improve conditions and performance, TERM estimates an incremental cost of \$4.15 billion per year would be required, resulting in an emissions reduction cost estimate of \$0.82 billion per million metric tons of CO_2 reduced.

Under highway SCS scenario (50 percent diversion), 48.5 billion in VMT are diverted to transit, resulting in a reduction in CO_2 emissions from auto users of roughly 21.7 million metric tons. This reduction translates into an increase of 53.4 billion in annual PMT and a corresponding increase in CO_2 emissions from transit modes of 11.7 million metric tons. The net reduction in CO_2 emissions for these diverted travelers is 10.0 million metric tons, or 46.0 percent. To maintain conditions and performance for the

Exhibit 9-10

Impact of Highway Congestion Pricing Scenarios on Transit Travel and CO_2 Emissions

		Highway Investment Scenario			
		Sustain Current Spending		Maximum Economic Investment	
Percent of VMT Reduction Diverted to Transit		**25%**	**50%**	**25%**	**50%**
Impact on Travel (Billions)					
Total VMT Diverted to Transit		24.0	48.5	21.4	42.9
Increase in PMT					
	Rail	14.2	26.4	13.7	25.4
	Non-Rail	12.2	27.0	9.8	21.8
	Total	26.4	53.4	23.5	47.2
Impact on CO_2 Emissions (Millions of Metric Tons)					
Reduction in Auto Carbon Emissions		10.7	21.7	9.6	19.2
Increase in Transit Carbon Emissions					
	Rail	2.6	4.9	2.5	4.7
	Non-Rail	3.0	6.8	2.4	5.4
	Total	5.7	11.7	4.9	10.2
Total Net Reduction in Carbon Emissions		5.0	10.0	4.6	9.0
Percent of CO_2 Emissions Eliminated		47.1%	46.0%	48.2%	46.9%
Incremental Costs to Transit to Support Increase in PMT (Billions of Dollars)					
Maintain (Benefit-Cost Ratio ≥ 1.0)					
Incremental Cost to Transit for Additional PMT		$3.98	$7.00	$3.53	$7.14
Cost to Transit per Million Metric Tons of CO_2 Reduced		$0.79	$0.70	$0.77	$0.79
Improve (Benefit-Cost Ratio ≥ 1.0)					
Incremental Cost to Transit for Additional PMT		$4.15	$7.16	$3.70	$7.31
Cost to Transit per Million Metric Tons of CO_2 Reduced		$0.82	$0.72	$0.80	$0.81

Source: Transit Economic Requirements Model.

increased ridership in this scenario, the incremental cost to TERM's transit capital expenditure projections is $7.0 billion per year, equating to $0.70 billion per million metric tons of CO_2 reduced. To improve conditions and performance, TERM estimates an incremental cost of $7.16 billion per year would be required, resulting in an emissions reduction cost estimate of $0.72 billion per million metric tons of CO_2 reduced.

Under HERS MEI scenario (25 percent diversion), 21.4 billion in VMT are diverted to transit, resulting in a reduction in CO_2 emissions from auto users of roughly 9.6 million metric tons. This reduction translates into an increase of 23.5 billion in annual PMT and a corresponding increase in CO_2 emissions from transit modes of 4.9 million metric tons. The net reduction in CO_2 emissions for these diverted travelers is 4.6 million metric tons, or a 48.2 percent. To maintain conditions and performance for the increased ridership in this scenario, the incremental cost to TERM's transit capital expenditure projections is $3.53 billion per year, equating to $0.77 billion per million metric tons of CO_2 reduced. To improve conditions and performance, TERM estimates an incremental cost of $3.70 billion per year would be required, resulting in an emissions reduction cost estimate of $0.80 billion per million metric tons of CO_2 reduced.

Finally, under the HERS MEI scenario (50 percent diversion), 42.9 billion in VMT are diverted to transit, resulting in a reduction in CO_2 emissions from auto users of roughly 19.2 million metric tons. This reduction translates into an increase of 47.2 billion in annual PMT and a corresponding increase in CO_2 emissions from transit modes of 10.2 million metric tons. The net reduction in CO_2 emissions for these diverted travelers is 9.0 million metric tons, or 46.9 percent. To maintain conditions and performance for the increased ridership in this scenario, the incremental cost to TERM's transit capital expenditure projections is $7.14 billion per year, equating to $0.79 billion per million metric tons of CO_2 reduced. To improve conditions and performance, TERM estimates an incremental cost of $7.31 billion per year would be required, resulting in an emissions reduction cost estimate of $0.81 billion per million metric tons of CO_2 reduced.

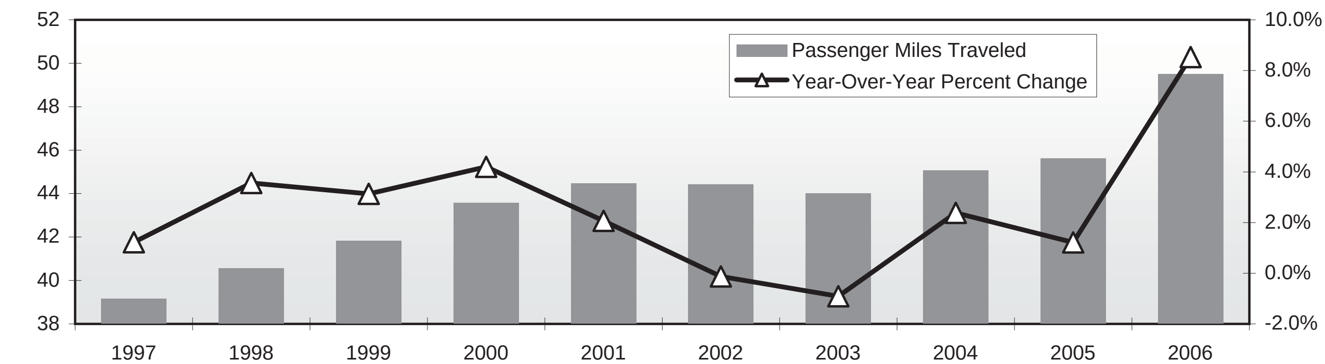
Transit Travel Growth

Historic Transit Travel Growth

From 1997 to 2006, annual transit PMT increased from 39.2 billion to 49.5 billion, growing at an average annual rate of 2.6 percent. Annual change in transit travel over the 10-year period, as shown in *Exhibit 9-11,* was not consistent, ranging from a low of -0.9 percent in 2003 to a high of 8.5 percent in 2006. The variance in PMT rates of change can be attributed to a variety of factors, including the strength of the U.S. economy, the prevalence of public transportation, and the price of gasoline.

Exhibit 9-11

Passenger Miles Traveled



Source: National Transit Database.

Transit Travel Growth Forecasts

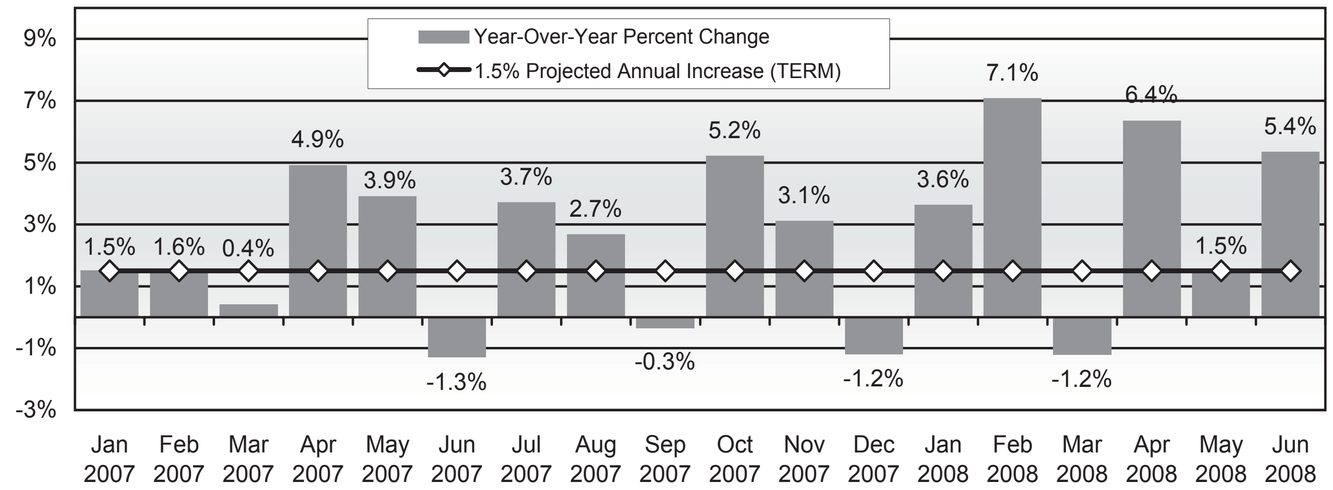
Forecasting demand for public transportation services is an inexact science. The growth rate forecasts used by TERM are provided by MPOs, regional planning authorities comprising representatives from local governments, regional and State transportation authorities, and other civic organizations. It is not uncommon for long-range demand forecasts to deviate from actual growth in demand for transit services.

This section of Chapter 9 describes how recent observed changes in PMT have diverged from the long-range demand forecasts used by TERM. Beginning with a discussion of how PMT are changing in all urbanized areas, the section moves to explore rates of change in PMT in the investment scenarios described in Chapters 7 and 8. [It is important to note that to calculate PMT for the periods shown in *Exhibit 9-11* through *Exhibit 9-15* (e.g., January 2007 to June 2008), the FTA multiplied current monthly unlinked trip data by 2006 average trip length data, which are the most recent data available.]

Exhibit 9-12 shows how the change in annual PMT for all urbanized areas in 2007 and 2008 has diverged from the average long-range transportation growth forecast used by TERM. The exhibit depicts the year-over-year percent change in PMT, showing, for example, that PMT grew 1.5 percent from January 2006 to January 2007. Note that PMT grew more rapidly than forecast in 11 of the 18 periods displayed in the exhibit. The horizontal line shows the annual growth forecast used by TERM (1.5 percent).

Exhibit 9-12

Year-Over-Year Percent Change in Passenger Miles Traveled, All Urbanized Areas

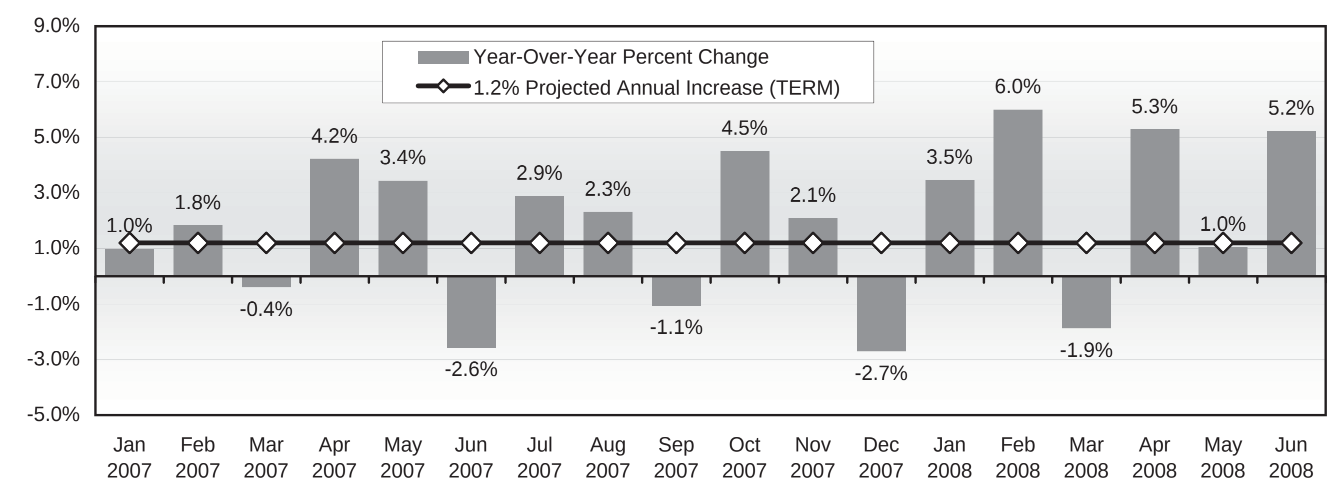


Source: National Transit Database, FTA Calculations.

Exhibit 9-13 shows the annual rate of change in PMT for transit agencies operating in large metropolitan areas with heavy rail transit systems. The horizontal line in the exhibit represents the projected annual increase in boardings used by TERM for these urbanized areas. Annual rates of change observed in 2007 and early 2008 ranged from -2.7 percent to 6.0 percent. At 1.2 percent, the growth forecast utilized by the model is less than the annual change in PMT experienced by transit agencies in 11 of the 18 periods observed.

Exhibit 9-13

Year-Over-Year Percent Change in Passenger Miles Traveled, Urbanized Areas With More Than 1 Million Residents and With HRT

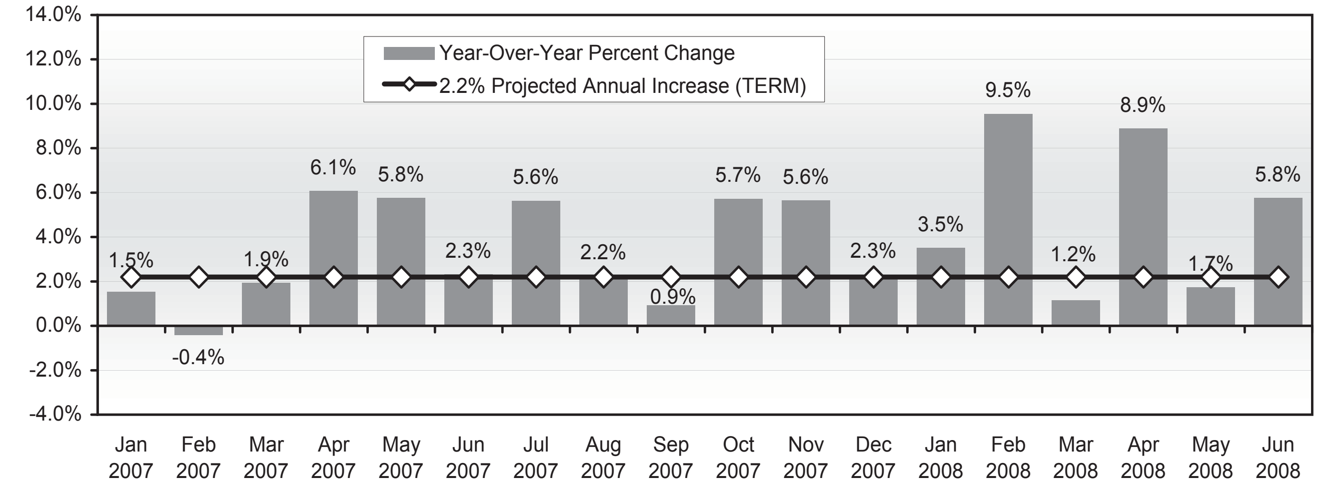


Source: National Transit Database, FTA Calculations.

As shown by the horizontal line in *Exhibit 9-14*, the demand for public transportation services in large cities without existing heavy rail systems is expected to increase at an annual rate of 2.2 percent. This estimate is used by TERM to make its investment projections, as discussed in Chapters 7 and 8. With the exception of February 2007, when PMT decreased by -0.4 percent when compared with a year earlier, *Exhibit 9-14* shows that PMT increased rapidly in 2007 and the beginning of 2008, growing at annual rates ranging from 0.9 percent to 9.5 percent. This suggests that current projections are underestimating the growth in demand for transit services in these metropolitan areas.

Exhibit 9-14

Year-Over-Year Percent Change in Passenger Miles Traveled, Urbanized Areas With More Than 1 Million Residents and Without HRT

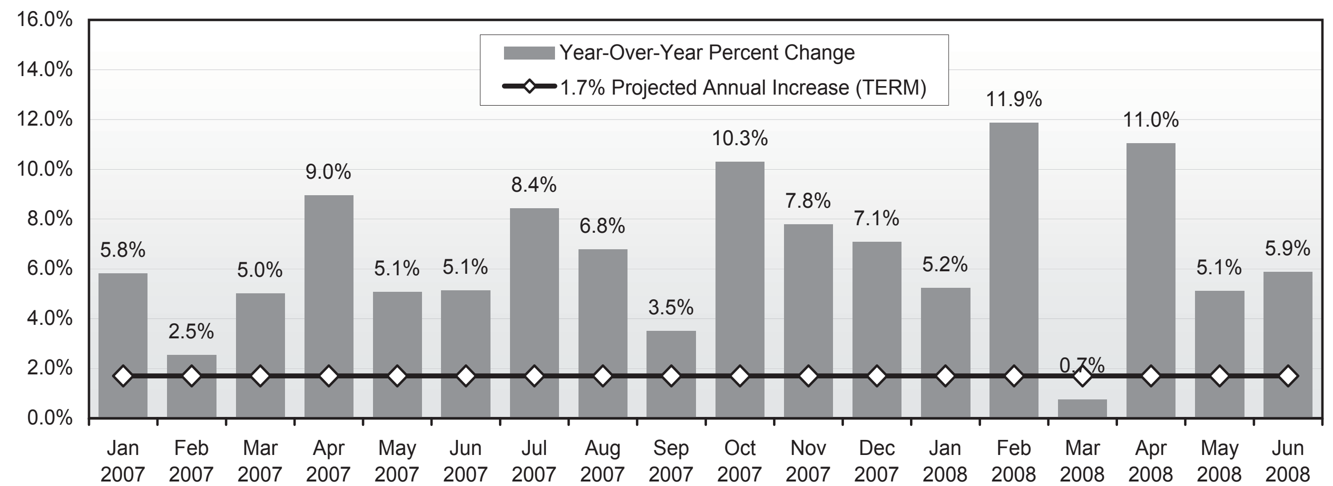


Source: National Transit Database, FTA Calculations.

Small cities and rural areas experienced relatively high levels of PMT growth in 2007 and early 2008, surpassing the rate of change used by TERM in 17 of the 18 periods shown in *Exhibit 9-15*. Growth in PMT, measured on an annual basis, ranged from 0.7 percent to 11.9 percent over the 18-month period.

Exhibit 9-15

Year-Over-Year Percent Change in Passenger Miles Traveled, Urbanized Areas With Less Than 1 Million Residents



Source: National Transit Database, FTA Calculations.

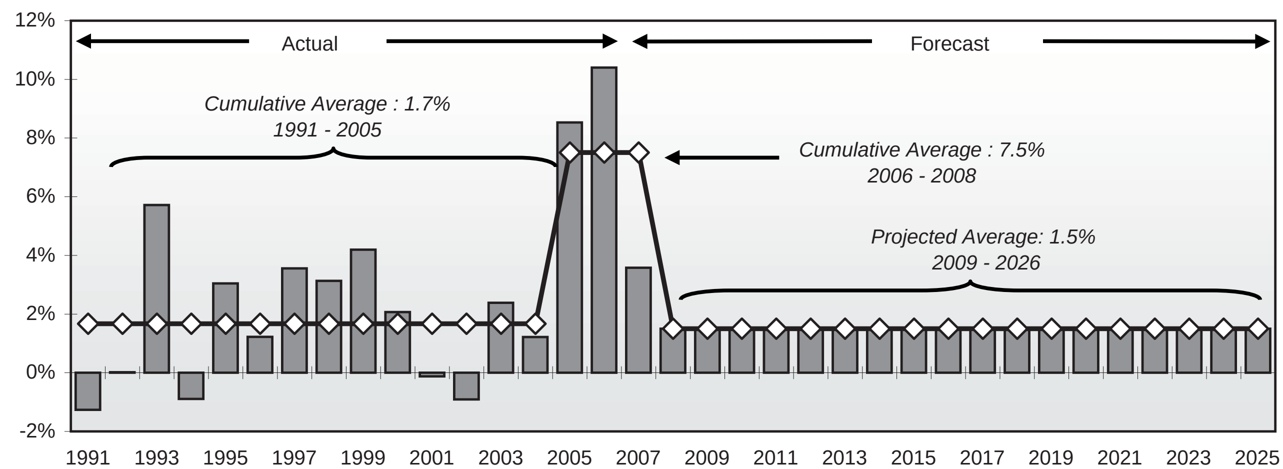
Projected and Historical Transit Travel Growth

TERM's projections of investments required to support the projected, natural growth in transit ridership are driven entirely by ridership and PMT forecasts provided by a sample of the Nation's MPOs. This sample is dominated by the Nation's largest urbanized areas (which are well represented) but also includes a mix of small- and medium-sized metropolitan areas from around the Nation. This section compares the 1.5 percent, weighted-average projected annual growth in PMT derived from these MPO projections (for the 2006 to 2026 forecast period), with the actual rate of growth in transit passenger miles as reported by the Nation's local transit agencies to the National Transit Database. This comparison suggests that the rate of growth projected by the MPOs (in aggregate) for the upcoming 20 years is less than that experienced nationally over the past decade. Should transit PMT continue to increase at rates closer to the recent historical rates (i.e., higher than the MPO projections), then the expansion (or maintain performance) needs estimates presented in Chapter 8 are less than will be required to maintain performance at today's levels.

Exhibit 9-16 presents the actual and MPO projected annual national growth rates for PMT for the period 1991 through 2026. Actual PMT data are presented for 1991 to 2007, with 2008 represented by 6 months of actual data and 6 months of forecast data. From 2009 through 2026, the exhibit presents the rate of increase of 1.5 percent derived from the MPO forecasts.

Exhibit 9-16

Annual Percent Change in Passenger Miles Traveled



Source: National Transit Database, Transit Economic Requirements Model, and FTA calculations.

As shown in the exhibit, the period 1991 through 2005 was characterized by wide variations in PMT growth. While growth was positive in most of these years, total PMT did contract in 1992, 1995, 2002, and 2003. The average rate of PMT growth for the entire period was 1.7 percent. The PMT data for 2006, 2007, and the first 6 months of 2008 are characterized by significantly higher growth rates (averaging 7.5 percent) as compared with the prior period, driven primarily by the recent increases in fuel prices and the resulting shift from automobile travel to transit (and which may be a one-time increase). When evaluated from 1991 through the first 6 months of 2008 (to date), the average rate of PMT growth is 2.7 percent. Hence, regardless of the period over which the historical PMT growth is evaluated (i.e., over the 1991 to 2006 period or over the 1991 to 2008 period that includes the recent jump in transit ridership), the historical rate of increase exceeds the rate based on MPO projections. Once again, if the actual rate of increase over the next 20 years more closely reflects recent historical growth than the MPO projected rate of growth, then the needs estimates for asset expansion presented in Chapter 8 would be insufficient to maintain current transit performance into the future.

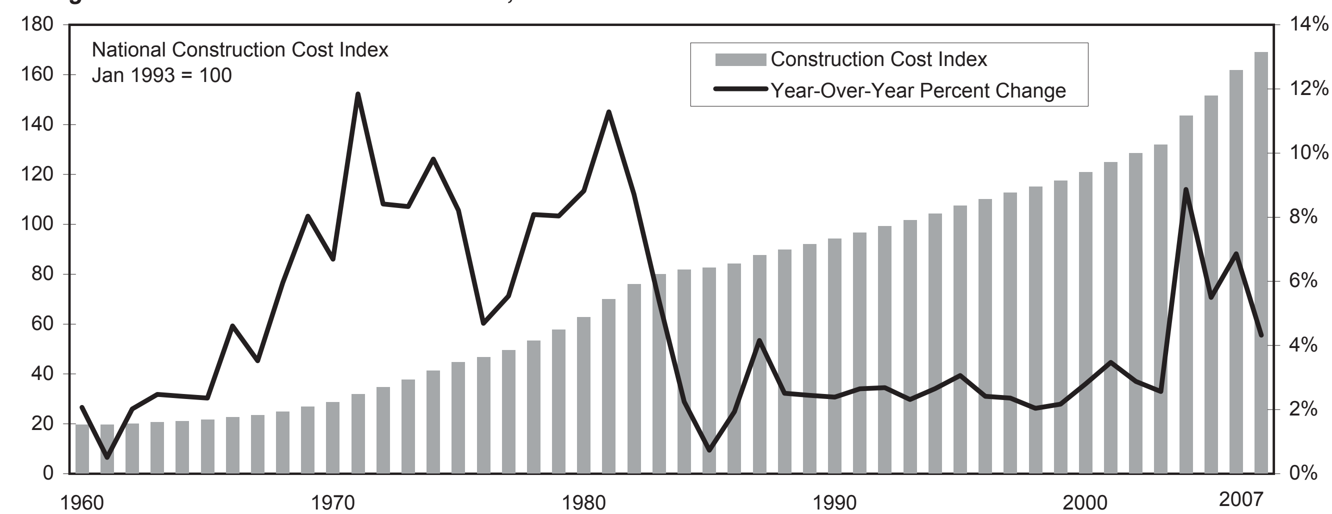
Commodity Inflation

The transit investment estimates described in Chapters 7 and 8 are presented in constant 2006 dollars and consequently do not capture any increases in prices from that time forward. At the same time, prices for materials and labor used in the construction industry have increased significantly in recent years, pushing the costs for constructing all types of capital projects upward. Most of this recent accelerated increase in construction and related materials inflation is not captured by the current TERM analysis.

Exhibit 9-17 presents the annual change in national construction costs since 1960. The vertical bars in the exhibit, measured on the left scale, are index numbers, while the line, measured on the right scale, represents the percent change in the index from year to year. While not fully representative of the materials and labor types used in transit capital projects (no index currently exists for transit capital projects), the index presented here is representative of construction costs in general. Following a period of high cost inflation from the late 1970s and early 1980s, cost growth moderated over the period from 1984 through 2003, ranging from 0.7 percent to 4.2 percent. In 2004, however, prices for construction goods and services began to rise at a more rapid pace, with year-over-year inflation reaching 8.9 percent before moderating to 4.3 percent in 2007. Much of this increase is driven by increases in the price of concrete, steel, and other key materials used in major transit capital projects.

Exhibit 9-17

Change in National Construction Cost Index, 1960 to 2007

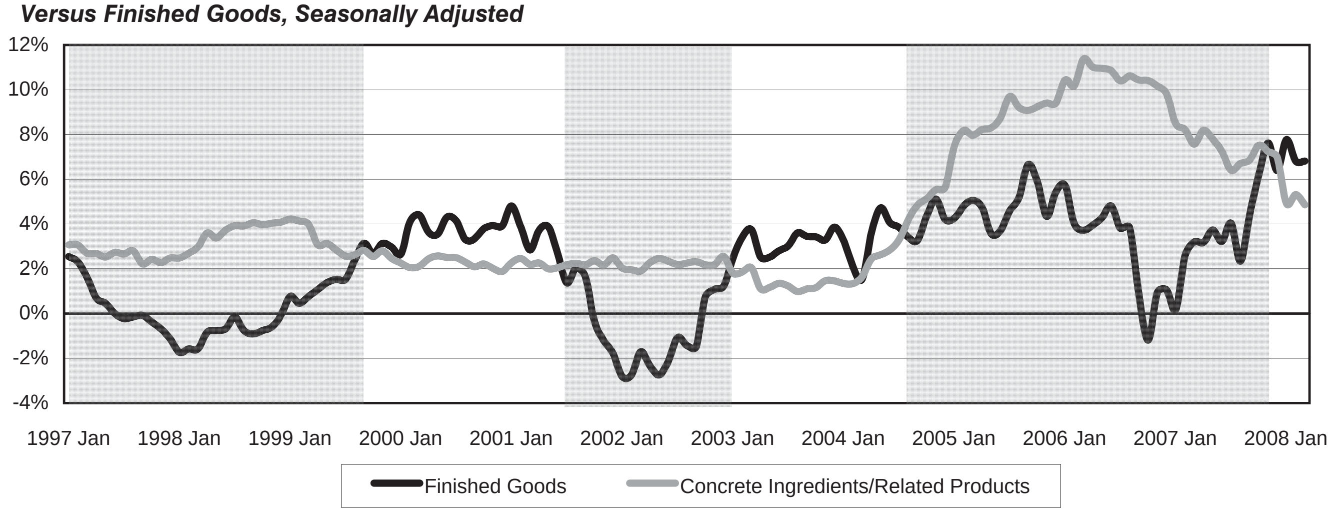


Source: RSMean Historical Cost Index.

Exhibit 9-18 displays the annual percent change in the price of concrete ingredients and related products. These increases are compared to the annual percent change in the price of finished goods, a frequent measure of inflation for goods purchased by private sector producers in the United States. Shaded areas on the

Exhibit 9-18

Year-Over-Year Percent Change in Construction-Related Prices for Concrete and Related Products Versus Finished Goods, Seasonally Adjusted



Source: Bureau of Labor Statistics.

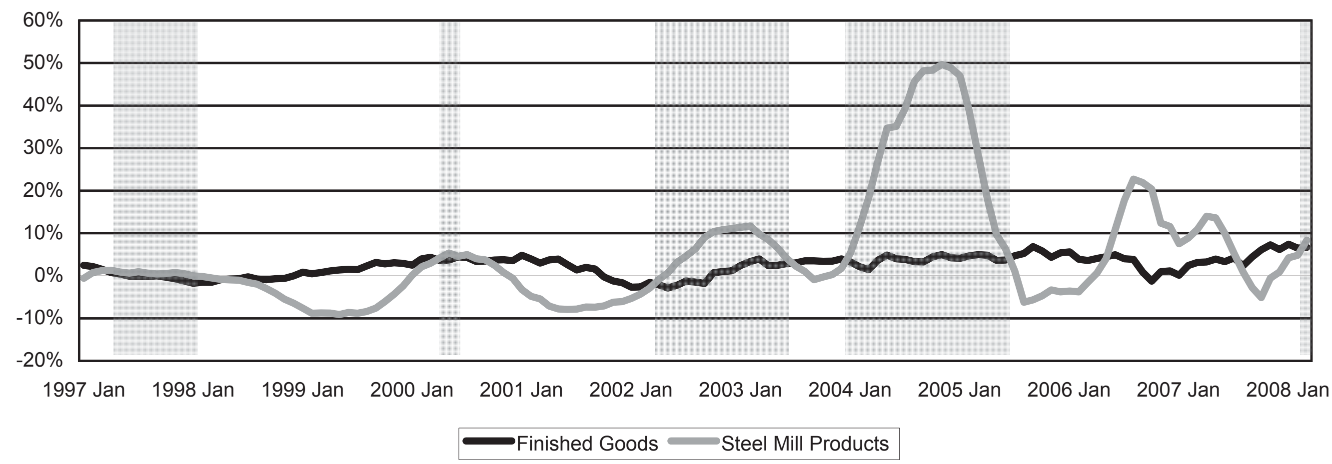
exhibit highlight periods of time when the rate of inflation for concrete ingredients and related products has exceeded that of finished goods. The data show that inflation for concrete products reached a peak in 2006, rising 11.4 percent from March 2005 to March 2006. While the pace has abated somewhat since 2005, price increases remains high by recent historical standards.

Steel is another major component in major transit capital projects, where it is used in the construction of new trackwork, elevated structures, bridges, facilities, and transit vehicles. Similar to other commodities used in the construction industry, the recent rate of increase in steel prices is high by historical standards. *Exhibit 9-19* displays the rate of price inflation for steel mill products over the past 10 years, compared with the price of finished goods. Once again, time periods where the increase in the steel prices outpaced the increase in finished goods prices are highlighted by shaded areas. Note that the price of steel rose rapidly in the period from 2003 to 2004, increasing by as much as 49.7 percent in the 12 months leading to November 2004, before decreasing by 6.2 percent in the 12 months leading to August 2005. Inflation also accelerated in 2006, when prices increased by 22.7 percent from August 2005 to August 2006.

Once again, the current TERM projections do not fully capture these recent increases in the rate of cost inflation for key transit capital inputs. This is primarily due to the absence of a transit-specific capital cost index.

Exhibit 9-19

Year-Over-Year Percent Change in Construction-Related Prices for Steel Mill Products Versus Finished Goods, Not Seasonally Adjusted



Source: Bureau of Labor Statistics.

Comparison

The layout and content of Part II of this edition of the C&P report, including Chapters 7 through 10, has been restructured significantly relative to that of recent editions. Some of the material presented in this chapter builds on analyses presented in Chapter 9 of the 2006 C&P Report, but this edition also adds a series of new analyses that address some additional key issues relating to relationships between capital investment and the conditions and performance of the transportation system. This information is provided to assist in the interpretation of the selected future capital investment scenarios presented in Chapter 8, and to tie together the historic financial information presented in Chapter 6 with the conditions and performance information presented in Chapters 3 and 4.

Exhibit 9-20 provides a crosswalk between the information presented in the exhibits located earlier in this chapter, and the location of comparable information in the 2006 C&P Report.

Exhibit 9-20

Cross-Reference Between Chapter 9 Exhibits and the Location of Comparable Information in the 2006 C&P Report

Chapter 9 Exhibit	Location of Comparable Information in the 2006 C&P Report
Exhibit 9-1	Comparable to information shown in Exhibit 9-5.
Exhibit 9-2	Comparable to information shown in Exhibit 9-6.
Exhibit 9-3	No direct equivalent.
Exhibit 9-4	No direct equivalent. A discussion of investment timing in HERS was included in Chapter 10.
Exhibit 9-5	No direct equivalent. A discussion of investment timing in HERS was included in Chapter 10.
Exhibit 9-6	No direct equivalent.
Exhibit 9-7	No direct equivalent.
Exhibit 9-8	No direct equivalent.
Exhibit 9-9	No direct equivalent.
Exhibit 9-10	No direct equivalent.
Exhibit 9-11	No direct equivalent.
Exhibit 9-12	No direct equivalent.
Exhibit 9-13	No direct equivalent.
Exhibit 9-14	No direct equivalent.
Exhibit 9-15	No direct equivalent.
Exhibit 9-16	No direct equivalent.
Exhibit 9-17	No direct equivalent.
Exhibit 9-18	No direct equivalent.
Exhibit 9-19	No direct equivalent.

Highways and Bridges

The highway section of this chapter retains two key elements from Chapter 9 in the 2006 C&P Report: (1) a discussion of the linkages among recent trends in system conditions, system performance, and capital spending, relative to what might have been expected based on the findings of the selected capital investment scenarios; and (2) a discussion of historic and projected future travel growth. *Exhibits 9-1* and *9-2* are directly comparable to exhibits in Chapter 9 of the 2006 C&P Report depicting past and projected future highway vehicle miles traveled (VMT).

This section includes new elements, including discussions of inflation, the timing of investment, and the timing of congestion topics. *Exhibit 9-3* illustrates how the constant dollar figures presented in this report could be converted to nominal dollars; previous C&P reports did not include this type of example. *Exhibits 9-4* through *9-7* describe the system performance implications of alternative assumptions about the timing of capital investments; the discussion relating to these exhibits draws in material on the existing backlog of cost-beneficial highway capital investments and investment timing that was included in Chapters 7 and 10, respectively, in the 2006 C&P Report. *Exhibit 9-8* discusses the implications of alternative assumptions regarding the timing of the widespread adoption of congestion pricing strategies; this topic was not addressed in the 2006 C&P Report.

Transit

For the transit section of this chapter, several new discussions have been added to the future impacts discussions. Future impact scenarios, which now compose the main content of this chapter, include the traditional ridership response to investment, as well as the added impact of congestion pricing on CO_2 emissions; a comparison of the growth rates of passenger miles traveled (PMT) used by TERM's asset expansion module with the recent, actual PMT growth rates; and a discussion on recent construction commodity price inflation. *Exhibits 9-9* and *9-10* focus on the assumptions driving the transition of VMT to PMT when highway users are diverted to transit and the impact of this diversion on rail and nonrail PMT. The key element of this analysis is the estimated reduction in CO_2 emissions. *Exhibits 9-11* through *9-16* focus on a detailed discussion of historic PMT growth rates through 2006, actual PMT between 2006 and 2008 which are significantly higher than historic and projected levels of growth, and the projections driven by data collected from metropolitan planning organizations. *Exhibits 9-17* through *9-19* present recent trends in construction cost indices that would impact transit capital projects. These are important to note because the majority of this recent inflationary trend in construction and related materials is not currently captured within TERM. A discussion of current impacts on physical conditions and operational performance has been removed from Chapter 9, but is included in detail in Chapters 7 and 8.

Chapter 10

Sensitivity Analysis

Highway Sensitivity Analysis

The results produced by the Highway Economic Requirements System (HERS), the National Bridge Investment Analysis System (NBIAS), and the Transit Economic Requirements Model (TERM) are strongly affected by the values that are supplied to them for certain key variables. In any modeling effort, evaluating the validity of the underlying assumptions is critical. The accuracy of the investment scenario estimates reported in Chapter 8 depends on the validity of the underlying assumptions used to develop the analysis.

This section explores the effects of varying some of the assumptions in the HERS and NBIAS analyses that were used to develop the projections of the potential impacts of highway capital investment presented in Chapter 7, which were used as input to the selected capital investment scenario estimates reported in Chapter 8. Subsequent sections within this chapter explore comparable information regarding the assumptions underlying the analyses developed using TERM.

The first part of this section considers the potential impacts that new technology could have on changing the baseline highway investment/performance relationships described in Chapter 7. This includes an analysis of the potential impacts of alternative deployment rates for selected operations strategies and intelligent transportation systems (ITS). The potential impacts of modifying pavement technologies and management practices to significantly extend the expected lives of reconstruction and resurfacing improvements is also explored. The second part of this section analyzes the potential impacts of alternative assumptions regarding future highway travel volumes, both in terms of highway travel demand and the elasticity of that demand with respect to changes in user costs. The third part of this section explores the effects of various economic assumptions, including fuel prices, the costs associated with different types of capital improvements, and the rate at which future benefits are discounted in constant dollar terms. This is followed by a discussion of the valuation of non-monetary benefits, including those associated with saving lives, saving time, and improving reliability. The last part of this section considers the potential impact of aging bridges on long term bridge rehabilitation and replacement needs.

It is important to note that the alternative investment levels identified in this section only consider those types of capital investments that are currently modeled in either HERS or NBIAS, which are reflected in the analyses presented in Chapter 7. These estimates do not reflect the full range of investments considered in the selected highway and bridge capital investment scenarios presented in Chapter 8, which combine estimates for HERS-derived, NBIAS-derived, and non-modeled components.

Each of the exhibits presented in this section reflects the results of alternative analyses developed using either HERS or NBIAS; the results obtained from the two models are not combined, even in cases where the comparable sensitivity analyses were performed in both models. In order to fully reconstruct a Chapter 8 scenario using input from this section, it would be necessary to combine a modified HERS-derived component with an NBIAS-derived component, and to re-estimate the non-modeled component of the scenario in the manner described in Chapter 8.

Potential Impacts of Technological Advances

As described in Chapter 7, the HERS analysis considers the potential impact of current and future ITS deployments and operations strategies on highway conditions and performance. Appendix A includes more information on the types of strategies considered, including those targeted at arterial management (upgraded

What are the costs associated with the alternative deployment strategies identified in this section?

Q&A

The alternative deployment strategies include both the capital costs of the equipment and infrastructure and the ongoing costs of operating and maintaining that infrastructure. The costs include those for both the basic infrastructure needed to support a given strategy (such as a traffic operations management center) and the incremental costs of increasing the coverage of that structure (such as additional ramp meters).

The estimated average annual capital cost of new deployments associated with the baseline existing deployment trends scenario is $142 million (in 2006 dollars). The estimated average annual operating and maintenance cost relating to these new deployments is $271 million. The average annual capital and operating costs related to existing infrastructure (including traffic signal replacement) over the 2007 to 2026 period are estimated to be $1.8 billion and $2.4 billion, respectively. These costs are not included in the alternative HERS-related spending levels described in Chapter 7, or the HERS-derived components of the capital investment scenarios presented in Chapter 8; the capital portion of these costs were assumed to be captured in by the adjustment for non-modeled improvement types described in Chapter 8.

The alternative strategy assuming **no additional deployments** was analyzed by increasing the funding targets analyzed in HERS by the amount of the capital and operating costs related to new deployments identified above as part of the baseline scenario. For each alternative funding level analyzed in HERS, the budget for capacity expansion and system rehabilitation was increased by an amount equating to $413 million annually, stated in constant 2006 dollars.

The estimated average annual capital costs of new deployments associated with both the **aggressive deployment** strategy is $1.9 billion stated in 2006 dollars. Taking into account the additional operating and maintenance costs related to these new deployments less savings associated with existing infrastructure that would be replaced, the average annual cost associated with this strategy is $3.4 billion higher than the baseline strategy. To analyze this strategy, the budget in HERS for capacity expansion and system rehabilitation was reduced by this amount.

The **full deployment** strategy assumes the same deployments as the aggressive deployment strategy, but assumes they would be implemented immediately, rather than spread out over 20 years. This would increase the total operating and maintenance costs within the 2007 to 2006 period, so that the estimated average annual cost associated with this strategy would be $4.5 billion higher than the baseline strategy, stated in constant 2006 dollars. These costs were deducted from the budget in HERS for capacity expansion and system rehabilitation in order to analyze this strategy.

Note that the costs shown above reflect only the particular types of improvements described in Appendix A, and thus represent a subset of total operations deployments that are expected to occur.

signal control, emergency vehicle signal preemption, electronic roadway monitoring, variable message signs), freeway management (ramp metering, electronic roadway monitoring, variable message signs, integrated corridor management, and variable speed limits), incident management (incident detection, verification, and response), and traveler information (511 systems and advanced in-vehicle navigation systems with real-time traveler information enabled by Vehicle-Infrastructure Integration deployment).

The assumptions reflected in the baseline analyses presented in Chapters 7 and 8 are consistent with those identified for the "Continuation of Existing Deployment Trends" scenario described in Appendix A. This section includes an analysis of the potential impacts of stopping all new deployments by examining the subset of this deployment scenario that focuses on the costs associated with existing deployments only. This section also includes analyses of more robust deployment strategies.

The "Aggressive Deployment" scenario described in Appendix A assumes an accelerated pace of deployment above existing trends, along with more advanced forms of operations strategies than are considered in the baseline. The "Full Deployment" scenario illustrates the maximum potential impact of the strategies and technologies modeled in HERS on highway operational performance.

The pavement performance and capital improvement cost assumptions reflected in the baseline HERS analyses in Chapters 7 and 8 are intended to be consistent with current pavement management practices, and do not make any explicit assumptions regarding changes in pavement technology. To the extent that technological improvements can extend the life of pavement improvements and/or reduce their life-cycle costs, this would benefit both highway agencies and system users. This section includes an analysis of the 20-year system performance implications of extending pavement lives by one-third.

The NBIAS model is not currently equipped to readily explore the potential impacts of new technologies.

Operations/ITS Deployments

While HERS can not currently directly compare the relative benefits and costs of increased operational deployments versus lane additions in a particular location, the model can be used to look at such tradeoffs on a systemwide basis by varying the amount of funding set aside to support the deployment of operations strategies and ITS within an overall fixed budget level. *Exhibit 10-1* compares the baseline assumption of a continuation of existing deployment trends with three alternatives scenarios: one assuming no additional deployments, an aggressive scenario assuming that the adoption of ITS infrastructure and operations strategies would accelerate in the future, and a hypothetical scenario that assumes full, immediate deployment of selected operations/ITS strategies in all urban areas. Appendix A includes more information on how these scenarios were defined. *Exhibit 10-1* uses adjusted average user costs as a proxy for changes in the overall performance of the highway system; as defined in Chapter 7, this measure excludes taxes and is normalized to offset the impacts of projected future changes in fuel economy.

No Additional Deployments Alternative

Exhibit 10-1 shows that, if no additional operations deployments were made, adjusted average user costs would be higher than the baseline values at all funding levels, regardless of whether these investments were supported by a fixed rate user financing mechanism or a variable rate financing mechanism. For example, while the baseline analyses assuming fixed rate user financing had projected a 2.9 percent reduction in adjusted average user costs if combined public and private highway capital investment were to grow by 7.45 percent annually in constant dollar terms, the alternative—no additional deployments—projects a reduction of only 2.7 percent. This suggests that highway users would be better off if existing operations/ ITS deployment trends were to continue than if this funding were to be redirected toward the types of system expansion and pavement rehabilitation improvements modeled in HERS. It should be noted that, based on projected travel volumes for 2026, each 1-percent decline in user costs would generate savings of approximately $40 billion annually to system users.

Assuming fixed rate user financing and a suspension of further ITS deployments, HERS projects that a 3.30 percent annual constant dollar increase in spending would be required to maintain adjusted user costs at 2006 levels. This is higher than the 3.07 percent annual growth figure computed for the baseline to reach this target. *Exhibit 10-1* also shows that the spending level associated with maintaining adjusted average user costs in a variable rate user financing system would be higher if no additional operations deployments were to occur.

The minimum benefit-cost ratio cutoffs identified in *Exhibit 10-1* for each level of investment represent the benefit-cost ratio of the least attractive project that would be implemented at that level of investment. The benefit-cost ratios associated with the baseline analyses and the alternative analyses for no additional deployments were relatively close to one another. The spending levels associated with a minimum benefit-cost ratio of 1.0 for the types of capital improvements modeled in HERS were the same in both cases, $111.5 billion assuming fixed rate user financing and $79.5 billion assuming variable rate user financing. As noted earlier, these figures exclude the types of investments modeled in NBIAS, as well as capital improvement types that are not currently modeled.

Exhibit 10-1

Impact of Alternative Operations Strategies Deployment Rate Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Adjusted Average User Cost, 2026 Compared With 2006: Deployment Rate Assumption				Minimum Benefit-Cost Ratio Cutoff: Deployment Rate Assumption			
		Baseline	Alternative			Baseline	Alternative		
		Existing Trends	No Additional	Aggressive	Full	Existing Trends	No Additional	Aggressive	Full
Assuming Fixed Rate User Financing									
7.45%	$111.5	-2.9%	-2.7%	-3.4%	-3.3%	**1.00**	**1.00**	1.03	1.06
6.41%	$98.6	-2.3%	-2.0%	-2.7%	-2.6%	**1.20**	1.22	1.24	1.26
5.03%	$84.0	-1.4%	-1.1%	-1.8%	-1.7%	**1.50**	1.51	1.58	1.61
4.55%	$79.5	-1.0%	-0.8%	-1.5%	-1.3%	1.62	1.62	1.68	1.72
4.17%	$76.1	-0.8%	-0.6%	-1.2%	-1.0%	1.71	1.72	1.80	1.84
3.30%	$69.0	-0.2%	0.0%	-0.6%	-0.4%	1.93	1.94	2.01	2.08
3.07%	$67.2	**0.0%**	0.2%	-0.4%	-0.2%	1.98	1.99	2.08	2.15
2.93%	$66.2	0.1%	0.3%	-0.3%	-0.1%	2.02	2.03	2.14	2.20
1.67%	$57.6	1.0%	1.2%	0.6%	0.8%	2.42	2.40	2.57	2.65
0.83%	$52.6	1.5%	1.7%	1.2%	1.4%	2.70	2.69	2.89	2.97
0.34%	$50.0	1.8%	2.1%	1.6%	1.8%	2.86	2.85	2.94	3.16
0.00%	**$48.2**	2.1%	2.3%	1.8%	2.0%	2.89	2.90	2.96	3.31
-0.78%	$44.4	2.6%	2.8%	2.3%	2.6%	2.94	2.95	3.01	3.39
-1.37%	$41.8	3.0%	3.2%	2.7%	3.0%	2.99	3.00	3.06	3.43
-4.95%	$29.5	5.2%	5.4%	5.2%	5.5%	3.24	3.26	3.31	3.78
-7.64%	$23.2	6.7%	6.9%	6.8%	7.1%	3.43	3.45	3.52	4.07
7.61%	$113.7			-3.5%				**1.00**	
7.72%	$115.2				-3.4%				**1.00**
Assuming Variable Rate User Financing									
5.03%	$84.0				-3.3%				1.01
4.55%	$79.5	-2.7%	-2.5%	-3.1%	-3.1%	**1.00**	**1.00**	1.05	1.08
4.17%	$76.1	-2.5%	-2.4%	-3.0%	-2.9%	1.06	1.06	1.11	1.15
3.30%	$69.0	-2.1%	-2.0%	-2.6%	-2.5%	**1.20**	1.20	1.27	1.32
3.07%	$67.2	-2.0%	-1.9%	-2.5%	-2.3%	1.24	1.24	1.31	1.36
2.93%	$66.2	-2.0%	-1.8%	-2.4%	-2.3%	1.26	1.26	1.34	1.39
1.67%	$57.6	-1.4%	-1.3%	-1.8%	-1.7%	**1.50**	1.50	1.62	1.69
0.83%	$52.6	-1.0%	-0.9%	-1.4%	-1.2%	1.71	1.70	1.84	1.91
0.34%	$50.0	-0.8%	-0.6%	-1.1%	-1.0%	1.82	1.81	1.99	2.05
0.00%	**$48.2**	-0.6%	-0.5%	-1.0%	-0.8%	1.90	1.89	2.07	2.16
-0.78%	$44.4	-0.3%	-0.1%	-0.6%	-0.4%	2.12	2.11	2.31	2.40
-1.37%	$41.8	**0.0%**	0.1%	-0.3%	-0.1%	2.25	2.24	2.35	2.59
-4.95%	$29.5	1.6%	1.7%	1.4%	1.7%	2.42	2.40	2.53	2.87
-7.64%	$23.2	2.6%	2.7%	2.6%	2.9%	2.55	2.53	2.68	3.08
4.87%	$82.4			-3.3%				**1.00**	
5.04%	$84.1				-3.3%				**1.00**

** Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

Aggressive Deployments Alternative

Exhibit 10-1 shows that the aggressive operations/ITS deployment scenario would result in lower adjusted average user costs at most of the combined levels of public and private capital spending that were analyzed. If funding levels were maintained somewhere near base year 2006 levels in constant dollars, or if they were increased above that level, then system users would benefit from significant increases in these types of deployments, even if this investment came at the expense of reduced spending on other types of highway improvements. Assuming that a fixed rate user financing mechanism was utilized, adjusted average user costs could be maintained at base year 2006 levels if combined public and private spending rose at a rate somewhere between 1.67 and 2.93 percent, compared to the growth rate of 3.07 percent computed for the baseline. Assuming variable rate user financing, the baseline analyses projected that adjusted average user costs could be maintained even if highway capital spending fell by 1.37 annually in constant dollar terms; under the aggressive deployments scenario this measure could be maintained at an even lower spending level.

Exhibit 10-1 also shows that, at the lower end of the range of the spending levels analyzed, shifting funding away from the types of system expansion and system rehabilitation actions modeled in HERS toward increased operational deployments would not be advantageous. Assuming fixed rate user financing, if combined public and private investment were to decline by 4.95 percent annually in constant dollar terms over 20 years, adjusted average user costs would increase by approximately 5.2 percent in 2026 relative to 2006 for both the aggressive deployment scenario and the existing deployment trends assumed in the baseline. If combined public and private capital spending were to decline by 7.64 percent annually, adjusted average highway user costs would be higher under the aggressive deployments scenario. This suggests that if available funding were constrained to that extent, then cutting spending on system expansion and system rehabilitation even further to accommodate a significant increase in ITS deployments would not be economically justified. Assuming variable rate user financing, the relative returns associated with aggressive operations deployments would be higher than those in the baseline unless combined public and private capital spending were to decline by 7.64 percent or more per year.

Assuming fixed rate user financing, the baseline analyses presented in Chapter 7 identified the level of investment associated with a minimum benefit-cost ratio of 1.0 to be $111.5 billion in constant 2006 dollars for the types of capital improvements modeled in HERS. Under the aggressive deployment scenario, HERS identifies even more potentially cost beneficial investments, so that the minimum benefit-cost ratio associated with this funding level would be 1.03. An average annual investment level of $113.7 billion would be associated with a benefit-cost ratio of 1.00 under this scenario. This finding suggests that the types of operations strategies and ITS deployments considered as part of this scenario are complementary to widening options in some circumstances; in some cases, expanding a facility while simultaneously deploying advanced operations technology can yield more benefits than could be achieved by either action alone.

For the variable rate user financing version of the baseline HERS analyses, an average annual investment level of $79.5 billion in constant 2006 dollars was associated with a minimum benefit-cost ratio cutoff of 1.00. Under the aggressive deployment scenario, the benefit-cost ratio associated with this level of investment would be 1.05. This suggests that applying congestion pricing in conjunction with the aggressive deployment of operations strategies and technology can increase the effectiveness of widening actions, where such actions are economically justified.

Full Deployments Alternative

Exhibit 10-1 shows that the full deployment alternative would not be as beneficial to system users as the aggressive deployment alternative described above. For every funding level analyzed, average user costs would be lower under the aggressive deployment scenario, which assumes a gradual adoption of new technologies, than the full deployment scenario which assumes the immediate deployment of these same technologies. This suggests that fully front-loading these operations/ITS deployments into the first 5 years analyzed by HERS at the expense of the system expansion and system rehabilitation improvements that would otherwise have been funded would create some system performance problems that would not be fully compensated for over time. The more gradual adoption of these same technologies assumed under the aggressive deployment alternative would appear to be a more effective approach.

It should be noted that the full deployments scenario would produce superior results to the baseline existing deployment trends assumption at higher levels of investment assuming fixed rate user financing. Assuming variable rate user financing, adjusted average user costs would be lower in this alternative than in the baseline, unless funding were to decline significantly in constant dollar terms below base year 2006 levels.

Exhibit 10-1 also shows that the minimum benefit-cost ratios associated with the full deployment alternative were higher than those for the baseline or the other alternatives that were analyzed. This appears to be a side effect of the front-loading of deployments under this scenario, because deferring a significant amount of system expansion and pavement rehabilitation actions in the first 5 years would result in additional system deterioration in these areas which would in turn cause the benefit-cost ratios of capital improvements aimed at addressing these deficiencies in later years to be higher.

Pavement Technology

Significant advances have been made in recent years in the development of long-life asphalt and concrete pavements. As these advanced materials and improved construction techniques are adopted more broadly, the average service life of pavements is expected to continue to increase. While some of these materials have higher initial costs than those widely used today, further research is ongoing to bring down these costs. In addition, the widespread adoption of improved construction management, scheduling, and procurement techniques could improve the efficiency of the construction process, thus reducing the overall costs associated with implementing a pavement improvement project.

Within the HERS modeling framework, extending pavement lives can be expected to have the following major effects: (1) pavement improvements would generate a longer stream of lifetime benefits, potentially increasing their benefit-cost ratios; (2) resurfacing or reconstruction actions taken in conjunction with widening improvements would generate a longer stream of lifetime benefits; (3) pavement improvements would be needed less frequently, potentially freeing up resources to be used for capacity expansion within a fixed budget level; and (4) the negative effects of deferring a pavement action would be smaller because pavement deterioration between the 5-year periods analyzed would be less severe.

The information presented in *Exhibit 10-2* represents the potential impacts of improved pavement technology under a hypothetical scenario that assumes that, starting immediately, the pavement lives associated with all new pavement reconstruction and reconstruction actions would extend one-third longer than is assumed in the baseline HERS analyses. Assuming fixed rate user financing, the baseline analyses presented in Chapter 7 identified the level of investment associated with a minimum benefit-cost ratio of 1.0 to be $111.5 billion in constant 2006 dollars. Longer pavement lives would tend to increase the benefits associated with each pavement improvement that is implemented, so the minimum benefit-cost ratio associated with this funding level would be 1.05; an average annual investment level of $115.0 billion would be associated with a benefit-cost ratio of 1.00 under this scenario.

For the variable rate user financing version of the baseline analyses, an average annual investment level of $79.5 billion in constant 2006 dollars was associated with a minimum benefit-cost ratio cutoff of 1.00. Assuming longer pavement lives, HERS projects an average annual investment level of $80.1 billion could be utilized in a cost-beneficial manner.

Exhibit 10-2

Impact of Alternative Pavement Life Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Baseline: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Baseline: Average Delay Per VMT	Baseline: Average IRI	Baseline: Minimum Benefit-Cost Ratio	Alternative: Pavement Lives Extended by 1/3: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Alternative: Average Delay Per VMT	Alternative: Average IRI	Alternative: Minimum Benefit-Cost Ratio Cutoff
Assuming Fixed Rate User Financing									
7.45%	$111.5	-2.9%	-10.2%	-23.1%	**1.00**	-3.1%	-10.9%	-25.5%	1.05
6.41%	$98.6	-2.3%	-6.9%	-18.1%	**1.20**	-2.4%	-7.5%	-20.8%	1.25
5.03%	$84.0	-1.4%	-2.7%	-11.2%	**1.50**	-1.5%	-3.1%	-13.6%	1.56
4.55%	$79.5	-1.0%	-1.1%	-8.6%	1.62	-1.2%	-1.5%	-11.1%	1.68
4.17%	$76.1	-0.8%	**0.0%**	-6.6%	1.71	-0.9%	-0.3%	-9.1%	1.77
3.30%	$69.0	-0.2%	2.9%	-2.3%	1.93	-0.3%	2.3%	-4.3%	2.00
3.07%	$67.2	**0.0%**	3.6%	-1.0%	1.98	-0.2%	2.9%	-3.0%	2.06
2.93%	$66.2	0.1%	3.9%	**0.0%**	2.02	-0.1%	3.4%	-2.3%	2.10
1.67%	$57.6	1.0%	7.0%	7.9%	2.42	0.8%	6.5%	5.9%	2.49
0.83%	$52.6	1.5%	9.1%	12.4%	2.70	1.4%	8.8%	10.2%	2.76
0.34%	$50.0	1.8%	10.3%	15.1%	2.86	1.7%	10.2%	12.9%	2.93
0.00%	$48.2	2.1%	11.1%	17.1%	2.89	1.9%	11.1%	14.8%	2.95
-0.78%	$44.4	2.6%	13.5%	20.8%	2.94	2.4%	13.4%	18.6%	3.01
-1.37%	$41.8	3.0%	15.1%	23.8%	2.99	2.8%	15.1%	21.5%	3.04
-4.95%	$29.5	5.2%	22.6%	42.0%	3.24	5.1%	22.5%	40.1%	3.30
-7.64%	$23.2	*	27.5%	53.1%	3.43	6.5%	27.0%	51.6%	3.50
7.71%	$115.0					-3.3%	-11.8%	-26.7%	**1.00**
Assuming Variable Rate User Financing									
4.55%	$79.5	-2.7%	-12.3%	-19.3%	**1.00**				
4.17%	$76.1	-2.5%	-11.6%	-17.6%	1.06	-2.7%	-11.7%	-20.4%	1.07
3.30%	$69.0	-2.1%	-10.3%	-14.0%	**1.20**	-2.3%	-10.3%	-16.8%	1.21
3.07%	$67.2	-2.0%	-9.9%	-13.0%	1.24	-2.2%	-9.9%	-15.9%	1.25
2.93%	$66.2	-2.0%	-9.8%	-12.5%	1.26	-2.1%	-9.7%	-15.4%	1.27
1.67%	$57.6	-1.4%	-7.7%	-6.7%	**1.50**	-1.5%	-7.7%	-9.4%	1.53
0.83%	$52.6	-1.0%	-6.5%	-2.6%	1.71	-1.1%	-6.5%	-5.2%	1.74
0.34%	$50.0	-0.8%	-5.8%	**0.0%**	1.82	-0.9%	-5.8%	-2.6%	1.86
0.00%	$48.2	-0.6%	-5.3%	1.8%	1.90	-0.7%	-5.3%	-0.8%	1.94
-0.78%	$44.4	-0.3%	-4.4%	5.7%	2.12	-0.4%	-4.4%	3.1%	2.15
-1.37%	$41.8	**0.0%**	-3.7%	8.4%	2.25	-0.1%	-3.6%	5.9%	2.30
-4.95%	$29.5	1.6%	**0.0%**	25.2%	2.42	1.4%	**0.0%**	23.0%	2.48
-7.64%	$23.2	2.6%	1.4%	37.1%	2.55	2.5%	1.3%	35.2%	2.62
4.62%	$80.1					-2.9%	-12.4%	-22.4%	**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

Relative to the baseline analyses, for all levels of investment that were analyzed, the hypothetical scenario assuming longer pavement lives would result in larger reductions in the average International Roughness Index (IRI) by 2026. The level of investment required to maintain average IRI at 2006 levels would be lower for both the fixed rate user financing and variable rate user financing versions of the scenario. For the fixed rate version of the scenario, average delay per VMT was lower for all levels of investment that were analyzed. While improvements in pavement technology would not significantly reduce congestion, extending the service life of pavements would tend to reduce the frequency of pavement improvements, freeing resources to be directed to capacity expansion.

It is important to note that extending pavement lives would have additional positive impacts beyond the 20-year analysis period addressed in this report. While the benefit-cost procedures in HERS take into account benefits for the full expected life of a project, the application of a 7 percent annual discount rate as part of the analysis significantly reduces the degree to which long-term benefits influence the benefit-cost ratios computed for each potential project. The theoretical basis for the application of a discount rate is discussed later in this section, along with a sensitivity analysis of the impacts of assuming higher or lower discount rates.

Alternative Estimates of Travel Demand

States provide forecasts of future vehicle miles traveled (VMT) for each individual Highway Performance Monitoring System (HPMS) sample highway section. As discussed in Chapter 9, HERS assumes that the forecast for each sample highway segment represents the level of travel that will occur if a constant level of service is maintained on that facility. This implies that VMT will occur at this level only if pavement and capacity improvements made on the segment over the 20-year analysis period are sufficient to maintain highway user costs at 2006 levels. If HERS predicts that highway user costs will deviate from baseline 2006 levels on a given highway segment, the model's travel demand elasticity features will modify the baseline VMT growth projections from HPMS.

The effective VMT growth rates predicted by the HERS model could be off-target if (1) the HPMS forecasts don't precisely represent the travel that will occur if a constant level of service is maintained or (2) the travel

Q&A

What are some of the technical limitations associated with the analysis of alternative travel growth rates included in this section?

One of the strengths of the State-provided VMT forecasts used in the baseline analysis is their geographic specificity. As separate forecasts are provided for the more than 100,000 HPMS sample sections, this provides States with the opportunity to take into account specific local factors that might influence travel growth on a particular highway section, and to reflect the assumptions they are making in their own long range planning regarding future travel patterns for particular routes or corridors. This allows for more refined analyses of projected future investment/performance relationships for particular system components than could be conducted based on regional or statewide travel estimates.

The analyses of alternative travel growth rates presented in this section use the HPMS forecasts as a starting point, but modify them up or down uniformly on a national basis. In reality, if VMT were to grow faster or slower than what has been projected by the States, these differences would not be uniform, and could be heavily concentrated in particular corridors, regions, or States; this could significantly impact the level of investment that might be required to achieve particular systemwide performance targets.

As the HERS analysis is conducted at the highway section level, it is important that the input data it uses take into account the specific characteristics of that section. As, the analyses of alternative VMT growth rates presented in this section deviate from this approach by applying nationwide adjustments, they should be considered less reliable.

demand elasticity procedures in HERS do not accurately predict how highway users will respond to changes in costs.

This section includes an analysis of three alternative constant levels of service VMT forecasts: one based on historic VMT growth rates, one based on projected population growth, and one assuming no future VMT growth on any highway section. This section also examines the effects of increasing the travel demand elasticity values applied in HERS, which would assume a greater sensitivity of drivers to changes in user costs than is currently reflected in the baseline scenarios.

Historic Travel Growth

As indicated in Chapter 9, the State-supplied VMT growth projections in HPMS for 2006 to 2026 average 1.84 percent per year, well below the 2.52 percent average annual VMT growth rate observed from 1986 to 2006. As noted in Chapter 4, however, the level of service on highways in the United States in terms of traveler delay and overall congestion has generally been declining over the past two decades. If States expect this trend to continue and factor this into their projections, then the HPMS forecasts might reflect a declining level of service, rather than the constant level of service assumed by HERS.

The "Historic Rates" values identified in *Exhibit 10-3* reflect the effects of modifying the HPMS forecasts to assume that the average annual VMT growth rate of 2.52 percent over the last 20 years represents the growth that would occur if a constant level of service were sustained for the next 20 years. Higher VMT would increase both overall congestion levels and the rate of pavement deterioration, which would result in higher adjusted average highway user costs for any given level of capital investment. Assuming fixed rate user financing, HERS projects that the annual constant dollar spending increase required to maintain adjusted average user costs lies in a range between 6.41 percent and 7.45 percent for the historic VMT alternative; this is significantly higher than the 3.07 percent annual growth rate associated with meeting this target in the baseline analyses. Assuming variable rate user financing, HERS projects that maintaining adjusted average user costs at 2006 levels would require an increase in combined public and private spending of between 1.67 percent and 2.93 percent annually. In contrast, the baseline analyses assuming variable rate user financing had projected that this target could be achieved even if spending fell by 1.37 percent per year in constant dollar terms.

The minimum benefit-cost ratios associated with the historic travel alternative are significantly higher than those identified for comparable investment levels in the baseline analyses for both the fixed rate and variable rate user financing options; the presence of more system users on all facilities would increase the potential total user benefits of improving each individual facility. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion of potentially cost beneficial investments assuming fixed rate user financing, this amount would increase to $148.9 billion for the higher VMT growth rates. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $99.9 billion in constant 2006 dollars assuming higher VMT growth, well above the $79.5 billion figure identified in the baseline analyses.

Population Growth

Annual VMT growth as reported by the States in HPMS has trended downward in recent years; annual growth rates were below 1 percent in 2005 and 2006, and are expected to be even lower in 2007 and 2008. While some of this decline can be attributed to higher fuel prices, which would not be relevant to a constant price VMT forecast, or to broader macroeconomic trends that are temporary in nature, some of this decline may be the result of fundamental changes in the underlying demand for highway transportation. To the extent that the factors that have led VMT growth per capita to rise for many years have permanently abated,

Exhibit 10-3

Impact of Alternative Constant Price Travel Growth Forecasts on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Adjusted Average User Cost, 2026 Compared With 2006: Constant Price VMT Growth Assumption				Minimum Benefit-Cost Ratio Cutoff: Constant Price VMT Growth Assumption			
		Baseline	Alternative			Baseline	Alternative		
		State-Projected	Historic Rates	Population-Driven	No Growth	State-Projected	Historic Rates	Population-Driven	No Growth
Assuming Fixed Rate User Financing									
7.45%	$111.5	-2.9%	-0.6%			**1.00**	1.50		
6.41%	$98.6	-2.3%	0.3%			**1.20**	1.78		
5.03%	$84.0	-1.4%	1.5%			**1.50**	2.20		
4.55%	$79.5	-1.0%	1.9%			1.62	2.33		
4.17%	$76.1	-0.8%	2.2%	-3.5%		1.71	2.45	1.02	
3.30%	$69.0	-0.2%	2.9%	-3.1%		1.93	2.76	1.18	
3.07%	$67.2	**0.0%**	3.1%	-3.0%		1.98	2.85	1.23	
2.93%	$66.2	0.1%	3.2%	-2.9%		2.02	2.92	1.26	
1.67%	$57.6	1.0%	4.3%	-2.3%		2.42	3.26	1.51	
0.83%	$52.6	1.5%	5.0%	-1.9%		2.70	3.31	1.70	
0.34%	$50.0	1.8%	5.4%	-1.6%	-3.4%	2.86	3.34	1.83	1.03
0.00%	**$48.2**	2.1%	5.6%	-1.4%	-3.4%	2.89	3.36	1.91	1.08
-0.78%	$44.4	2.6%	6.2%	-1.0%	-3.1%	2.94	3.43	2.11	1.20
-1.37%	$41.8	3.0%	6.7%	-0.7%	-2.9%	2.99	3.48	2.30	1.31
-4.95%	$29.5	5.2%	9.2%	1.0%	-1.6%	3.24	3.77	2.78	2.04
-7.64%	$23.2	6.7%	10.8%	2.2%	-0.8%	3.43	3.99	2.97	2.42
9.84%	$148.9		-2.5%				**1.00**		
4.28%	$77.1			-3.5%				**1.00**	
0.55%	$51.1				-3.5%				**1.00**
Assuming Variable Rate User Financing									
6.41%	$98.6		-1.9%				1.02		
5.03%	$84.0		-1.2%				1.26		
4.55%	$79.5	-2.7%	-1.0%			**1.00**	1.34		
4.17%	$76.1	-2.5%	-0.8%			1.06	1.41		
3.30%	$69.0	-2.1%	-0.3%			**1.20**	1.60		
3.07%	$67.2	-2.0%	-0.2%			1.24	1.66		
2.93%	$66.2	-2.0%	-0.1%			1.26	1.69		
1.67%	$57.6	-1.4%	0.5%	-3.4%		**1.50**	1.99	1.02	
0.83%	$52.6	-1.0%	1.0%	-3.1%		1.71	2.23	1.16	
0.34%	$50.0	-0.8%	1.3%	-2.9%		1.82	2.36	1.25	
0.00%	**$48.2**	-0.6%	1.4%	-2.8%		1.90	2.45	1.32	
-0.78%	$44.4	-0.3%	1.8%	-2.5%		2.12	2.49	1.46	
-1.37%	$41.8	**0.0%**	2.1%	-2.3%		2.25	2.52	1.58	
-4.95%	$29.5	1.6%	3.8%	-1.0%	-2.8%	2.42	2.69	2.13	1.60
-7.64%	$23.2	2.6%	5.0%	-0.1%	-2.1%	2.55	2.83	2.26	1.94
6.52%	$99.9		-2.0%				**1.00**		
1.82%	$58.6			-3.5%				**1.00**	
-1.73%	$40.3				-3.6%				**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

projected population growth could serve as a proxy for constant price VMT growth. The Census Bureau's population forecasts for 2026 relative to 2006 equate to an average annual growth rate of 0.95 percent.

The "Population-Driven" values identified in *Exhibit 10-3* reflect the effects of modifying the HPMS forecasts to assume that that VMT per capita will remain unchanged in the future, and that projected population growth years represents the growth that would occur if a constant level of service were sustained for the next 20 years. Reducing the VMT growth rate would tend to reduce congestion levels and the rate of pavement deterioration relative to what was projected in the baseline analyses, which assumed a constant price VMT growth of 1.84 percent per year. Assuming population-driven VMT growth, HERS projects that adjusted average user costs in 2026 could be reduced below base year levels if combined public and private highway capital investment were sustained at base year 2006 levels, regardless of whether or not variable rate user charges were imposed.

The minimum benefit-cost ratios associated with the population-driven travel alternative are significantly lower than those identified for comparable investment levels in the baseline analyses for both the fixed rate and variable rate user financing options. The presence of fewer system users on all facilities would decrease the potential total user benefits of improving each individual facility. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion of potentially cost beneficial investments assuming fixed rate user financing, this amount would decrease to $77.1 billion assuming lower VMT growth. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $58.6 billion in constant 2006 dollars assuming lower travel growth, well below the $79.5 billion figure identified in the baseline analyses.

No Growth

In order to isolate future investment needs associated with accommodating current system users rather than costs associated with accommodating future travel growth, it is useful to compare the baseline analyses to a no growth option. The "No-Growth" values identified in *Exhibit 10-3* reflect the effects of modifying the HPMS VMT forecasts for each sample highway section so that they are equal to current travel volumes. This approach effectively assumes that the only changes in VMT that would occur in the future would be driven by drivers' responses to changes in user costs, rather than by population growth, economic growth, or other factors.

Assuming a constant price VMT growth forecast of zero, the minimum benefit-cost ratios associated with each alternative investment level would be lower than those for the baseline analyses for both the fixed rate and variable rate user financing options because the presence of fewer system users on all facilities would decrease the potential total user benefits of improving each individual facility. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion in potentially cost beneficial investments assuming fixed rate user financing, this amount would decrease to $51.1 billion if no exogenous increase in travel demand is assumed. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $40.3 billion in constant 2006 dollars for the no-growth alternative, well below the $79.5 billion figure identified in the baseline analyses. These findings suggest that a significant percentage of future investment needs are attributable to the costs of accommodating either new system users or additional travel by existing system users on a transportation network that is already over-stressed.

HERS recommends devoting a larger share of total capital investment to system rehabilitation for the no-growth alternative than for the baseline. However, the system expansion investments that are made would reduce congestion, rather than simply slowing its growth, since any new lanes added would not fill up quickly with new traffic. Adjusted average user costs would be expected to decline even if highway capital investment levels were significantly reduced below 2006 levels in constant dollar terms.

Elasticity Values

HERS applies both short-run and long-run travel demand elasticity procedures in its analysis, using assumed input values for these parameters. There is considerable uncertainty, however, about what the appropriate values would be in this context. The elasticity values used in the analyses for this report (-0.4 for short-run elasticity and -0.8 for long-run elasticity) are lower than the comparable parameter values that were used in the 2004 C&P Report (-0.6 for short-run elasticity and -1.2 for long-run elasticity). Appendix A includes a description of the HERS elasticity procedures. Higher elasticity values would cause the changes in VMT associated with increases or decreases in highway user costs to be larger in magnitude. It should be noted that the HERS procedures apply these elasticity values to all costs that would be perceived by highway users, which would include user taxes and the effects of future changes in fuel economy. Both of these are excluded from the adjusted highway user costs statistics presented in this Chapter as a proxy for overall system conditions and performance.

Assuming fixed rate user financing, *Exhibit 10-4* shows that projected 2026 VMT would be higher for most levels of investment based on higher elasticity values assumed in the 2004 C&P Report than for the baseline analyses. This occurs because the reductions in user costs associated with increased investment would translate into higher levels of future travel growth. However, if spending were to decline by approximately 4.95 percent or more per year, or to increase by approximately 5.03 percent or more annually, the higher elasticities would result in lower projected VMT. At lower levels of investment, increased user costs would suppress some travel that would otherwise have occurred. The relatively lower projected VMT at higher levels of investment is an artifact of the way the analyses were constructed; as discussed in Chapter 7, the fixed rate user charges are set at a level sufficient to cover not only the types of investment modeled in HERS, but also proportional increases to the types of investment modeled in NBIAS and non-modeled improvement types. Consequently, at the highest levels of investment analyzed, the increase in fixed rate user charges required to support the investment would exceed the user costs savings derived from them.

Assuming variable rate user financing, *Exhibit 10-4* shows that projected 2026 VMT would be lower for all levels of investment based on higher elasticity values assumed in the 2004 C&P Report than for the baseline analyses. These analyses assume the widespread adoption of congestion pricing; the higher elasticity values would translate into lower levels of future travel growth in response to these user charges. For all levels of investment, adjusted average user costs and average delay per VMT would be lower than in the baseline analyses. Similarly, the higher elasticity values would reduce the level of investment required to maintain these performance indicators at base year levels.

The minimum benefit-cost ratios associated with the higher elasticity alternative are lower than those identified for comparable investment levels in the baseline analyses for both the fixed rate and variable rate user financing options. With fewer travelers to accommodate, the relative benefits associated with many potential capital improvements would be lower. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion of potentially cost beneficial investments assuming fixed rate user financing, this amount would decrease to $100.2 billion based on higher elasticity values. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $70.5 billion in constant 2006 dollars assuming higher elasticity values, compared to $79.5 billion in the baseline analyses.

Exhibit 10-4

Impact of Alternative Travel Demand Elasticity Values on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Baseline: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Baseline: Percent Change, 2026 Compared With 2006: Average Delay Per VMT	Baseline: Projected VMT in 2026 (Trillions)	Baseline: Minimum Benefit-Cost Ratio Cutoff	Alternative: Elasticity from 2004 C&P Report: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Alternative: Percent Change, 2026 Compared With 2006: Average Delay Per VMT	Alternative: Projected VMT in 2026 (Trillions)	Alternative: Minimum Benefit-Cost Ratio Cutoff
Assuming Fixed Rate User Financing									
7.45%	$111.5	-2.9%	-10.2%	4.338	**1.00**				
6.41%	$98.6	-2.3%	-6.9%	4.349	**1.20**	-2.6%	-7.6%	4.342	1.02
5.03%	$84.0	-1.4%	-2.7%	4.358	**1.50**	-1.7%	-3.6%	4.358	1.28
4.55%	$79.5	-1.0%	-1.1%	4.359	1.62	-1.4%	-2.3%	4.360	1.38
4.17%	$76.1	-0.8%	**0.0%**	4.360	1.71	-1.2%	-1.1%	4.362	1.45
3.30%	$69.0	-0.2%	2.9%	4.360	1.93	-0.7%	1.0%	4.365	1.66
3.07%	$67.2	**0.0%**	3.6%	4.360	1.98	-0.5%	1.5%	4.366	1.73
2.93%	$66.2	0.1%	3.9%	4.360	2.02	-0.4%	1.9%	4.366	1.77
1.67%	$57.6	1.0%	7.0%	4.358	2.42	0.3%	5.1%	4.365	2.10
0.83%	$52.6	1.5%	9.1%	4.356	2.70	0.8%	7.2%	4.362	2.32
0.34%	$50.0	1.8%	10.3%	4.354	2.86	1.1%	8.3%	4.360	2.49
0.00%	**$48.2**	2.1%	11.1%	4.352	2.89	1.3%	9.0%	4.358	2.58
-0.78%	$44.4	2.6%	13.5%	4.349	2.94	1.8%	10.7%	4.353	2.62
-1.37%	$41.8	3.0%	15.1%	4.346	2.99	2.1%	12.0%	4.350	2.65
-4.95%	$29.5	5.2%	22.6%	4.322	3.24	4.1%	18.2%	4.321	2.87
-7.64%	$23.2	6.7%	27.5%	4.304	3.43	5.3%	21.7%	4.299	3.03
6.55%	$100.2					-2.6%	-8.1%	4.340	**1.00**
Assuming Variable Rate User Financing									
4.55%	$79.5	-2.7%	-12.3%	4.260	**1.00**				
4.17%	$76.1	-2.5%	-11.6%	4.260	1.06				
3.30%	$69.0	-2.1%	-10.3%	4.258	**1.20**	-2.5%	-12.9%	4.237	1.03
3.07%	$67.2	-2.0%	-9.9%	4.257	1.24	-2.4%	-12.6%	4.237	1.07
2.93%	$66.2	-2.0%	-9.8%	4.257	1.26	-2.4%	-12.4%	4.236	1.10
1.67%	$57.6	-1.4%	-7.7%	4.251	**1.50**	-1.9%	-10.8%	4.232	1.31
0.83%	$52.6	-1.0%	-6.5%	4.246	1.71	-1.5%	-9.8%	4.228	1.49
0.34%	$50.0	-0.8%	-5.8%	4.243	1.82	-1.3%	-9.2%	4.224	1.59
0.00%	**$48.2**	-0.6%	-5.3%	4.240	1.90	-1.2%	-8.9%	4.222	1.67
-0.78%	$44.4	-0.3%	-4.4%	4.235	2.12	-0.9%	-8.0%	4.216	1.83
-1.37%	$41.8	**0.0%**	-3.7%	4.231	2.25	-0.6%	-7.5%	4.212	1.96
-4.95%	$29.5	1.6%	**0.0%**	4.205	2.42	0.7%	-4.9%	4.185	2.17
-7.64%	$23.2	2.6%	1.4%	4.187	2.55	1.6%	-3.8%	4.165	2.30
3.50%	$70.5					-2.6%	-13.1%	4.237	**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

Alternative Economic Analysis Assumptions

The economic assumptions underlying a benefit-cost analysis can have significant impacts on its overall findings. The economic parameter values applied in HERS and NBIAS are generally based on observed conditions in 2006, and are assumed to remain constant unless otherwise specified. However, recent sharp changes in the values for some key parameters increases the uncertainty associated with these assumptions. Conducting sensitivity analyses on these types of parameters is a method for gauging the significance of the baseline assumptions by assessing their relative impact on the overall findings. This section includes an analysis of the potential impacts of significantly raising the values for three key input parameters: the fuel prices assumed in the HERS model, the highway construction costs assumed in the HERS model, and the bridge repair and rehabilitation costs assumed in the NBIAS model.

The benefit-cost analysis procedures employed in the HERS and NBIAS models also require a discount factor to be applied in order to compare the future benefit streams produced by a highway improvement with the initial cost of that improvement. For the baseline investment analyses presented in this report, a 7-percent discount rate is used in accordance with the guidelines for Federal infrastructure investment analyses under OMB Circular A-94. This section includes an analysis of the potential impacts on the HERS and NBIAS analysis of assuming two alternative discount rates: 4 percent and 10 percent.

Fuel Prices

The baseline assumption regarding fuel prices in HERS is generally consistent with the Energy Information Administration's (EIA's) reference case forecast of future fuel prices from its *Annual Energy Outlook 2008* publication. EIA identified 2006 prices of $2.63 per gallon for gasoline and $2.71 per gallon for diesel fuel; the reference case forecast through 2030 projects that costs will rise above this level in the short term, but will fall back below these levels in constant dollar terms in the long run. EIA's publication also includes a high price forecast, which projects an increase in prices by 2030 to $3.52 per gallon for gasoline and $3.80 per gallon for diesel, stated in constant 2006 dollars. The high price forecast also reflects changes to projected vehicle fuel efficiency in response to these price increases.

Exhibit 10-5 demonstrates the impact on the HERS analyses of substituting in the fuel price and vehicle fleet assumption from EIA's high price case in lieu of those from EIA's reference case. Through the operation of the HERS travel demand elasticity procedures, higher fuel prices would result in lower projections for 2026 VMT for all funding levels, regardless of the financing mechanism employed to support that level of investment. As a result of lower overall travel volumes, average delay per VMT in 2026 is projected to be lower for each level of investment analyzed assuming the high price case, relative to the comparable baseline analyses. Average IRI in 2026 is also projected to be lower under the high price case; a portion of this decline is attributable to reduced wear and tear on pavements resulting from lower VMT, but the majority is attributable to changes in HERS investment patterns. Under the high price case alternative, HERS recommends devoting a larger share of total investment to pavement rehabilitation, as the relative benefits of system expansion improvements would be lower in light of the reduced overall traffic volumes relative to the baseline.

Assuming fixed rate user financing and higher fuel prices, HERS projects that the annual constant dollar spending increase required to maintain average delay per VMT would be lower than the 4.17-percent growth figure computed for the baseline. *Exhibit 10-5* also shows that the annual spending increase associated with maintaining average IRI would be lower than the 2.93-percent growth rate computed for the baseline. Assuming variable rate user financing, HERS projects that average delay could be maintained at 2006 levels even if combined public and private highway capital investment were to decline by 7.64 percent annually under the high fuel price alternative; the comparable rate to meet this target under the base case is an annual

Exhibit 10-5

Impact of Alternative Fuel Price Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Baseline: EIA Reference Case				Alternative: EIA High Price Case			
		Percent Change, 2026 Compared With 2006: Average Delay Per VMT	Percent Change, 2026 Compared With 2006: Average IRI	Projected VMT in 2026 (Trillions)	Minimum Benefit-Cost Ratio Cutoff	Percent Change, 2026 Compared With 2006: Average Delay Per VMT	Percent Change, 2026 Compared With 2006: Average IRI	Projected VMT in 2026 (Trillions)	Minimum Benefit-Cost Ratio Cutoff
Assuming Fixed Rate User Financing									
7.45%	$111.5	-10.2%	-23.1%	4.34	**1.00**				
6.41%	$98.6	-6.9%	-18.1%	4.35	**1.20**	-8.4%	-19.1%	4.27	1.13
5.03%	$84.0	-2.7%	-11.2%	4.36	**1.50**	-4.4%	-11.9%	4.28	1.42
4.55%	$79.5	-1.1%	-8.6%	4.36	1.62	-3.0%	-9.7%	4.28	1.53
4.17%	$76.1	**0.0%**	-6.6%	4.36	1.71	-1.7%	-7.7%	4.28	1.61
3.30%	$69.0	2.9%	-2.3%	4.36	1.93	0.9%	-3.4%	4.28	1.83
3.07%	$67.2	3.6%	-1.0%	4.36	1.98	1.7%	-2.1%	4.28	1.89
2.93%	$66.2	3.9%	**0.0%**	4.36	2.02	2.1%	-1.5%	4.28	1.93
1.67%	$57.6	7.0%	7.9%	4.36	2.42	5.2%	6.3%	4.28	2.31
0.83%	$52.6	9.1%	12.4%	4.36	2.70	7.2%	11.2%	4.28	2.60
0.34%	$50.0	10.3%	15.1%	4.35	2.86	8.5%	13.7%	4.28	2.77
0.00%	**$48.2**	11.1%	17.1%	4.35	2.89	9.2%	15.6%	4.28	2.86
-0.78%	$44.4	13.5%	20.8%	4.35	2.94	11.4%	19.6%	4.27	2.91
-1.37%	$41.8	15.1%	23.8%	4.35	2.99	12.9%	22.6%	4.27	2.95
-4.95%	$29.5	22.6%	42.0%	4.32	3.24	20.4%	40.8%	4.25	3.21
-7.64%	$23.2	27.5%	53.1%	4.30	3.43	24.9%	52.0%	4.23	3.39
7.06%	$106.5					-10.3%	-22.1%	4.26	**1.00**
Assuming Variable Rate User Financing									
4.55%	$79.5	-12.3%	-19.3%	4.26	**1.00**				
4.17%	$76.1	-11.6%	-17.6%	4.26	1.06				
3.30%	$69.0	-10.3%	-14.0%	4.26	**1.20**	-11.2%	-14.7%	4.18	1.13
3.07%	$67.2	-9.9%	-13.0%	4.26	1.24	-10.8%	-13.7%	4.18	1.17
2.93%	$66.2	-9.8%	-12.5%	4.26	1.26	-10.6%	-13.2%	4.18	1.19
1.67%	$57.6	-7.7%	-6.7%	4.25	**1.50**	-8.6%	-7.5%	4.17	1.42
0.83%	$52.6	-6.5%	-2.6%	4.25	1.71	-7.4%	-3.4%	4.17	1.62
0.34%	$50.0	-5.8%	**0.0%**	4.24	1.82	-6.8%	-1.1%	4.17	1.74
0.00%	**$48.2**	-5.3%	1.8%	4.24	1.90	-6.3%	0.6%	4.17	1.82
-0.78%	$44.4	-4.4%	5.7%	4.23	2.12	-5.3%	4.8%	4.16	2.03
-1.37%	$41.8	-3.7%	8.4%	4.23	2.25	-4.6%	7.5%	4.16	2.17
-4.95%	$29.5	**0.0%**	25.2%	4.20	2.42	-1.3%	24.4%	4.13	2.39
-7.64%	$23.2	1.4%	37.1%	4.19	2.55	0.0%	36.4%	4.12	2.52
4.14%	$75.8					-12.5%	-18.1%	4.18	**1.00**

** Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

decline of 4.95 percent. The annual spending increase associated with maintaining average IRI would be lower than the 0.34 percent growth rate computed for the baseline, assuming variable rate user financing.

The minimum benefit-cost ratios associated with EIA's high price case are lower than those identified for comparable investment levels in the baseline analyses for both the fixed rate and variable rate user financing options. With fewer travelers to accommodate, the relative benefits associated with many potential capital improvements would be lower. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion of potentially cost beneficial investments under a fixed rate user financing mechanism, this amount would decline to $106.5 billion assuming higher fuel prices. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $75.8 billion in constant 2006 dollars assuming higher fuel prices, compared to $79.5 billion in the baseline analyses.

Note that *Exhibit 10-5* does not include information of adjusted average user costs; this omission was intentional, as the high price case changes in fuel cost and efficiency would logically affect the base year value for this statistic, so any percentage changes from the base year would not be directly comparable between the baseline and this alternative.

Improvement Costs

The unit improvement costs used in HERS and NBIAS to calculate total investment costs, while periodically resurveyed and adjusted for inflation, are subject to uncertainty. Particularly in light of the recent sharp increases in highway construction costs discussed in Chapters 6 and 9, it is prudent to consider the impact that higher-than-expected capital improvement costs would have on the results of the baseline HERS and NBIAS analyses.

The last several editions of the C&P report have included sensitivity analyses identifying the effect of increasing all constant dollar capital improvement costs by 25 percent in constant dollar terms. This edition includes analyses of this nature, which are presented separately for HERS and NBIAS.

Alternative HERS Improvement Costs

If construction costs for all potential highway capital projects were 25 percent higher, this would limit the total number of projects that could be completed within a fixed budget level, and thus the impacts of that level of investment would be smaller. *Exhibit 10-6* demonstrates this effect, as the projected percent changes between 2006 and 2026 in adjusted average user costs, average delay per VMT, and average IRI are projected to be smaller in magnitude for this alternative relative to the base case for each level of investment analyzed.

Assuming fixed rate user financing and higher construction costs, HERS projects that the annual constant dollar spending increase required to maintain adjusted average user costs lie in a range between 4.55 percent and 5.03 percent, which is significantly higher than the 3.07-percent annual growth rate associated with meeting this target in the baseline analyses. Assuming variable rate user financing, HERS projects that maintaining adjusted average user costs at 2006 levels would require an increase in combined public and private spending of between 0.34 percent and 0.83 percent annually. In contrast, the baseline analyses assuming variable rate user financing had projected that this target could be achieved even if spending fell by 1.37 percent per year in constant dollar terms.

The minimum benefit-cost ratios associated with a 25-percent increase in highway construction costs are higher than those identified for comparable investment levels in the baseline analyses for both the fixed

Exhibit 10-6

Impact of Alternative Construction Cost Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Baseline: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Baseline: Average Delay Per VMT	Baseline: Average IRI	Baseline: Minimum Benefit-Cost Ratio Cutoff	Alternative: Increase Costs by 25 Percent: Percent Change, 2026 Compared With 2006: Adjusted Average User Costs	Alternative: Average Delay Per VMT	Alternative: Average IRI	Alternative: Minimum Benefit-Cost Ratio Cutoff
Assuming Fixed Rate User Financing									
7.45%	$111.5	-2.9%	-10.2%	-23.1%	**1.00**	-1.8%	-5.5%	-14.4%	1.09
6.41%	$98.6	-2.3%	-6.9%	-18.1%	**1.20**	-1.1%	-2.1%	-8.6%	1.29
5.03%	$84.0	-1.4%	-2.7%	-11.2%	**1.50**	-0.1%	2.5%	-1.2%	1.57
4.55%	$79.5	-1.0%	-1.1%	-8.6%	1.62	0.2%	3.9%	1.9%	1.69
4.17%	$76.1	-0.8%	**0.0%**	-6.6%	1.71	0.5%	4.7%	4.4%	1.79
3.30%	$69.0	-0.2%	2.9%	-2.3%	1.93	1.2%	6.8%	10.7%	2.02
3.07%	$67.2	**0.0%**	3.6%	-1.0%	1.98	1.3%	7.3%	12.0%	2.08
2.93%	$66.2	0.1%	3.9%	**0.0%**	2.02	1.4%	7.7%	12.8%	2.12
1.67%	$57.6	1.0%	7.0%	7.9%	2.42	2.3%	11.5%	19.5%	2.50
0.83%	$52.6	1.5%	9.1%	12.4%	2.70	2.9%	13.9%	24.1%	2.67
0.34%	$50.0	1.8%	10.3%	15.1%	2.86	3.2%	15.3%	26.6%	2.70
0.00%	**$48.2**	2.1%	11.1%	17.1%	2.89	3.5%	16.2%	28.5%	2.72
-0.78%	$44.4	2.6%	13.5%	20.8%	2.94	4.0%	18.0%	33.1%	2.75
-1.37%	$41.8	3.0%	15.1%	23.8%	2.99	4.4%	19.2%	36.3%	2.80
-4.95%	$29.5	5.2%	22.6%	42.0%	3.24	6.5%	26.3%	52.7%	3.01
-7.64%	$23.2	6.7%	27.5%	53.1%	3.43	7.9%	30.6%	63.3%	3.18
7.94%	$118.3					-2.2%	-7.1%	-17.0%	**1.00**
Assuming Variable Rate User Financing									
4.55%	$79.5	-2.7%	-12.3%	-19.3%	**1.00**	-1.8%	-9.8%	-10.8%	1.06
4.17%	$76.1	-2.5%	-11.6%	-17.6%	1.06	-1.6%	-9.1%	-8.8%	1.12
3.30%	$69.0	-2.1%	-10.3%	-14.0%	**1.20**	-1.2%	-7.8%	-4.4%	1.27
3.07%	$67.2	-2.0%	-9.9%	-13.0%	1.24	-1.1%	-7.5%	-3.2%	1.32
2.93%	$66.2	-2.0%	-9.8%	-12.5%	1.26	-1.1%	-7.2%	-2.5%	1.36
1.67%	$57.6	-1.4%	-7.7%	-6.7%	**1.50**	-0.4%	-5.3%	4.2%	1.60
0.83%	$52.6	-1.0%	-6.5%	-2.6%	1.71	-0.1%	-4.2%	8.1%	1.79
0.34%	$50.0	-0.8%	-5.8%	**0.0%**	1.82	0.2%	-3.6%	10.8%	1.90
0.00%	**$48.2**	-0.6%	-5.3%	1.8%	1.90	0.3%	-3.2%	12.6%	1.97
-0.78%	$44.4	-0.3%	-4.4%	5.7%	2.12	0.7%	-2.3%	16.5%	2.06
-1.37%	$41.8	**0.0%**	-3.7%	8.4%	2.25	1.0%	-1.6%	19.4%	2.09
-4.95%	$29.5	1.6%	**0.0%**	25.2%	2.42	2.5%	0.8%	36.9%	2.22
-7.64%	$23.2	2.6%	1.4%	37.1%	2.55	3.5%	2.1%	48.2%	2.36
4.94%	$83.1					-2.0%	-10.5%	-12.7%	**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

rate and variable rate user financing options. While the benefit-cost ratios for each individual project would be reduced under this alternative, the number of projects that could be implemented would also be reduced, resulting in a higher benefit-cost ratio cutoff point for each level of investment. While the baseline analyses identified an average annual constant dollar amount of $111.5 billion of potentially cost beneficial investments assuming fixed rate user financing, this amount would increase by 6.1 percent to $118.3 billion assuming higher construction costs. For the analyses reflecting variable rate user financing, the average annual combined public and private spending level associated with a 1.00 minimum benefit-cost ratio would be $83.1 billion in constant 2006 dollars assuming higher construction costs, 4.5 percent higher than the $79.5 billion figure identified in the baseline analyses. It should be noted that these percentage increases are smaller than the 25-percent increase in construction costs, as this alternative would cause some capital improvement projects with a benefit-cost ratio below 1.25 that were included in the baseline analyses to be excluded because their revised benefit-cost ratios assuming higher construction costs would fall below 1.00.

Alternative NBIAS Improvement Costs

As discussed in Chapter 7, the NBIAS model considers bridge deficiencies at the level of individual bridge elements based on engineering criteria, and computes a value for the cost of a set of corrective actions that would address all such deficiencies. The portion of this engineering-based backlog that would pass a benefit-cost test is identified as an economic bridge investment backlog. If construction costs for all potential bridge repair and rehabilitation actions were 25 percent higher, this would limit the total number of bridge projects that could be completed within a fixed budget level to address that backlog.

The baseline NBIAS analyses presented in Chapter 7 projected that an annual constant dollar growth rate of 5.15 percent in combined public and private spending on the types of bridge capital improvements modeled in NBIAS would be sufficient to eliminate the economic bridge investment backlog by 2026; this rate of growth would translate into an average annual investment level of $17.9 billion stated in constant 2006 dollars. As shown in *Exhibit 10-7*, this level of investment would not be adequate to eliminate the bridge investment backlog if bridge repair and rehabilitation costs were to rise by 25 percent in constant dollar terms, and would leave a backlog of $21.2 billion in 2026. NBIAS predicts that eliminating the economic bridge backlog under this alternative assuming higher construction costs would require an average annual

Exhibit 10-7

Impact of Alternative Repair and Rehabilitation Cost Assumptions on Projected Bridge Investment Backlog in 2026 (for Different Possible Funding Levels)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in NBIAS (Billions of 2006 Dollars)[1]	2026 Bridge Economic Investment Backlog for for System Rehabilitation (Billions of 2006 Dollars)[2]	
		Baseline	Alternative: Increase Costs by 25%
5.15%	$17.9	**$0.0**	$21.2
5.03%	$17.6	$3.5	$24.0
4.55%	$16.7	$18.4	$35.4
4.17%	$16.0	$28.5	$43.9
3.30%	$14.5	$49.7	$62.3
3.07%	$14.1	$55.0	$65.2
2.93%	$13.9	$57.8	$69.9
1.67%	$12.1	$83.4	$94.8
0.83%	$11.1	**$98.9**	$109.4
0.34%	$10.5	$107.0	$117.5
0.00%	**$10.1**	$112.6	$123.0
-0.78%	$9.3	$125.9	$135.0
-1.37%	$8.8	$134.9	$144.1
-4.95%	$6.2	$180.9	$186.4
-7.64%	$4.9	$206.0	$190.2
6.04%	$19.8		**$0.0**
2006 Baseline Value:		**$98.9**	

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $10.1 billion (12.9 percent) was used for types of capital improvements modeled in NBIAS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The amounts shown do not reflect system expansion needs; the bridge component of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

investment level of $19.8 billion, which would equate to an annual growth rate of 6.04 percent over the base year 2006 spending level.

It should be noted that this sensitivity analysis applies only to the repair and rehabilitation costs assumed in NBIAS; the cost of bridge replacements was not modified, as the model is not currently equipped to vary that parameter in an automated fashion. Had all construction costs in NBIAS been included as part of this sensitivity analysis, the impact on the economic backlog would have been larger.

Discount Rate

The discount rate is a mechanism used in benefit-cost analysis to address the time value of resources, otherwise referred to as the time value of money or the opportunity cost (or value) of resources. It reflects the fact that there is a cost associated with diverting resources needed for a highway or bridge capital improvement from other productive uses in the public or private sector. The appropriate discount rate to use in any particular situation could vary depending on the potential alternative uses of the resources involved. OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, directs that a real 7 percent discount rate should be used for constant dollar analyses such as those presented in this report, indicating that this rate "approximates the marginal pretax rate of return on an average investment in the private sector in recent years." The OMB Circular A-94 guidance suggests that sensitivity analyses be conducted using alternative discount rates; rates of 4 percent and 10 percent have been selected for such analyses in this report.

The benefit-cost analysis procedures employed in the HERS and NBIAS models each apply the discount rate in order to compare the future benefit streams produced by a highway improvement with the initial cost of that improvement. This information feeds into the benefit-cost ratios that are used to prioritize potential investments. **The discount rate should not be confused with the rate of inflation; each involves a completely different set of economic concepts.**

Alternative HERS Discount Rates

Exhibit 10-8 compares the impacts of assuming real discount rates in HERS of 4 percent or 10 percent compared to the baseline assumption of 7 percent. Applying a smaller discount rate of 4 percent would increase the lifetime benefits computed for a project, and would thus raise its benefit-cost ratio. *Exhibit 10-8* shows that the minimum benefit-cost ratio cutoff associated with each investment level analyzed is higher for the 4 percent discount rate alternative than for the 7 percent baseline. The application of a lower discount ratio would tend to favor longer-lived capital improvements, and thus has an impact on the mix of investments recommended by HERS for each level of investment. Consequently, there are small variations between the projected changes in adjusted average user costs and average delay per VMT for the baseline analyses and the 4 percent discount rate alternative.

Applying a discount rate of 10 percent would decrease the lifetime benefits computed for a project, particularly for potential improvements with relatively long lives. This would alter the mix of investment recommended by HERS, which would cause small changes in performance indicators such as adjusted average user costs or average delay per VMT. *Exhibit 10-8* shows that the minimum benefit-cost ratio cutoff associated with each investment level analyzed is lower for the 10 percent discount rate alternative than for the 7 percent baseline.

The baseline analyses identified an average annual level of $111.5 billion of potentially cost-beneficial investments for the types of capital improvements modeled in HERS assuming fixed rate user financing based on a 7 percent real discount rate; the comparable amount assuming a 4 percent discount rate would be $127.5 billion, while applying a 10 percent discount rate would trim this amount to $95.4 billion. Assuming variable rate user financing, HERS identifies $79.5 billion of potential investments with a benefit-

Exhibit 10-8

Impact of Alternative Discount Rates on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Adjusted Average User Cost, 2026 Compared With 2006: Discount Rate			Percent Change in Average Delay Per VMT, 2026 Compared With 2006: Discount Rate			Minimum Benefit-Cost Ratio Cutoff: Discount Rate		
		Baseline	Alternative		Baseline	Alternative		Baseline	Alternative	
		7.0 Percent	4.0 Percent	10.0 Percent	7.0 Percent	4.0 Percent	10.0 Percent	7.0 Percent	4.0 Percent	10.0 Percent
Assuming Fixed Rate User Financing										
7.45%	$111.5	-2.9%	-2.9%		-10.2%	-10.3%		**1.00**	1.29	
6.41%	$98.6	-2.3%	-2.2%		-6.9%	-6.8%		**1.20**	1.55	
5.03%	$84.0	-1.4%	-1.3%	-1.4%	-2.7%	-2.5%	-2.5%	**1.50**	1.94	1.19
4.55%	$79.5	-1.0%	-1.0%	-1.1%	-1.1%	-1.0%	-1.3%	1.62	2.06	1.31
4.17%	$76.1	-0.8%	-0.7%	-0.8%	**0.0%**	0.2%	0.1%	1.71	2.18	1.38
3.30%	$69.0	-0.2%	-0.1%	-0.2%	2.9%	2.6%	2.8%	1.93	2.48	1.55
3.07%	$67.2	**0.0%**	0.1%	-0.1%	3.6%	3.4%	3.5%	1.98	2.55	1.59
2.93%	$66.2	0.1%	0.2%	0.0%	3.9%	3.8%	4.0%	2.02	2.59	1.61
1.67%	$57.6	1.0%	1.1%	0.9%	7.0%	6.9%	7.6%	2.42	3.09	1.91
0.83%	$52.6	1.5%	1.6%	1.4%	9.1%	9.0%	9.5%	2.70	3.49	2.16
0.34%	$50.0	1.8%	2.0%	1.8%	10.3%	10.3%	10.6%	2.86	3.70	2.29
0.00%	**$48.2**	2.1%	2.2%	2.0%	11.1%	11.2%	11.7%	2.89	3.73	2.34
-0.78%	$44.4	2.6%	2.7%	2.5%	13.5%	13.1%	13.6%	2.94	3.80	2.37
-1.37%	$41.8	3.0%	3.1%	2.9%	15.1%	14.4%	15.2%	2.99	3.86	2.40
-4.95%	$29.5	5.2%	5.3%	5.1%	22.6%	21.8%	23.6%	3.24	4.20	2.59
-7.64%	$23.2	6.7%	6.7%	6.6%	27.5%	27.0%	28.4%	3.43	4.48	2.74
8.58%	$127.7		-3.6%			-13.8%			**1.00**	
6.13%	$95.4			-2.1%			-5.9%			**1.00**
Assuming Variable Rate User Financing										
5.03%	$84.0		-2.8%			-13.0%			1.18	
4.55%	$79.5	-2.7%	-2.6%		-12.3%	-12.3%		**1.00**	1.28	
4.17%	$76.1	-2.5%	-2.5%		-11.6%	-11.7%		1.06	1.37	
3.30%	$69.0	-2.1%	-2.1%		-10.3%	-10.4%		**1.20**	1.54	
3.07%	$67.2	-2.0%	-2.0%		-9.9%	-10.0%		1.24	1.59	
2.93%	$66.2	-2.0%	-1.9%	-2.0%	-9.8%	-9.7%	-9.7%	1.26	1.63	1.01
1.67%	$57.6	-1.4%	-1.3%	-1.4%	-7.7%	-7.7%	-7.7%	**1.50**	1.95	1.20
0.83%	$52.6	-1.0%	-0.9%	-1.0%	-6.5%	-6.6%	-6.5%	1.71	2.21	1.36
0.34%	$50.0	-0.8%	-0.7%	-0.8%	-5.8%	-5.8%	-5.8%	1.82	2.37	1.45
0.00%	**$48.2**	-0.6%	-0.5%	-0.7%	-5.3%	-5.4%	-5.4%	1.90	2.48	1.52
-0.78%	$44.4	-0.3%	-0.2%	-0.3%	-4.4%	-4.3%	-4.4%	2.12	2.76	1.67
-1.37%	$41.8	**0.0%**	0.1%	-0.1%	-3.7%	-3.6%	-3.7%	2.25	2.87	1.79
-4.95%	$29.5	1.6%	1.7%	1.5%	**0.0%**	-0.2%	0.1%	2.42	3.08	1.95
-7.64%	$23.2	2.6%	2.7%	2.5%	1.4%	1.1%	1.5%	2.55	3.27	2.05
5.94%	$93.3		-3.2%			-14.6%			**1.00**	
3.00%	$66.7			-2.0%			-9.8%			**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

> **Q&A**
>
> **How do the discount rates as applied in HERS correspond to internal rates of return?**
>
> The real rate of return associated with an improvement with a benefit-cost ratio of 1.0 would generally be equal to the real discount rate assumed in the analysis.
>
> The baseline analyses presented in Chapter 7 applied a real discount rate of 7 percent. The analyses, assuming fixed rate user financing, identified an average annual level of potentially cost beneficial investment of $111.5 billion for the types of capital improvements modeled in HERS; the comparable amount for a minimum benefit-cost ratio of 1.0, assuming variable rate user financing, was $79.5 billion. Consequently, the marginal rate of return at these levels is estimated to be 7 percent.
>
> By varying the discount rate, and determining the dollar amount associated with a minimum benefit-cost ratio of 1.0, it is possible to estimate the rate of return associated with other investment levels.
>
> Exhibit 7-14 identified the levels of HERS-modeled investment associated with minimum benefit-cost ratios of 1.2 or 1.5 to be $98.6 billion and $84.0 billion, respectively, assuming fixed rate user financing. The estimated real rates of return associated with these levels of investment are 9.5 percent and 12.6 percent, respectively. These findings are consistent with those presented in Exhibit 10-8, which found that assuming a 10 percent discount rate would yield an estimated $95.4 billion of investment considered by HERS to have a benefit-cost ratio of 1.0 or higher.
>
> For the analyses assuming variable rate user financing, Exhibit 7-14 identified the levels of HERS-modeled investment associated with minimum benefit cost ratios of 1.2 or 1.5 to be $69.0 billion and $57.6 billion, respectively. The estimated real rates of return associated with these levels of investment are 9.4 percent and 12.7 percent, respectively. This is consistent with Exhibit 10-8, which indicates that assuming a 10 percent discount rate would yield an estimated $66.7 billion of investment considered by HERS to be cost-beneficial.
>
> It should be noted that the investment levels identified above as associated with minimum benefit-cost ratios of 1.0, 1.2, and 1.5, represent the HERS-modeled component of the MinBCR=1.0, MinBCR=1.2, and MinBCR=1.5 scenarios presented in Chapter 8. Consequently, the implied rates of return cited above would be linked to the HERS components of those scenarios.

cost ratio of 1.00 or higher; the comparable amounts assuming a 4 percent or 10 percent discount rate are $93.3 billion or $66.7 billion, respectively. All of these amounts are stated in constant 2006 dollars.

Alternative NBIAS Discount Rates

Given the relatively long lives of many of the bridge improvements evaluated in NBIAS, the discount rate applied can have a significant impact on the estimated economic bridge investment backlog. Applying a lower discount rate would tend to increase the portion of the engineering-based backlog computed by NBIAS that would pass a benefit-cost test, while applying a higher discount rate would reduce the number of potential bridge improvements determined to be cost beneficial. *Exhibit 10-9* compares the impacts of assuming real discount rates in NBIAS of 4 percent or 10 percent compared to the baseline assumption of 7 percent. Assuming a 4 percent discount rate, the size of the initial economic bridge investment backlog would be $119.4 billion, well above the $98.9 billion estimated in the baseline analysis. Assuming a 10 percent discount rate, the size of the initial economic bridge investment backlog would be $81.7 billion.

The baseline NBIAS analyses presented in Chapter 7 projected that an annual constant dollar growth rate of 5.15 percent in combined public and private spending on the types of bridge capital improvements modeled in NBIAS would be sufficient to eliminate the economic bridge investment backlog by 2026; this rate of growth would translate into an average annual investment level of $17.9 billion, stated in constant 2006 dollars. As shown in *Exhibit 10-9*, this level of investment would not be adequate to eliminate the larger economic bridge investment backlog estimated assuming a 4 percent discount rate; this level of investment would leave a backlog of $33.5 billion in 2026. NBIAS projects that eliminating the economic bridge backlog assuming a 4 percent discount rate would require an average annual investment level of $20.4 billion, which would equate to an annual growth rate of 6.26 percent over the base year 2006 spending level in constant dollar terms. Assuming a 10 percent discount rate would reduce the level of investment associated with eliminating the economic bridge backlog to $15.2 billion, which would equate to an annual growth rate of 3.71 percent over base year spending in constant dollar terms.

Exhibit 10-9

Impact of Alternative Discount Rates on Projected Bridge Investment Backlog in 2026 (for Different Possible Funding Levels)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in NBIAS (Billions of 2006 Dollars) [1]	2026 Bridge Economic Investment Backlog for System Rehabilitation (Billions of 2006 Dollars) [2]		
		Discount Rate		
		Baseline	Alternatives	
		7 Percent	4 Percent	10 Percent
5.15%	$17.9	**$0.0**	$33.5	
5.03%	$17.6	$3.5	$36.6	
4.55%	$16.7	$18.4	$49.9	
4.17%	$16.0	$28.5	$59.5	
3.30%	$14.5	$49.7	$79.2	$12.3
3.07%	$14.1	$55.0	$84.1	$19.4
2.93%	$13.9	$57.8	$87.2	$23.3
1.67%	$12.1	$83.4	$113.4	$49.7
0.83%	$11.1	**$98.9**	$129.4	$64.7
0.34%	$10.5	$107.0	$138.3	$73.5
0.00%	**$10.1**	$112.6	$143.8	$79.5
-0.78%	$9.3	$125.9	$156.5	$91.5
-1.37%	$8.8	$134.9	$165.5	$101.1
-4.95%	$6.2	$180.9	$210.9	$148.8
-7.64%	$4.9	$206.0	$235.0	$175.4
6.26%	$20.4		**$0.0**	
3.71%	$15.2			**$0.0**
	2006 Baseline Value:	**$98.9**	**$119.4**	**$81.7**

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $10.1 billion (12.9 percent) was used for types of capital improvements modeled in NBIAS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The amounts shown do not reflect system expansion needs; the bridge component of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

Alternative Valuation of Non-Monetary Benefits

The appropriate valuation of non-monetary benefits such as the prevention of a fatality or the reduction of travel time is a subject of significant debate within the academic community, and no single dollar figures have been uniformly accepted. To ensure consistency among the analyses developed by the Department of Transportation, guidance has been developed requiring the use of standard procedures for the valuation of a statistical life and travel time. The guidance pertaining to the treatment of the economic value of a statistical life was revised in February 2008, and requires a standard value of $5.8 million be applied, which represents a significant increase over the previous standard value of $3.0 million used in the 2006 C&P Report. The guidance further requires that supplementary analyses be conducted based on assumptions of $3.2 million and $8.4 million for the value associated with each life saved. Separate analyses reflecting the impacts that changing this assumption would have on the HERS and NBIAS findings, respectively, are presented below.

The Department of Transportation's standard methodology regarding the valuation of travel time has not been revised recently, so the approach used to develop value of time savings estimates in HERS for the analyses presented in this edition of the C&P report are consistent with the approach utilized in the 2006 edition. This section includes analyses describing the impact of increasing or lowering the baseline estimates of the value of travel time by 25 percent.

Research has indicated that unpredictable delay associated with traffic incidents may be perceived by highway users as more onerous (and thus more "costly" on a per hour basis) than the predictable, routine delay typically associated with peak traffic volumes. The HERS model accounts for this by allowing for a user-specified parameter for the "reliability premium" associated with reductions in incident delay, which is expressed as a multiple of the value of ordinary travel time. This section includes analyses comparing the effects of setting this parameter at 1.0, 2.0, and 3.0.

Note that the tables presented in this section do not include information of adjusted average user costs; this omission was intentional because each of these alternative valuations of non-monetary benefits would logically affect the base year value for this statistic, so any percentage changes from the base year would not be directly comparable between the baseline and these alternatives.

Value of a Statistical Life

The effect of changes to the value of a statistic life would generally be more noticeable in evaluating targeted safety-oriented capital improvements that are primarily directed at saving lives than in evaluating the ancillary safety impacts of capital improvements oriented toward system expansion or system rehabilitation, such as those modeled in HERS and NBIAS. The Afterword in Part IV of this report contains discussion of future research options for improving the analytical capabilities of HERS and NBIAS in this area.

Alternative HERS Values of a Statistical Life

Exhibit 10-10 shows the impacts of assuming statistical values of life of $3.2 million or $8.4 million in HERS compared to the baseline assumption of $5.8 million. Applying a lower statistical value of life would tend to reduce the estimated safety benefits of highway capital improvements, and thus would reduce their benefit-cost ratios; applying a higher value of life would tend to increase their benefit-cost ratios. The baseline analyses identified an average annual level of $111.5 billion of potentially cost beneficial investments stated in constant 2006 dollars for the types of capital improvements modeled in HERS assuming fixed rate user financing; the comparable amount assuming an $3.2 million value of life would be $109.8 billion, while applying a value of $8.4 million would boost this amount to $112.1 billion. Assuming variable rate user financing, HERS identifies $79.5 billion of potential investments with a benefit-cost ratio of 1.00 or higher in the baseline analyses; the comparable amounts assuming a $3.2 million or $8.4 million value of life are $78.0 billion or $80.4 billion, respectively.

Changing the statistical value of life would have a small effect on the mix of investments recommended by HERS for each level of investment; a higher value of life would favor projects with higher potential safety benefits or lower potential safety risks. In general, regardless of the financing mechanism assumed, the investment levels associated with either maintaining average delay per VMT or maintaining average IRI would be slightly higher assuming a $8.4 million value of life than the baseline. The converse is true for the $3.2 million value of life alternative, as the costs associated with either maintaining average delay per VMT or maintaining average IRI would be slightly lower.

Alternative NBIAS Values of a Statistical Life

As shown in *Exhibit 10-11,* assuming a statistical value of life of $8.4 million, the estimated size of the initial economic bridge investment backlog would be $103.3 billion, which is 4.4 percent higher than the $98.9 billion estimated in the baseline analysis assuming a $5.8 million value of life. Assuming a statistical value of life of $3.2 million, the size of the initial economic bridge investment backlog would be $94.2 billion stated in constant 2006 dollars.

Exhibit 10-10

Impact of Alternative Value of a Statistical Life Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Average Delay Per VMT, 2026 Compared With 2006: Value of a Statistical Life			Percent Change in Average IRI, 2026 Compared With 2006: Value of a Statistical Life			Minimum Benefit-Cost Ratio Cutoff: Value of a Statistical Life		
		Baseline	Alternative		Baseline	Alternative		Baseline	Alternative	
		$5.8 Million	$3.2 Million	$8.4 Million	$5.8 Million	$3.2 Million	$8.4 Million	$5.8 Million	$3.2 Million	$8.4 Million
Assuming Fixed Rate User Financing										
7.45%	$111.5	-10.2%		-10.1%	-23.1%		-22.8%	**1.00**		1.01
6.41%	$98.6	-6.9%	-7.0%	-6.7%	-18.1%	-18.6%	-17.6%	**1.20**	1.18	1.23
5.03%	$84.0	-2.7%	-2.8%	-2.7%	-11.2%	-11.5%	-10.5%	**1.50**	1.48	1.53
4.55%	$79.5	-1.1%	-1.3%	-1.0%	-8.6%	-9.0%	-8.0%	1.62	1.59	1.64
4.17%	$76.1	**0.0%**	0.0%	0.2%	-6.6%	-7.0%	-6.1%	1.71	1.68	1.73
3.30%	$69.0	2.9%	2.8%	3.0%	-2.3%	-2.6%	-1.8%	1.93	1.90	1.96
3.07%	$67.2	3.6%	3.5%	3.7%	-1.0%	-1.4%	-0.6%	1.98	1.96	2.01
2.93%	$66.2	3.9%	3.9%	4.0%	**0.0%**	-0.5%	0.4%	2.02	2.00	2.04
1.67%	$57.6	7.0%	6.8%	7.1%	7.9%	7.6%	8.4%	2.42	2.40	2.42
0.83%	$52.6	9.1%	9.0%	9.2%	12.4%	12.2%	13.0%	2.70	2.66	2.71
0.34%	$50.0	10.3%	10.4%	10.4%	15.1%	14.6%	15.5%	2.86	2.84	2.87
0.00%	**$48.2**	11.1%	11.2%	11.2%	17.1%	16.6%	17.6%	2.89	2.86	2.93
-0.78%	$44.4	13.5%	13.4%	13.7%	20.8%	20.2%	21.3%	2.94	2.92	2.97
-1.37%	$41.8	15.1%	14.9%	15.2%	23.8%	23.3%	24.4%	2.99	2.96	3.01
-4.95%	$29.5	22.6%	22.5%	22.8%	42.0%	41.5%	42.5%	3.24	3.21	3.27
-7.64%	$23.2	27.5%	27.4%	27.7%	53.1%	52.5%	53.5%	3.43	3.38	3.45
7.32%	$109.8		-10.0%			-22.8%			**1.00**	
7.49%	$112.1			-10.1%			-23.0%			**1.00**
Assuming Variable Rate User Financing										
4.55%	$79.5	-12.3%		-12.0%	-19.3%		-18.9%	**1.00**		1.02
4.17%	$76.1	-11.6%	-11.9%	-11.4%	-17.6%	-18.2%	-17.1%	1.06	1.03	1.08
3.30%	$69.0	-10.3%	-10.6%	-10.0%	-14.0%	-14.5%	-13.4%	**1.20**	1.17	1.23
3.07%	$67.2	-9.9%	-10.2%	-9.7%	-13.0%	-13.5%	-12.5%	1.24	1.21	1.27
2.93%	$66.2	-9.8%	-10.0%	-9.5%	-12.5%	-12.9%	-11.8%	1.26	1.24	1.29
1.67%	$57.6	-7.7%	-7.9%	-7.5%	-6.7%	-7.0%	-6.2%	**1.50**	1.48	1.53
0.83%	$52.6	-6.5%	-6.7%	-6.7%	-2.6%	-2.9%	-2.9%	1.71	1.68	1.68
0.34%	$50.0	-5.8%	-6.0%	-5.6%	**0.0%**	-0.4%	0.4%	1.82	1.80	1.85
0.00%	**$48.2**	-5.3%	-5.5%	-5.2%	1.8%	1.3%	2.2%	1.90	1.88	1.94
-0.78%	$44.4	-4.4%	-4.6%	-4.2%	5.7%	5.1%	5.9%	2.12	2.10	2.15
-1.37%	$41.8	-3.7%	-3.9%	-3.4%	8.4%	8.0%	8.8%	2.25	2.22	2.27
-4.95%	$29.5	**0.0%**	-0.1%	0.2%	25.2%	24.7%	25.6%	2.42	2.39	2.46
-7.64%	$23.2	1.4%	1.1%	1.6%	37.1%	36.6%	37.6%	2.55	2.52	2.58
4.39%	$78.0		-12.2%			-19.1%			**1.00**	
4.65%	$80.4			-12.2%			-19.3%			**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

The baseline NBIAS analyses presented in Chapter 7 projected that an annual constant dollar growth rate of 5.15 percent in combined public and private spending on the types of bridge capital improvements modeled in NBIAS would be sufficient to eliminate the economic bridge investment backlog by 2026; this rate of growth would translate into an average annual investment level of $17.9 billion, stated in constant 2006 dollars. As shown in *Exhibit 10-11*, this level of investment would not be adequate to eliminate the larger economic bridge investment backlog estimated assuming an $8.4 million statistical value of life; this level of investment would leave a backlog of $21.6 billion in 2026. NBIAS projects that eliminating the economic bridge backlog assuming an $8.4 million value of life would require an average annual investment level of $19.2 billion, which would equate to an annual growth rate of 5.75 percent over the base year 2006 spending level in constant dollar terms.

Assuming a $3.2 million statistical value of life would reduce the estimated level of investment associated with eliminating the economic bridge backlog to $16.4 billion. This would equate to an annual growth rate of 4.39 percent over base year spending in constant dollar terms.

Exhibit 10-11

Impact of Alternative Value of a Statistical Life Assumptions on Projected Bridge Investment Backlog in 2026 (for Different Possible Funding Levels)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in NBIAS (Billions of 2006 Dollars) [1]	2026 Bridge Economic Investment Backlog for System Rehabilitation (Billions of 2006 Dollars) [2]		
		Value of a Statistical Life		
		Baseline	Alternatives	
		$5.8 Million	$3.2 Million	$8.4 Million
5.15%	$17.9	**$0.0**		$20.2
5.03%	$17.6	$3.5		$23.3
4.55%	$16.7	$18.4		$36.2
4.17%	$16.0	$28.5	$6.5	$45.9
3.30%	$14.5	$49.7	$29.7	$66.1
3.07%	$14.1	$55.0	$35.5	$71.3
2.93%	$13.9	$57.8	$38.7	$74.4
1.67%	$12.1	$83.4	$65.4	$98.3
0.83%	$11.1	$98.9	$82.1	$113.9
0.34%	$10.5	$107.0	$90.8	$122.5
0.00%	$10.1	$112.6	$97.2	$128.2
-0.78%	$9.3	$125.9	$109.7	$140.2
-1.37%	$8.8	$134.9	$119.6	$149.0
-4.95%	$6.2	$180.9	$168.9	$192.0
-7.64%	$4.9	$206.0	$195.9	$216.0
4.39%	$16.4		**$0.0**	
5.75%	$19.2			**$0.0**
	2006 Baseline Value:	**$98.9**	**$94.2**	**$103.3**

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $10.1 billion (12.9 percent) was used for types of capital improvements modeled in NBIAS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The amounts shown do not reflect system expansion needs; the bridge component of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

Value of Ordinary Travel Time

Exhibit 10-12 shows the impacts of assuming values of time that are 25 percent higher or lower than the baseline assumption. Increasing the value of time causes HERS to attribute more benefits, particularly to widening projects (which reduce travel time costs). The baseline analyses assuming fixed rate user financing identified an average annual level of $111.5 billion of potentially cost beneficial investments stated in constant 2006 dollars for the types of capital improvements modeled in HERS assuming fixed rate user financing; the minimum benefit-cost ratio associated with this level of investment assuming a 25 percent increase in the value of time would be 1.13. Assuming fixed rate user financing and a value of time 25 percent higher than the baseline, HERS identifies $119.5 billion of potential investments with a benefit-cost ratio of 1.00 or higher; the comparable amount assuming a 25 percent decrease in the value of time would be $100.7 billion. Assuming variable rate user financing, HERS identifies $79.5 billion of potential investments with a benefit-cost ratio of 1.00 or higher in the baseline analyses stated in constant 2006 dollars; this would rise to $84.6 billion or fall to $73.1 billion assuming a 25 percent increase or decrease, respectively, in the value of time.

Changing the value of time would affect the mix of investments at any given funding level. A higher value of time would be associated with a higher percentage of investment going toward system expansion, a greater relative impact on improving average delay per VMT, and a smaller relative impact on improving average IRI. Assuming a lower value of time, HERS would direct more investment to system rehabilitation, and thus projected average IRI for 2026 would be lower than in the baseline analysis and projected average delay per VMT would be higher.

Value of Incident Delay Reduction

The investment scenario estimates in Chapters 7 and 8 used a baseline value of 2.0 times the value of ordinary travel time for the reliability premium, which was chosen on the basis of available research. *Exhibit 10-13* shows the impact of changing this premium at a higher level of 3.0 times the value of ordinary travel time, or setting it at a lower level of 1.0, which effectively assumes that no premium exists and that the value of incident delay is equal to that of ordinary time.

Increasing the reliability premium would affect the mix of investments at any given funding level, favoring those that would tend to have the largest impact on reducing incident delay. The 3.0 times reliability premium alternative would direct a higher percentage of investment toward system expansion at all funding levels, producing a greater relative impact on improving average delay per VMT, and a smaller relative impact on improving average IRI. Assuming no reliability premium, HERS would direct more investment to system rehabilitation, and thus projected average IRI for 2026 would be lower than in the baseline analysis and projected average delay per VMT would be higher for all of the combined public and private highway capital spending levels that were analyzed.

The baseline analyses assuming fixed rate user financing identified an average annual level of $111.5 billion of potentially cost beneficial investments stated in constant 2006 dollars for the types of capital improvements modeled in HERS assuming fixed rate user financing; the minimum benefit-cost ratio associated with this level of investment assuming a reliability premium for incident delay of 3.0 times ordinary time would be 1.10. Assuming fixed rate user financing and a reliability premium of 3.0, HERS identifies $117.8 billion of potential investments with a benefit-cost ratio of 1.00 or higher; the comparable amount assuming a reliability premium of 1.0 would be $102.4 billion. Assuming variable rate user financing, HERS identifies $79.5 billion of potential investments with a benefit-cost ratio of 1.00 or higher in the baseline analyses stated in constant 2006 dollars; this would rise to $83.8 billion or fall to $74.1 billion assuming reliability premiums of 3.0 or 1.0, respectively.

Exhibit 10-12

Impact of Alternative Value of Time Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Average Delay Per VMT, 2026 Compared With 2006: Value of Time			Percent Change in Average IRI, 2026 Compared With 2006: Value of Time			Minimum Benefit-Cost Ratio Cutoff: Value of Time		
		Baseline	Alternative: Reduce by 25%	Alternative: Increase by 25%	Baseline	Alternative: Reduce by 25%	Alternative: Increase by 25%	Baseline	Alternative: Reduce by 25%	Alternative: Increase by 25%
Assuming Fixed Rate User Financing										
7.45%	$111.5	-10.2%		-11.2%	-23.1%		-21.6%	**1.00**		1.13
6.41%	$98.6	-6.9%	-5.2%	-8.0%	-18.1%	-19.9%	-16.3%	**1.20**	1.03	1.37
5.03%	$84.0	-2.7%	-0.8%	-4.0%	-11.2%	-12.8%	-9.2%	**1.50**	1.31	1.70
4.55%	$79.5	-1.1%	1.0%	-2.5%	-8.6%	-10.4%	-6.4%	1.62	1.40	1.83
4.17%	$76.1	**0.0%**	2.2%	-1.3%	-6.6%	-8.5%	-4.5%	1.71	1.49	1.93
3.30%	$69.0	2.9%	5.3%	1.2%	-2.3%	-4.2%	0.0%	1.93	1.67	2.18
3.07%	$67.2	3.6%	5.9%	1.9%	-1.0%	-2.7%	1.1%	1.98	1.73	2.25
2.93%	$66.2	3.9%	6.2%	2.3%	**0.0%**	-1.8%	1.9%	2.02	1.77	2.29
1.67%	$57.6	7.0%	9.7%	5.5%	7.9%	5.7%	9.5%	2.42	2.08	2.74
0.83%	$52.6	9.1%	12.0%	7.4%	12.4%	10.3%	14.6%	2.70	2.31	3.08
0.34%	$50.0	10.3%	13.4%	8.7%	15.1%	12.9%	17.1%	2.86	2.46	3.25
0.00%	**$48.2**	11.1%	14.5%	9.5%	17.1%	14.4%	19.1%	2.89	2.55	3.26
-0.78%	$44.4	13.5%	16.8%	11.5%	20.8%	18.3%	22.9%	2.94	2.60	3.31
-1.37%	$41.8	15.1%	18.2%	12.9%	23.8%	21.5%	25.8%	2.99	2.64	3.35
-4.95%	$29.5	22.6%	26.1%	20.3%	42.0%	40.1%	43.5%	3.24	2.86	3.66
-7.64%	$23.2	27.5%	31.2%	24.7%	53.1%	51.4%	54.4%	3.43	3.00	3.89
6.59%	$100.7		-5.8%			-20.9%			**1.00**	
8.03%	$119.5			-12.9%			-24.5%			**1.00**
Assuming Variable Rate User Financing										
5.03%	$84.0			-14.3%			-20.2%			1.02
4.55%	$79.5	-12.3%		-13.6%	-19.3%		-18.1%	**1.00**		1.10
4.17%	$76.1	-11.6%		-13.1%	-17.6%		-16.4%	1.06		1.16
3.30%	$69.0	-10.3%	-7.9%	-11.8%	-14.0%	-14.9%	-12.8%	**1.20**	1.08	1.31
3.07%	$67.2	-9.9%	-7.5%	-11.5%	-13.0%	-14.0%	-11.8%	1.24	1.12	1.36
2.93%	$66.2	-9.8%	-7.3%	-11.2%	-12.5%	-13.4%	-11.2%	1.26	1.13	1.39
1.67%	$57.6	-7.7%	-5.2%	-9.5%	-6.7%	-7.9%	-5.2%	**1.50**	1.36	1.66
0.83%	$52.6	-6.5%	-4.0%	-8.4%	-2.6%	-3.8%	-1.1%	1.71	1.54	1.87
0.34%	$50.0	-5.8%	-3.2%	-7.6%	**0.0%**	-1.3%	1.3%	1.82	1.65	2.01
0.00%	**$48.2**	-5.3%	-2.7%	-7.2%	1.8%	0.4%	2.9%	1.90	1.73	2.10
-0.78%	$44.4	-4.4%	-1.6%	-6.2%	5.7%	4.1%	6.8%	2.12	1.90	2.35
-1.37%	$41.8	-3.7%	-0.8%	-5.6%	8.4%	6.8%	9.7%	2.25	2.04	2.43
-4.95%	$29.5	**0.0%**	2.9%	-1.9%	25.2%	23.9%	26.7%	2.42	2.21	2.65
-7.64%	$23.2	1.4%	4.5%	-0.6%	37.1%	36.0%	38.7%	2.55	2.35	2.77
3.82%	$73.1		-8.9%			-17.2%			**1.00**	
5.10%	$84.6			-14.4%			-20.7%			**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

Exhibit 10-13

Impact of Alternative Reliability Premium Assumptions on Selected Indicators (for Different Possible Funding Levels and Financing Mechanisms)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in HERS (Billions of 2006 Dollars)*	Percent Change in Average Delay Per VMT, 2026 Compared With 2006: Reliability Premium			Percent Change in Average IRI, 2026 Compared With 2006: Reliability Premium			Minimum Benefit-Cost Ratio Cutoff: Reliability Premium		
		Baseline	Alternative		Baseline	Alternative		Baseline	Alternative	
		2.0 Times	1.0 Times	3.0 Times	2.0 Times	1.0 Times	3.0 Times	2.0 Times	1.0 Times	3.0 Times
Assuming Fixed Rate User Financing										
7.45%	$111.5	-10.2%		-11.2%	-23.1%		-21.7%	**1.00**		1.10
6.41%	$98.6	-6.9%	-5.1%	-7.9%	-18.1%	-20.1%	-16.3%	**1.20**	1.06	1.33
5.03%	$84.0	-2.7%	-0.7%	-4.0%	-11.2%	-13.2%	-8.7%	**1.50**	1.35	1.66
4.55%	$79.5	-1.1%	1.1%	-2.5%	-8.6%	-11.0%	-6.1%	1.62	1.44	1.79
4.17%	$76.1	**0.0%**	2.3%	-1.4%	-6.6%	-9.1%	-4.2%	1.71	1.54	1.89
3.30%	$69.0	2.9%	5.6%	1.0%	-2.3%	-4.8%	0.6%	1.93	1.74	2.12
3.07%	$67.2	3.6%	6.3%	1.6%	-1.0%	-3.6%	1.9%	1.98	1.80	2.18
2.93%	$66.2	3.9%	6.8%	2.0%	**0.0%**	-2.9%	2.7%	2.02	1.84	2.23
1.67%	$57.6	7.0%	10.1%	5.0%	7.9%	4.2%	10.6%	2.42	2.19	2.61
0.83%	$52.6	9.1%	12.2%	7.1%	12.4%	9.5%	15.5%	2.70	2.44	2.94
0.34%	$50.0	10.3%	13.9%	8.5%	15.1%	11.7%	17.9%	2.86	2.58	3.13
0.00%	**$48.2**	11.1%	14.7%	9.5%	17.1%	13.7%	19.6%	2.89	2.61	3.21
-0.78%	$44.4	13.5%	16.9%	11.3%	20.8%	17.3%	23.7%	2.94	2.66	3.26
-1.37%	$41.8	15.1%	18.7%	12.5%	23.8%	20.3%	26.9%	2.99	2.69	3.29
-4.95%	$29.5	22.6%	27.8%	19.6%	42.0%	37.9%	45.1%	3.24	2.90	3.57
-7.64%	$23.2	27.5%	32.5%	24.0%	53.1%	49.6%	56.0%	3.43	3.07	3.76
6.73%	$102.4		-6.2%			-21.4%			**1.00**	
7.91%	$117.8			-12.4%			-23.9%			**1.00**
Assuming Variable Rate User Financing										
4.55%	$79.5	-12.3%		-13.8%	-19.3%		-18.0%	**1.00**		1.07
4.17%	$76.1	-11.6%		-13.2%	-17.6%		-16.4%	1.06		1.14
3.30%	$69.0	-10.3%	-7.2%	-12.0%	-14.0%	-15.0%	-12.6%	**1.20**	1.10	1.29
3.07%	$67.2	-9.9%	-6.7%	-11.7%	-13.0%	-14.0%	-11.7%	1.24	1.14	1.33
2.93%	$66.2	-9.8%	-6.5%	-11.4%	-12.5%	-13.5%	-11.0%	1.26	1.16	1.36
1.67%	$57.6	-7.7%	-4.2%	-9.7%	-6.7%	-8.0%	-5.0%	**1.50**	1.39	1.62
0.83%	$52.6	-6.5%	-2.9%	-8.6%	-2.6%	-4.2%	-0.6%	1.71	1.56	1.85
0.34%	$50.0	-5.8%	-2.0%	-8.0%	**0.0%**	-1.9%	1.8%	1.82	1.68	1.96
0.00%	**$48.2**	-5.3%	-1.5%	-7.6%	1.8%	-0.1%	3.3%	1.90	1.76	2.05
-0.78%	$44.4	-4.4%	-0.3%	-6.8%	5.7%	3.8%	7.4%	2.12	1.98	2.24
-1.37%	$41.8	-3.7%	0.6%	-6.1%	8.4%	6.5%	10.4%	2.25	2.09	2.39
-4.95%	$29.5	**0.0%**	4.7%	-2.8%	25.2%	23.4%	26.9%	2.42	2.26	2.58
-7.64%	$23.2	1.4%	6.0%	-1.3%	37.1%	35.9%	38.9%	2.55	2.40	2.72
3.94%	$74.1		-8.3%			-17.7%			**1.00**	
5.01%	$83.8			-14.4%			-20.1%			**1.00**

* *Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $48.2 billion (61.3 percent) was used for types of capital improvements modeled in HERS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the percentage shown in each row in constant dollar terms.*

Source: Highway Economic Requirements System.

Potential Impacts of Aging Structures

The internal logic of the NBIAS model is designed to project the future performance of structures based on the conditions states of various individual bridge elements, rather than the chronological age of the bridge. The underlying bridge management philosophy inherent in this approach is that following a program of timely maintenance, repair, and rehabilitation actions to keep a bridge in good condition can extend the service life of that bridge for an extended or theoretically indefinite period. This approach assumes that the probability of a bridge element deteriorating from one condition state to the next is completely independent of a structure's age. However, this assumption may not be warranted in all cases, particularly in situations in which a bridge has not been aggressively maintained over its full lifetime and/or has been subject to loadings in excess of what was anticipated when the structure was built. In such instances, an older structure may tend to deteriorate more quickly or require more aggressive treatments than a newer facility in otherwise similar condition.

Another issue of concern regarding older bridges is functional adequacy. In many cases, older bridges were built to standards that are not consistent with current requirements, particularly in the area of safety design standards. A bridge may also be functionally inadequate simply as a result of the difference between current utilization rates and the uses envisioned at the time it was constructed. Even if an existing older bridge can successfully be kept in a state of good repair indefinitely, functional considerations may warrant its eventual replacement.

As discussed in Chapters 2 and 11, the pace of construction of new bridges has not been uniform over time; in particular, many of the existing bridges on the Interstate system were constructed in a relatively short time frame. To the extent that a bridge's age (independent of current bridge conditions) has an effect on its deterioration rate and the need for bridge replacement, this could create a situation in which bridge investment needs would be clustered in certain time frames rather than distributed more evenly over time. To the extent that such spikes can be anticipated, such information would be very useful in designing systemwide bridge management strategies.

The baseline NBIAS analyses presented in Chapter 7 had identified a backlog of potentially cost-beneficial bridge investments of $98.9 billion in 2006. This economic backlog excluded $19.1 billion of potential corrective actions to address engineering deficiencies that would not pass a benefit-cost test; the total backlog identified by NBIAS based solely on engineering criteria was $118.0 billion in 2006. While NBIAS does not directly model age-related bridge deterioration effects, it does allow the user to specify mandatory bridge replacement criteria relating to bridge age and other factors. *Exhibit 10-14* shows the relative impacts of requiring all bridges to be reconstructed at either age 75 or 50, subject to the availability of funding within the investment level being analyzed, compared to the baseline analyses which did not impose any form of age constraint. Assuming mandatory replacement ages of 75 years or 50 years would increase the base year 2006 engineering backlog estimated by NBIAS to $125.4 billion or $160.8 billion, respectively.

Assuming a fixed life span for bridges of 50 or 75 years would make it more difficult to reduce the backlog over time as additional bridges reached the specified age threshold. The baseline NBIAS analyses presented in Chapter 7 projected that an annual constant dollar growth rate of 5.15 percent in combined public and private spending on the types of bridge capital improvements modeled in NBIAS would be sufficient to eliminate the economic bridge investment backlog by 2026, leaving an engineering backlog of $19.1 billion. This rate of growth would translate into an average annual investment level of $17.9 billion, stated in constant 2006 dollars. As shown in *Exhibit 10-14*, assuming either a fixed life span of 75 or 50 years, this level of investment would leave an engineering backlog of either $78.9 billion or $335.4 billion, respectively, in 2026. The impact of assuming a fixed 50-year life span is particularly dramatic because a large percentage

Exhibit 10-14

Impact of Alternative Age-Based Bridge Replacement Strategies on Projected Bridge Investment Backlog in 2026 (for Different Possible Funding Levels)

Annual Percent Change Relative to 2006	Average Annual Spending Modeled in NBIAS (Billions of 2006 Dollars)[1]	Baseline 2026 Bridge Economic Investment Backlog for System Rehabilitation (Billions of 2006 Dollars) [2]	2026 Bridge Engineering Investment Backlog for System Rehabilitation (Billions of 2006 Dollars) [2]		
			Mandatory Replacement Age		
			Baseline	Alternatives	
			None	75 Years	50 Years
5.15%	$17.9	**$0.0**	**$19.1**	$78.9	$335.4
5.03%	$17.6	$3.5	$22.6	$81.4	$336.4
4.55%	$16.7	$18.4	$37.5	$92.3	$341.0
4.17%	$16.0	$28.5	$47.6	$100.5	$344.5
3.30%	$14.5	$49.7	$68.8	$117.9	$351.9
3.07%	$14.1	$55.0	$74.1	$121.9	$353.7
2.93%	$13.9	$57.8	$76.9	$124.3	$354.9
1.67%	$12.1	$83.4	$102.5	$145.8	$363.9
0.83%	$11.1	$98.9	$118.0	$159.4	$369.2
0.34%	$10.5	$107.0	$126.1	$165.9	$372.3
0.00%	$10.1	$112.6	$131.7	$170.8	$374.2
-0.78%	$9.3	$125.9	$145.0	$181.9	$378.8
-1.37%	$8.8	$134.9	$154.0	$189.4	$381.8
-4.95%	$6.2	$180.9	$200.0	$228.3	$397.4
-7.64%	$4.9	$206.0	$225.1	$249.9	$406.4
5.95%	$19.6			**$58.6**	
9.27%	$29.2				**$286.8**
2006 Baseline Value:		**$98.9**	**$118.0**	**$125.4**	**$160.8**

[1] Of the $78.7 billion of total capital expenditures for highways and bridges in 2006, $10.1 billion (12.9 percent) was used for types of capital improvements modeled in NBIAS. The amounts shown represent the average annual investment over 20 years that would occur if spending for these types of improvements grows annually by the constant dollar growth rate specified.

[2] The amounts shown do not reflect system expansion needs; the bridge component of such needs are addressed as part of the HERS model analysis.

Source: National Bridge Investment Analysis System.

of bridges are currently between 30 and 50 years of age; such bridges would not exceed the alternative 75-year threshold until after the end of the 20-year analysis period in 2026.

NBIAS projects that assuming a fixed life span of 75 years, the engineering backlog could be reduced to $58.6 billion by 2026 if combined public and private spending on the types of bridge improvements modeled in NBIAS rose to an average annual investment level of $19.6 billion; this would equate to an annual growth rate of 5.95 percent over the base year 2006 spending level in constant dollar terms. NBIAS estimates that spending above this level would not be cost-beneficial.

Assuming a fixed bridge life span of 50 years, NBIAS identifies a sufficiently large pool of

For the sensitivity analyses assuming fixed life spans, are all bridges replaced immediately when they reach age 50 or 75?

No. The gradual ramping up of spending assumed in these sensitivity analyses would tend to spread out the pace of bridge replacements, so that in any given year, all bridges reaching the age of 50 years or 75 years would not automatically be replaced immediately. In the absence of such funding constraints, NBIAS would spend $108.5 billion immediately assuming a fixed bridge life span of 50 years, and would spend an average of $38.0 billion annually over 20 years.

potentially cost-beneficial improvements to justify a 9.27 percent annual increase in spending over the base year 2006 level, equating to an average annual investment level of $29.2 billion. This level of investment is projected to reduce the engineering backlog in 2026 to $286.8 billion. While this represents a sharp increase over the 2006 backlog of $160.8 billion assuming a 50-year bridge life span, NBIAS projects that additional investment above this level could not be justified on economic grounds.

Transit Sensitivity Analysis

This section examines the sensitivity of projected transit investment estimates by the Transit Economic Requirements Model (TERM) to variations in the values of the following exogenously determined model inputs:

- Passenger miles traveled (PMT) on transit
- Capital costs
- Value of time
- User travel cost elasticities.

These alternative projections illustrate how the baseline investment estimates for transit presented in Chapter 8 will vary in response to changes in the assumed values of input variables.

Changes in Passenger Miles Traveled

TERM relies heavily on forecasts of PMT in large urbanized areas. These forecasts are the primary driver behind TERM's estimates of the amount of investment that will be needed in the Nation's transit system to maintain performance, as defined by current passenger travel speeds and vehicle utilization rates, as ridership increases. PMT forecasts are generally made by metropolitan planning organizations (MPOs) in conjunction with projections of vehicle miles traveled as a part of the regional transportation planning process. These projections incorporate assumptions about the relative growth of travel on transit and in private vehicles in a metropolitan area. The average annual growth rate in PMT of 1.5 percent used in this report is a weighted average based on the most recent update of rates from a sample of MPO forecasts available for the Nation's largest metropolitan areas. National Transit Database (NTD) data show that PMT increased at an average annual rate of 2.3 percent between 1997 and 2006 and at an average annual rate of 3.1 percent between 2004 and 2006.

Future transit investment levels have been estimated by TERM for three alternative projected PMT scenarios to examine the sensitivity of transit investment needs to variations in PMT *[Exhibit 10-15*]. These three scenarios are compared to the baseline as presented in chapter 8. These scenarios are as follows:

(1) PMT growth is 50 percent greater than the forecast levels

(2) PMT growth is 50 percent less than the forecast levels

(3) PMT remains unchanged (zero growth).

Varying the assumed rate of growth in PMT significantly affects estimated projected transit investment. This effect is more pronounced under the **Maintain Conditions and Performance** scenario than under the **Improve Conditions and Performance** scenario because PMT growth rates primarily affect asset expansion costs, which comprise a larger portion of the total amount to maintain conditions and performance than the total amount to improve conditions and performance. As *Exhibit 10-15* shows, TERM projects that a 50-percent increase in PMT growth would increase the cost to **Maintain Conditions and Performance** by

Exhibit 10-15

Impact of Alternative PMT Growth Rates on Transit Investment Estimates by Scenario*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
Annual PMT Growth Rate	**(Billions of 2006 Dollars)**	**Percent Change**	**(Billions of 2006 Dollars)**	**Percent Change**
Baseline (1.5%)	$15.07	-	$21.11	-
Increased 50% (to 2.25%)	$16.72	11.0%	$23.27	10.2%
Decreased 50% (to 0.75%)	$12.86	-14.6%	$19.42	-8.0%
Decreased 100% (to 0%)	$10.27	-31.8%	$11.08	-47.5%

* *Investment estimates for rural and special service vehicles are included in the totals, but are not subject to the sensitivity analysis. They account for 5 percent or less of the total.*

Source: Transit Economic Requirements Model and FTA staff estimates.

11.0 percent and the cost to **Improve Conditions and Performance** by 10.2 percent. On the other hand, a 50-percent decrease in PMT growth will decrease the cost to **Maintain Conditions and Performance** by 14.6 percent and the cost to **Improve Conditions and Performance** by 8.0 percent. TERM estimates of future investment to maintain conditions and performance would decrease by 31.8 percent if PMT ceases to grow, and by 47.5 percent for the improve conditions and performance scenario.

Changes in Capital Costs

The capital costs used in TERM are based on actual prices paid by agencies for asset purchases as reported to the Federal Transit Administration in the Transit Electronic Award and Management System (TEAM) and in special surveys. Asset prices in the current version of TERM have been converted to 2006 dollars as necessary. Given the uncertain nature of capital costs, a sensitivity analysis has been performed to examine the effect that higher capital costs would have on the dollar value of TERM's baseline projected transit investment.

As shown in *Exhibit 10-16,* TERM projects that a 25-percent increase in capital costs would increase the cost to **Maintain Conditions and Performance** by 9.9 percent, but the cost to **Improve Conditions and Performance** would decrease by 20.7 percent. With this increase in costs, fewer investments are economically viable under the **Improve Conditions and Performance** scenario than under the **Maintain Conditions and Performance** scenario.

Exhibit 10-16

Impact of a 25 Percent Increase in Capital Costs on Transit Investment Estimates by Scenario*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
	(Billions of 2004 Dollars)	**Percent Change**	**(Billions of 2004 Dollars)**	**Percent Change**
Baseline	$15.07	–	$21.11	–
Increase Costs 25%	$16.56	9.9%	$16.73	-20.7%

** Investment estimates for rural and special service vehicles are included in the totals, but are not subject to the sensitivity analysis. They account for 5 percent or less of the total.*

Source: Transit Economic Requirements Model and FTA staff estimates.

Changes in the Value of Time

The value of time is a key input to TERM's benefit-cost analysis and is one of the factors used to determine the level of investment in capital assets for both the Maintain Performance and the Improve Performance scenarios. The value of time is used to estimate changes in the total benefits accruing to transit users from investments in transit infrastructure that change the duration of passengers' travel time.

Exhibit 10-17 shows the effect of varying the value of time. The baseline value of time is assumed to be $11.20, as recommended by the Department of Transportation's Office of the Secretary for local travel in vehicles for all purposes, personal and business. TERM values waiting and transfer times at $22.40 per hour, double the value of in-vehicle travel time. (Departmental guidance on the value of time has not changed since the 2004 C&P Report, which also used these values.) Future transit investment levels have been estimated by TERM based on three different scenarios to examine the sensitivity of transit investment needs to changes in the value of time. These scenarios are as follows:

(1) Value of time is double (increase by 100 percent)

(2) Value of time is half (decrease by 50 percent)

(3) Value of time is inflated to 2006 dollars.

By increasing the value of time to $22.40 per hour, the cost to **Maintain Conditions and Performance** is projected to increase by 16.0 percent, while the cost to **Improve Conditions and Performance** would increase by 10.8 percent. A decrease by 50 percent in the value of time would decrease the cost to **Maintain Conditions and Performance** by 46.6 percent and the cost to **Improve Conditions and Performance** by 35.4 percent. Inflating the value of time to 2006 dollars had a smaller upward effect, adding between 4.0 and 2.7 percent to the costs for both maintaining and improving conditions and performance, respectively. Overall, increases in the value of time increase the benefits of investment in transit modes that offer passenger travel times that are faster than nontransit modes, such as the automobile, and decrease the benefits of investment in transit modes with passenger travel speeds that are slower than nontransit modes. Hence, an increase in the value of time reduces projected investment in modes with relatively slower transit services (and some travel shifts from transit to automobiles) and increases projected investment in modes with relatively faster transit services (and some travel shifts from automobiles to transit). The opposite occurs in response to a decrease in the value of time.

Exhibit 10-17

Impact of Change in the Value of Time on Transit Investment Estimates by Scenario*

Value of Time	Annual Cost to Maintain Conditions & Performance (Billions of 2006 Dollars)	Annual Cost to Maintain Conditions & Performance Percent Change	Annual Cost to Improve Conditions & Performance (Billions of 2006 Dollars)	Annual Cost to Improve Conditions & Performance Percent Change
Baseline	$15.07	–	$21.11	–
Increase 100%	$17.48	16.0%	$23.39	10.8%
Decrease 50%	$8.05	-46.6%	$13.64	-35.4%
Inflate to $2006	$15.67	4.0%	$21.69	2.7%

* *Investment estimates for rural and special service vehicles are included in the totals, but are not subject to the sensitivity analysis. They account for 5 percent or less of the total.*

Source: Transit Economic Requirements Model.

Changes in User Cost Elasticities

User cost elasticity is the percentage change in ridership resulting from a change in user costs. TERM uses cost elasticities to estimate the changes in ridership that will result from changes in fare and travel time costs. These changes are due to infrastructure investment to increase speeds, decrease vehicle occupancy levels, and increase frequency. TERM assumes that these elasticities range from –0.22 to –0.40, depending on the mode. User cost elasticities are negative, reflecting an inverse relationship between ridership and costs. As ridership costs decrease, ridership increases. The larger the absolute value of the elasticity, the more responsive ridership will be to changes in user costs. As shown in *Exhibit 10-18*, a doubling of these elasticities or setting them to zero has almost no effect on projected investment scenarios; the largest projected effect is a decrease of 6.5 percent in the costs to improve conditions and performance when elasticities are estimated at 0 percent.

Exhibit 10-18

Impact of Change in the Value of User Cost Elasticities on Transit Investment Estimates by Scenario*

User Cost Elasticities	Annual Cost to Maintain Conditions & Performance (Billions of 2004 Dollars)	Percent Change	Annual Cost to Improve Conditions & Performance (Billions of 2004 Dollars)	Percent Change
Baseline	$15.07	–	$21.11	–
Increase 100%	$15.07	0.0%	$21.19	0.4%
Decrease 100%	$15.07	0.0%	$19.73	-6.5%

* *Investment estimates for rural and special service vehicles are included in the totals, but are not subject to the sensitivity analysis. They account for 5 percent or less of the total.*

Source: Transit Economic Requirements Model.

Comparison

The layout and content of Part II of this edition of the C&P report, including Chapters 7 through 10, has been restructured significantly relative to that of recent editions. Among the four chapters in Part II, this chapter changed the least, and has retained the chapter title that was used in the 2006 C&P Report. However, some new sensitivity analyses have been added to this chapter, others have been rearranged relative to how they were presented in previous editions, and some have been excluded.

This chapter was first added to the 1999 C&P Report to open up more of the modeling process and to make the report more useful for supplementary analysis efforts. This chapter explores the effects of altering some of the key assumptions underlying the potential capital investment impacts and selected capital investment scenarios presented in Chapters 7 and 8.

Exhibit 10-19 provides a crosswalk between the information presented in the exhibits located in the highway and transit sections of this chapter and the location of comparable information in the 2006 C&P Report.

Exhibit 10-19

Cross-Reference Between Chapter 10 Exhibits and the Location of Comparable Information in the 2006 C&P Report

Chapter 10 Exhibit	Location of Comparable Information in the 2006 C&P Report
Exhibit 10-1	"Fixed Rate User Charges" values for "Aggessive" and "Full" deployments in the "7.45%" and "3.07%" rows are comparable to information shown in Exhibit 10-1. "Variable Rate User Charges" values for "Baseline" deployments in the "4.55%" and "-1.37%" rows are somewhat comparable to information shown in Exhibit 10-1.
Exhibit 10-2	No direct equivalent.
Exhibit 10-3	"Fixed Rate User Charges" values for "Historic Rates" VMT growth in the "7.45%" and "3.07%" rows are comparable to information shown in Exhibit 10-3.
Exhibit 10-4	"Fixed Rate User Charges" values in the "7.45%" row are comparable to information shown in Exhibit 10-4 for elasticity values.
Exhibit 10-5	No direct equivalent.
Exhibit 10-6	No direct equivalent. Similar information for capital improvement costs for HERS and NBIAS combined are shown in Exhibit 10-4.
Exhibit 10-7	No direct equivalent. Similar information for capital improvement costs for HERS and NBIAS combined are shown in Exhibit 10-4.
Exhibit 10-8	No direct equivalent.
Exhibit 10-9	No direct equivalent.
Exhibit 10-10	No direct equivalent. Information regarding a different set of alternative values of a statistical life are shown in Exhibit 10-4.
Exhibit 10-11	No direct equivalent.
Exhibit 10-12	"Fixed Rate User Charges" values in the "7.45%" row are comparable to information shown in Exhibit 10-4 for the value of ordinary travel time.
Exhibit 10-13	"Fixed Rate User Charges" values in the "7.45%" row are comparable to information shown in Exhibit 10-4 for the value of incident delay reduction.
Exhibit 10-14	No direct equivalent.
Exhibit 10-15	Equivalent exhibit presented in Exhibit 10-5.
Exhibit 10-16	Equivalent exhibit presented in Exhibit 10-6.
Exhibit 10-17	Equivalent exhibit presented in Exhibit 10-9.
Exhibit 10-18	Equivalent exhibit presented in Exhibit 10-10.

Highways and Bridges

The sensitivity analyses presented in the highway section of this chapter reflect the impact of varying key assumptions in the analyses used to develop the projections of potential impacts of highway capital investment presented in Chapter 7. Unlike the 2006 C&P Report, which focused primarily on the impact that alternative assumptions would have on the average annual investment level for one or two capital investment scenarios, this section presents projected performance impacts for a range of alternative funding levels.

Exhibits 10-1 and *10-2* describe the potential impacts of technological advances; the analysis of operations/ITS deployments are comparable to those in the 2006 C&P Report, but the pavement technology is a new addition. *Exhibits 10-3* and *10-4* describe the potential impacts of alternative estimates of travel demand. The impacts of alternative VMT growth forecasts presented in *Exhibit 10-3* represent an extension of comparable analyses in prior reports, while the analysis of alternative travel demand elasticity values are directly comparable to those shown in the 2006 C&P Report.

Exhibits 10-5 through *10-9* show the potential impacts of alternative economic assumptions. The analysis of alternative fuel price assumptions in *Exhibit 10-5* is a new addition; the projected impacts of increasing capital costs in HERS and NBIAS shown in *Exhibits 10-6* and *10-7* are comparable to analyses presented in the 2006 C&P Report. The analyses of the application of alternative discount rates in *Exhibits 10-8* and *10-9* also represent new additions to this chapter.

Exhibits 10-10 through *10-13* describe the impacts of alternative valuation of non-monetary benefits, including the value of a statistical life, the value of ordinary time, and the reliability premium associated with reducing incident delay. Comparable analyses were included in the 2006 C&P Report, although the alternative values of a statistical life that were studied were different from those in this edition. *Exhibit 10-14* reflects a new analysis conducted using NBIAS projecting the impacts of alternative age-based bridge replacement strategies.

Certain sensitivity analyses from the 2006 C&P Report were dropped; these include estimates of the impacts of "No Link Between Revenue and Investment" and "Universal Congestion Pricing," as these alternatives evolved into two of the alternative financing mechanisms presented in Chapter 7, assuming funding from non-user sources and variable rate user charges, respectively. The "Minimum BCR" analysis was moved to Chapter 9 as part of the analysis of alternative timing of investment; the "No Work Zone Delay" and "Geometric VMT Growth" alternatives were dropped from this edition of the report entirely.

Transit

The sensitivity analysis conducted for transit is consistent with the 2006 C&P Report in that it examines the sensitivity of projected transit investment estimates by the Transit Economic Requirements Model (TERM) to variations in the following assumptions: passenger miles traveled (PMT), capital costs, value of time, and user travel cost elasticities. In the 2006 C&P Report, two additional scenarios were assessed that are not included in this edition's discussion: type of performance enhancing investment and replacement condition thresholds. The analyses included in this chapter illustrate how the baseline investment estimates for transit presented in Chapter 8 will vary in response to changes in the assumed values of input variables. For all of the analyses presented in Chapter 10, it is important to note that investment estimates for rural and special service vehicles are included in the totals, but are not subject to the sensitivity analysis.

Exhibit 10-15 presents the impact of alternative PMT growth rates on transit investment estimates by scenario (the **Maintain Conditions and Performance scenario** and the **Improve Conditions and Performance scenario**). The impact of a 25-percent increase in capital costs on transit investment estimates by scenario is presented in *Exhibit 10-16*. *Exhibit 10-17* presents the impact of change in the value of time on transit investment estimates by scenario. The final exhibit in this year's report presents the impact of change in the value of user cost elasticities on transit investment estimates by scenario. These exhibits are all consistent with those presented in the 2006 C&P Report.

PART III

Special Topics

Introduction

Chapters 11 and 12 provide an in-depth look at specific components of the Nation's transportation system. Chapters 13 through 15 offer a more extensive discussion of topics that were touched upon in the core analytical portion of the report, Chapters 2 through 10. These chapters highlight and present additional insights into these issues and related activities currently underway within the U.S. Department of Transportation.

Chapter 11, **NHS Bridge Performance Projections**, examines the serviceability of bridges on the National Highway System (NHS) and projects the future state of these bridges during the next 50 years under alternative financial and management strategies. This chapter builds on the analytical work presented in Chapter 7 by looking at a broader range of bridge performance indicators over a much longer period of time.

Chapter 12, **Transportation Serving Federal and Indian Lands**, includes an analysis of the condition and performance of transportation serving Federal and Indian lands and details the funding mechanisms for transportation on these lands. A substantial portion of this chapter highlights the role of transportation in these regions and the benefits of Federal lands to the larger American economy.

Chapter 13, **Freight Transportation**, discusses the role of freight transportation and identifies investment and performance issues specific to freight. This chapter details the demands placed on the Nation's freight network, the costs of congestion, and the safety and environmental challenges that need to be overcome in developing a more robust freight infrastructure. It concludes with a discussion of the steps policymakers have taken to address the Nation's freight needs.

Chapter 14, **Congestion Reduction Strategies**, identifies potential solutions to the highway operational performance problems identified in Chapter 4. This chapter outlines four broad types of strategies including strategic additions of capacity, improved system management and operations, travel demand management, and creating an efficient transportation market through road pricing.

Chapter 15, **National Household Travel Survey**, discusses selected findings from the 2001 National Household Travel Survey (NHTS). Since 1969, the NHTS and related studies have provided key information on how the American public uses the Nation's highway system. This chapter uses NHTS data to illustrate several broad themes about travelers, trips, and vehicles in the early Twenty-First Century.

Chapter 11

NHS Bridge Performance Projections

NHS Bridge Performance Projections

Introduction

Chapter 2 of this report presented the characteristics of the bridge network on the National Highway System (NHS). The network consisted of 115,203 bridges, represented approximately 19.4 percent of the total bridges on the Nation's roadway system, comprised approximately 49.5 percent of the Nation's total bridge deck area, and carried 71.1 percent of the total travel on bridges in the Nation.

The second section of Chapter 3, "Bridge System Conditions," presents the performance of the NHS bridge network. The level of performance was reported based on the primary performance measure adopted by the Federal Highway Administration (FHWA)—the percent of deck area on structurally deficient and functionally obsolete bridges compared with the total deck area of bridges on the NHS network. For 2006, the percent of deck area on structurally deficient bridges on the NHS was 8.4 percent and the percent of deck area on functionally obsolete bridges on the NHS was 20.8 percent.

Additional performance measures for NHS bridges were provided in Chapter 3. The shares of average daily traffic (ADT) carried on structurally deficient and on functionally obsolete NHS bridges were 6.6 percent and 20.1 percent, respectively, in 2006. The shares of structurally deficient and functionally obsolete NHS bridges in 2006 were 5.5 percent and 16.8 percent, respectively.

All bridges are a vital link in the Nation's transportation system, and the NHS bridge network has an extremely important role in the system based on the volume of public and commercial traffic it carries. The continued ability of these bridges to carry the Nation's traffic is critical to maintaining the economic health of the Nation and to providing access to services by the public.

This chapter will evaluate the effect of several alternative potential management strategies in a study of the projected health of the Nation's bridge system over the next 50 years, based on select performance metrics and criteria. These strategies are intended to be illustrative. Other strategies based on different targets could be used and be equally valid from a technical perspective. **All costs are provided in constant 2006 dollars. Estimated costs provided do not reflect the effects of inflation and any future increases in construction costs.**

Performance Measures

In this study of NHS bridges, five metrics were used: the average sufficiency rating; the average health index; and the percentage of NHS bridges with condition ratings of 5 ("fair") or greater for deck, superstructure, and substructure. Metrics were used as part of the overall management strategy scenarios calculated using the National Bridge Investment Analysis System (NBIAS) model to project future performance of structures by measuring the health of bridges. A more detailed explanation of the capabilities of NBIAS is presented in Appendix B.

Sufficiency Rating

The sufficiency rating of an individual bridge on a scale of 0 to 100 is based on the structural adequacy and safety, essentiality for public use, and serviceability and functional obsolescence of the bridge. The sufficiency rating considers multiple aspects of a structure and its level of performance and is the basis for establishing eligibility and initial priority for replacement and rehabilitation of bridges under the Highway Bridge Replacement and Rehabilitation Program. In general, a low sufficiency rating for a structure will place that structure at a higher priority.

For this study, the sufficiency ratings of bridges on the NHS were combined and averaged to determine the overall status of all bridges on the NHS. **The initial Average Sufficiency Rating of NHS bridges in 2006 was 82.8.**

Health Index

The health index is a measure of the structural integrity of an element of the bridge. Each element is evaluated individually; these values are then compiled to arrive at a total bridge score. The health index ranges from a high of 100 to a low of 0; the lower the health index number, the higher the priority for rehabilitation or maintenance of the structure.

For this study, the average health index provides a composite for the structural integrity of bridges on the NHS. **The Average Health Index of NHS bridges in 2006 was 91.1.**

Condition Ratings

Condition ratings are used to describe the existing, in-place status of a component. Bridge inspectors assign condition ratings by evaluating the severity of the deterioration or disrepair and the extent to which it affects the component being rated. These ratings provide an overall characterization of the general condition of the entire component being rated and not an indication of localized conditions. Ratings of 5 or greater indicate a situation where maintenance work and minor rehabilitation of the general component can return a bridge to a high performance level. It is highly desirable to implement actions before the general component reaches a rating of 4 or lower. *Exhibit 11-1* describes the bridge condition ratings in more detail.

Exhibit 11-1

Bridge Condition Rating Categories

Rating	Condition Category	Description
9	Excellent	
8	Very Good	No problems noted.
7	Good	Some minor problems.
6	Satisfactory	Structural elements show some minor deterioration.
5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	Poor	Advanced section loss, deterioration, spalling, or scour.
3	Serious	Loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
1	Imminent Failure	Major deterioration or section loss present in critical structural components, or obvious loss present in critical structural components, or obvious vertical or horizontal movement affecting structural stability. Bridge is closed to traffic, but corrective action may put bridge back in light service.
0	Failed	Out of service; beyond corrective action.

Source: Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, Report No. FHWA-PD-96-001.

This chapter uses the percent of bridges in each area—deck, superstructure, and substructure—with ratings of 5 or greater as a measure of the aggregate condition of the components of that category. **In 2006 the percentage of NHS bridges with Deck Ratings of 5 or greater was 95.0; with Superstructure Ratings of 5 or greater it was 97.9; and with Substructure Ratings of 5 or greater it was 98.1.**

Comparison Standards

In general, when comparing the performance of management and funding alternatives, those alternatives with higher values for the chosen metrics at the end of the period of analysis are more desirable. However, the values of the metrics during the analysis period must also be considered. It is possible for an alternative to yield acceptable metrics at the conclusion of the analysis period but some or all of the metrics may fall below the level of acceptability at various points during the analysis period. Therefore not only should the final results of an alternative be evaluated but also the performance during the analysis period.

Funding schedules are also considered as part of the evaluation of alternatives. It is possible for a selected strategy to be highly desirable but the required funding levels are not realistic. Also, there are other practical items to be considered. If an alternative requires a large amount of work to be undertaken in a short period of time, are there sufficient qualified contractors available? Are sufficient amounts of needed construction materials available? What will be the impact on the ability of the NHS to support the transportation of goods and the public?

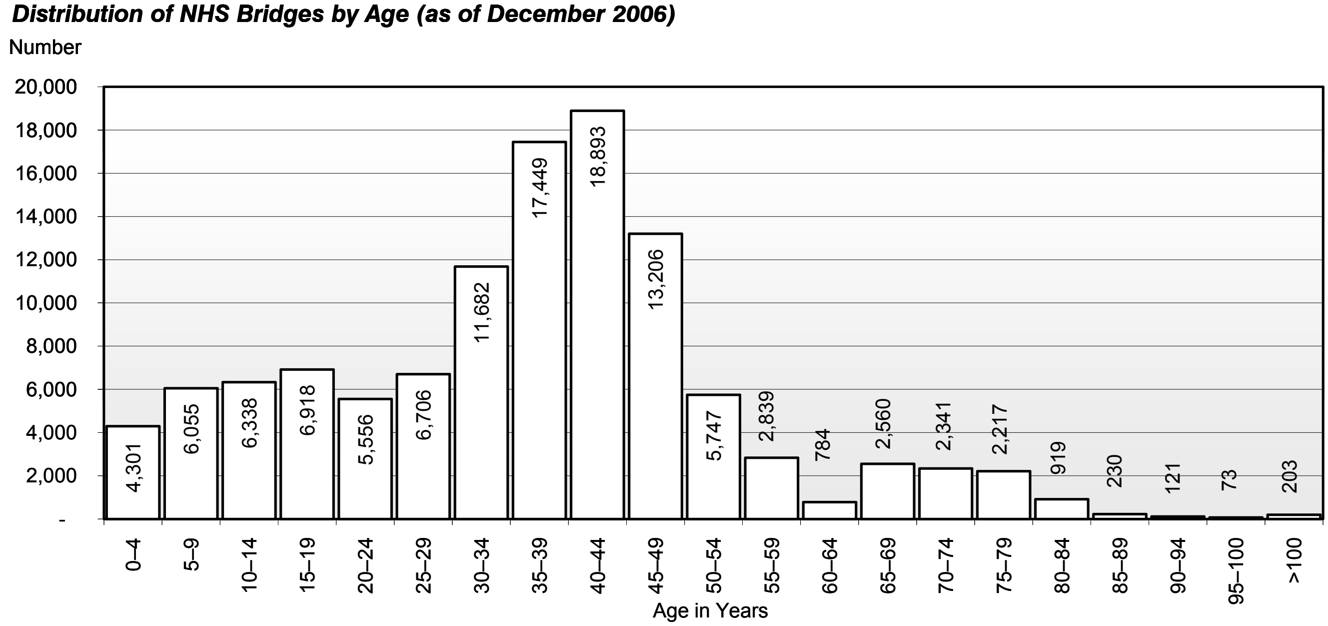
Age of NHS Bridges

Exhibit 11-2 shows the distribution of NHS bridges by age. Approximately 61,230 NHS structures are 30 years but less than 50 years old. This constitutes 53.1 percent of the total NHS bridge network.

The pace of construction of new bridges has not been uniform over time. Many existing bridges were constructed in a relatively short time frame, around the time the Interstate System was constructed. Concern has been expressed that the bridges in that age range will reach their service life limit in the near future based on estimates of a 50-year design life of a bridge structure.

Exhibit 11-2

Distribution of NHS Bridges by Age (as of December 2006)



Source: National Bridge Inventory.

The assumption of a maximum design life of 50 years may not apply in situations where a structure has been kept in good repair through timely maintenance and rehabilitation, thus potentially extending the service life of that bridge. However, estimates of the total service life of a bridge and the remaining service life for that structure are a valid concern. Other factors can affect the service life of a bridge such as less than aggressive maintenance over its full lifetime or loading in excess of its anticipated, as-built limit. These factors will tend to make a structure deteriorate more quickly or need more extensive rehabilitation than a new bridge in similar condition.

Of the remaining NHS bridges, approximately 35,874 structures, 31.1 percent, are less than 30 years old and the remaining 18,034 structures, 15.7 percent, are 50 years of age or older. The year of construction was not available for 65 NHS bridges.

Management Strategy Definitions

The management strategies below each reflect a philosophy that provides theoretical bridge replacement time frames, relating to issues such as bridge age or other factors.

The **No Special Rules strategy** applies the default NBIAS criteria in which bridge actions are only implemented when their estimated benefit-cost ratio is 1.0 or higher, to the extent possible based on the funding alternative being considered.

An **SR 50 strategy** assumes structures that reach a sufficiency rating of 50 or less are selected for replacement in addition to any actions, in order of benefit-cost ratio, selected for work on bridges that have a minimum 1.0 benefit-cost ratio, to the extent possible based on the funding alternative being considered. The 20-year analyses of bridge needs presented in Chapter 7 applied this strategy.

An **Age 50 strategy** assumes any structure that becomes 50 years in age or older during the analysis period will be replaced in addition to any actions, in order of benefit-cost ratio, selected for work on bridges that have a minimum 1.0 benefit-cost ratio, to the extent possible based on the funding alternative being considered.

The **75 Health Index strategy** assumes any structure with a health index equal to or less than 75 during the analysis period will be replaced in addition to any actions, in order of benefit-cost ratio, selected for work on bridges that have a minimum 1.0 benefit-cost ratio, to the extent possible based on the funding alternative being considered.

The **80 Health Index strategy** assumes any structure with a health index equal to or less than 80 during the analysis period will be replaced in addition to any actions, in order of benefit-cost ratio, selected for work on bridges that have a minimum 1.0 benefit-cost ratio, to the extent possible based on the funding alternative being considered.

The **85 Health Index strategy** assumes any structure with a health index equal to or less than 85 during the analysis period will be replaced in addition to any actions, in order of benefit-cost ratio, selected for work on bridges that have a minimum 1.0 benefit-cost ratio, to the extent possible based on the funding alternative being considered.

Funding Approach Definitions

The **Current Funding (CF) Alternative** assumes the expenditure of funds will be sustained in constant dollar terms at the 2006 level of $4.3 billion per year for the duration of the analysis period of 2006 through 2056.

The **Maximum Ramped Funding (MRF) Alternative** assumes an increase in spending at a fixed annual rate above the base year 2006 level for the 50-year period ending in 2056. For each management strategy to which this alternative is applied, the rate of increase is determined as the maximum rate for which NBIAS can identify a sufficient number of potential projects meeting the specified criteria for that strategy in each individual year to allow the funding available in each year to be fully expended. This funding approach is consistent with the 20-year analyses of bridge needs presented in Chapter 7 in this report.

The **Maximum Flat Funding (MFF) Alternative** assumes an immediate increase in spending to a higher level that would be maintained in constant dollar terms for the entire 50-year period from 2006 to 2056. For each management strategy to which this alternative is applied, this investment level is determined as the maximum level for which NBIAS can identify a sufficient number of potential projects meeting the specified criteria for that strategy in each individual year to allow the funding available in each year to be fully expended. This funding approach is consistent with the flat spending alternative for 20-year analyses of bridge needs described in the "Alternative Timing of Investment in NBIAS" section of Chapter 9 in this report.

The **Unconstrained Funding (UF) Alternative** assumes that spending in each year will be based solely on the criteria of the management strategy being analyzed. This funding approach is consistent with the BCR-driven alternative for 20-year analyses of bridge needs described in the "Alternative Timing of Investment in NBIAS" section of Chapter 9 in this report. As discussed in that section, such an approach would tend to front-load spending in the first year of the analysis to address the existing backlog of bridge deficiencies.

The current funding, ramped funding, flat funding, and unconstrained spending alternatives have been applied to various bridge management philosophies to show the budget implications for the various management strategies presented.

Sufficiency Rating 50 Management Strategy

In addition to any other actions to be taken as indicated by NBIAS for bridges on the NHS, any NHS bridge having or reaching a sufficiency rating of 50 or less will be replaced following this strategy.

Maintain Current Funding (CF) Alternative

This alternative to address the needs of the NHS bridge network maintains the current level of funding with the SR 50 management strategy. This results in spending $4.3 billion per year (2006 funding), expending $215.0 billion over a 50-year analysis period of 2006 to 2056. Applying the SR 50 management strategy, all metrics declined by the end of the 50-year analysis period, as shown in *Exhibit 11-3*. In particular, the share of bridges with substructure ratings of 5 or greater was projected to decline from 98.1 percent to 48.9 percent by 2056, a drop of more than 49 points. The average sufficiency rating would decrease from 82.8 to 67.1 and the average health index would drop from 92.0 to 66.8 over the same period. The funds expended totaled $215.0 billion.

Exhibit 11-3

Performance Projections—SR 50 Driven Strategy: Maintain Current Funding Alternative

Metric	Year 2006	2016	2026	2036	2046	2056
Sufficiency Rating	82.8	75.9	69.2	68.6	67.7	67.1
Health Index	92.0	81.6	75.2	70.7	68.2	66.8
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	95.8%	93.2%	88.5%	85.3%	84.5%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	95.3%	87.6%	88.5%	78.3%	84.5%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	87.1%	51.4%	50.1%	51.0%	48.9%

Source: National Bridge Investment Analysis System.

Maximum Flat Funding Alternative

The maximum annual level of funding based on the parameters of this approach was $7.5 billion per year, totaling $375.0 billion (2006 dollars) in 50 years.

Trends for the five metrics are shown in *Exhibit 11-4*. Four of the five metrics declined over the analysis period; however, all metrics remained at or above the acceptable criteria for the duration of the 50-year analysis period except the share of structures with substructure ratings of 5 or greater, which is projected to be 73.7 percent in 2026.

Exhibit 11-4

Performance Projections—SR 50 Driven Strategy: Maximum Flat Funding Alternative

Metric	Year 2006	2016	2026	2036	2046	2056
Sufficiency Rating	82.8	80.0	76.5	77.3	77.6	76.8
Health Index	92.0	85.2	81.4	79.5	79.4	78.9
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	97.9%	98.1%	98.3%	97.6%	98.2%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	97.2%	94.9%	94.2%	95.1%	92.9%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	95.0%	73.7%	77.1%	77.8%	75.7%

Source: National Bridge Investment Analysis System.

Maximum Ramped Funding Alternative

Exhibit 11-5 shows the trends for the five metrics using the SR 50 strategy with ramped spending for the 50-year analysis period. In 2026 and 2036, the shares of structures with substructure ratings of 5 or greater declined to 57.1 percent and 61.6 percent, respectively. The sufficiency rating is projected to be 71.4 in 2026 and 73.0 in 2036. The projected health index declines to 75.7 in 2036. The share of bridges with deck ratings of 5 or greater increased from 95.4 percent in 2006 to 98.4 percent in 2056.

Exhibit 11-5

Performance Projections—SR 50 Driven Strategy: Maximum Ramped Funding Alternative

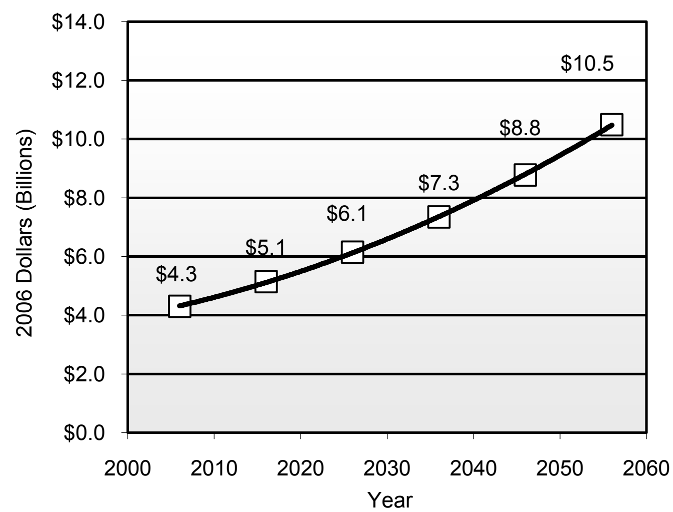
	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	76.5	71.4	73.0	75.4	78.3
Health Index	92.0	82.2	77.3	75.7	77.3	80.3
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	96.1%	94.8%	92.3%	94.3%	98.4%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	95.7%	89.6%	86.4%	88.9%	94.2%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	88.1%	57.1%	61.6%	67.8%	77.3%

Source: National Bridge Investment Analysis System.

The maximum percent increase under this approach was 1.8 percent compounded per year. The funding level at which all available funds per year would be allocated was $350.2 billion (2006 dollars) over the 50-year period. *Exhibit 11-6* shows that early funding ranged from approximately $4.4 billion in 2007 to approximately $10.5 billion by 2056.

Exhibit 11-6

Annual Funding Levels—SR 50 Driven Strategy: Maximum Ramped Funding Alternative



Health Index 75 Management Strategy

In addition to any other actions to be taken as indicated by NBIAS for bridges on the NHS, any NHS bridge having or reaching a Health Index of 75 or less will be replaced following this strategy.

Maximum Flat Funding Alternative

The maximum flat funding level based on the parameters of the HI 75 management strategy was $11.0 billion per year, totaling $550.0 billion (2006 dollars) in 50 years.

Exhibit 11-7 shows that, at the end of the 50-year analysis period, the share of bridges with deck ratings of 5 or greater increased from 95.4 percent to 98.7 percent. The share of bridges with superstructure ratings of 5 or greater remained almost constant, declining only 0.2 percent. The average sufficiency rating decreased by 3.6 from 82.8 to 79.2. The share of bridges with substructure ratings of 5 or greater dropped from 98.1 percent to 89.1, and the average health index declined by 9.3 points to 82.7 from 92.0.

Exhibit 11-7

Performance Projections—HI 75 Driven Strategy: Maximum Flat Funding Alternative

Metric	Year 2006	2016	2026	2036	2046	2056
Sufficiency Rating	82.8	82.2	81.6	80.8	80.3	79.2
Health Index	92.0	87.4	85.3	84.0	83.2	82.7
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.4%	98.6%	98.7%	98.7%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.0%	98.2%	98.0%	97.8%	97.7%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	97.7%	92.4%	92.9%	92.3%	89.1%

Source: National Bridge Investment Analysis System.

Maximum Ramped Funding Alternative

Exhibit 11-8 shows the trends for the five metrics using the HI 75 strategy and Maximum Ramped Funding alternative for the 50-year analysis period. The share of structures with deck ratings of 5 or greater and superstructure ratings of 5 or greater remained above 90 percent throughout the analysis period and showed increases to 98.7 percent and 98.4 percent, respectively, in 2056. The share of structures with substructure ratings of 5 or greater declined to 57.7 percent in 2026, increased to only 64.1 percent in 2036, continued to increase to 79.5 percent in 2046, and ended at 96.1 percent in 2056. The average sufficiency rating declined to 76.1 in 2026 and the health index declined to 77.7 in 2036. These values increased in 2056 to 83.8 and 87.5, respectively.

Exhibit 11-8

Performance Projections—HI 75 Driven Strategy: Maximum Ramped Funding Alternative

Metric	Year 2006	2016	2026	2036	2046	2056
Sufficiency Rating	82.8	76.1	76.1	73.9	78.1	83.8
Health Index	92.0	82.0	77.7	77.7	81.8	87.5
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	96.2%	96.3%	96.5%	98.1%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	95.6%	91.6%	90.3%	94.7%	98.4%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	87.4%	57.7%	64.1%	79.5%	96.1%

Source: National Bridge Investment Analysis System.

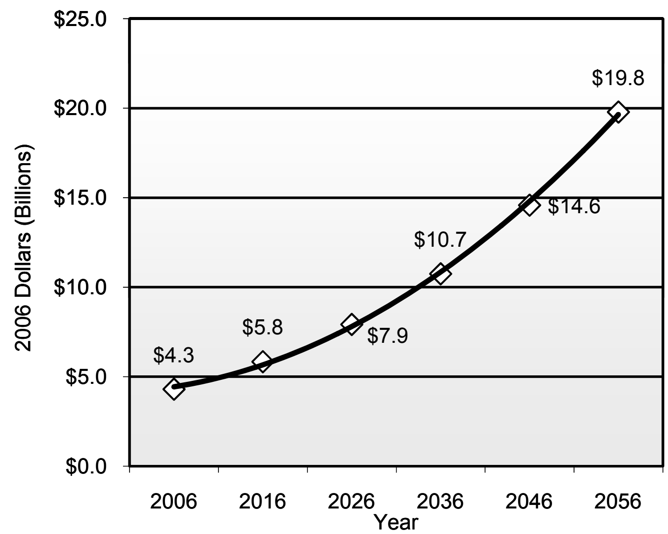
To provide funding to replace bridges with a health index of 75 each year, for the duration of the 50-year analysis period, the maximum percent increase under this approach was 3.1 percent compounded per year. The funding level at which all available funds per year would be allocated was $515.1 billion (2006 dollars) over the 50-year period. *Exhibit 11-9* shows that yearly funding ranged from approximately $4.4 billion in 2007 to a maximum of slightly less than $19.8 billion in 2056.

Health Index 80 Management Strategy

In addition to any other actions to be taken as indicated by NBIAS for bridges on the NHS, any NHS bridge having or reaching a Health Index of 80 or less will be replaced following this strategy.

Exhibit 11-9

Annual Funding Levels—HI 75 Driven Strategy: Maximum Ramped Funding Alternative



Source: National Bridge Investment Analysis System.

Maximum Flat Funding Alternative

The maximum annual level of funding based on the parameters HI 80 management strategy was $14.4 billion per year, totaling $720.0 billion (2006 dollars) in 50 years.

Exhibit 11-10 shows that the average health index is projected to decline steadily from 92.0 in 2006 to 84.2 in 2056. The average sufficiency rating increased slightly during the first 10 years of the analysis period but decreased from 82.8 in 2006 to 80.4 in 2056. The shares of bridges with superstructure and substructure ratings of 5 or greater also showed slight increases during the first 10 years but declined from 97.9 percent and 98.1 percent, respectively, in 2006 to 96.6 percent and 88.0 percent, respectively, in 2056. The share of structures with deck ratings of 5 or greater increased from 95.4 percent in 2006 to 98.6 percent in 2056.

Exhibit 11-10

Performance Projections—HI 80 Driven Strategy: Maximum Flat Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	84.4	82.5	82.0	81.2	80.4
Health Index	92.0	89.4	89.4	85.4	84.7	84.2
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.6%	98.7%	98.7%	98.6%	98.6%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.4%	98.2%	97.5%	96.7%	96.6%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	99.1%	93.2%	93.0%	89.1%	88.0%

Source: National Bridge Investment Analysis System.

Maximum Ramped Funding Alternative

Exhibit 11-11 shows the trends for the five metrics using the HI 80 management strategy with ramped spending for the 50-year analysis period. The share of structures with deck and superstructure ratings of 5 or greater are projected to reach 98.7 percent and 98.3 percent, respectively, by 2056. The share of structures with substructure ratings of 5 or greater is shown to decline to 48.5 percent in 2026 and increase to only 58.8 percent in 2036. This share improves to 76.3 percent in 2046 and ends at 98.0 percent in 2056. The

Exhibit 11-11

Performance Projections—HI 80 Driven Strategy: Maximum Ramped Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	75.9	75.9	72.9	78.7	85.8
Health Index	92.0	81.8	76.9	76.7	82.8	90.1
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	96.1%	95.4%	93.8%	98.1%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	95.4%	88.9%	87.7%	93.7%	98.3%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	86.3%	48.5%	58.8%	76.3%	98.0%

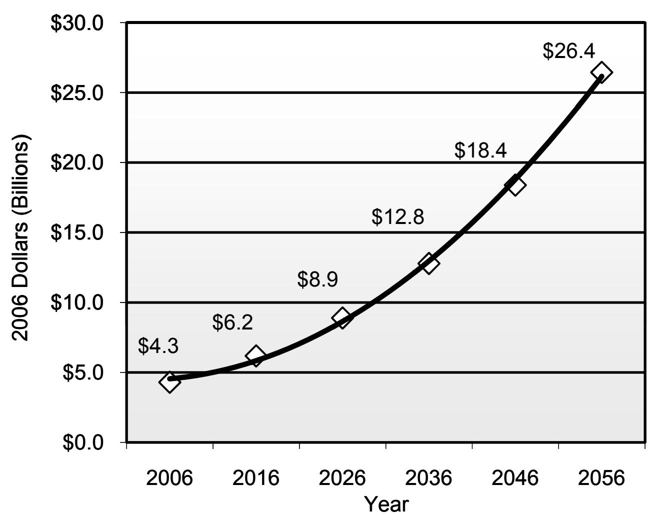
Source: National Bridge Investment Analysis System.

average sufficiency rating is predicted to be 75.9 in 2026 and 72.9 in 2036. The average health index is shown to decrease to a low of 76.7 in 2036. The values for the average sufficiency rating and the average health index in 2056 are 85.8 and 90.1, respectively.

The maximum percent increase under this approach was 3.7 percent compounded per year. The funding level at which all available funds per year would be allocated was $620.8 billion (2006 dollars) over the 50-year period. *Exhibit 11-12* shows that yearly funding ranged from approximately $4.4 billion in 2007 to a maximum of slightly more than $26.4 billion in 2056.

Exhibit 11-12

Annual Funding Levels—HI 80 Driven Strategy: Maximum Ramped Funding Alternative



Source: National Bridge Investment Analysis System.

Health Index 85 Management Strategy

In addition to any other actions to be taken as indicated by NBIAS for bridges on the NHS, any NHS bridge having or reaching a Health Index of 85 or less will be replaced following this strategy.

Maximum Flat Funding Alternative

The maximum annual level of funding based on the parameters of the HI 85 management strategy was $18.5 billion per year, totaling $925.0 billion (2006 dollars) in 50 years.

Exhibit 11-13 shows that the average health index is projected to decline steadily from 92.0 in 2006 to 85.5 in 2056. The average sufficiency rating increased slightly during the first 10 years of the analysis period to 85.2 in 2016 and 2026 but decreased to 80.9 in 2056. The share of bridges with superstructure and substructure ratings of 5 or greater also showed slight increases during the first 10 years but declined from

Exhibit 11-13

Performance Projections—HI 85 Driven Strategy: Maximum Flat Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	85.2	85.2	81.5	81.3	80.9
Health Index	92.0	90.5	87.6	86.2	85.9	85.5
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.6%	98.6%	98.6%	98.6%	98.6%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.3%	97.3%	96.2%	95.4%	95.0%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	99.0%	93.4%	86.8%	85.1%	83.8%

Source: National Bridge Investment Analysis System.

97.9 percent and 98.1 percent, respectively, in 2006 to 95.0 percent and 83.8 percent, respectively, in 2056. The share of structures with deck ratings of 5 or greater increased from 95.4 percent in 2006 to 98.6 percent in 2056.

Maximum Ramped Funding Alternative

Exhibit 11-14 shows the trends for the five metrics using the HI 85 management strategy combined with the MRF alternative over the 50-year analysis period. The share of structures with substructure ratings of 5 or greater varied greatly through the analysis period from 42.5 percent in 2026, to 51.0 percent in 2036, and to 72.2 percent in 2046. The average health index also exhibited variability, though not to the same extent, dropping from 92.0 in 2006 to 75.6 in 2026 and 2036 before increasing to 91.6 in 2036. The sufficiency rating declined from 82.8 in 2006 to 71.2 in 2036 and then rose to 86.6 in 2056. The deck and superstructure metrics remained at relatively high levels during the 50-year analysis period.

Exhibit 11-14

Performance Projections—HI 85 Driven Strategy: Maximum Ramped Funding Alternative

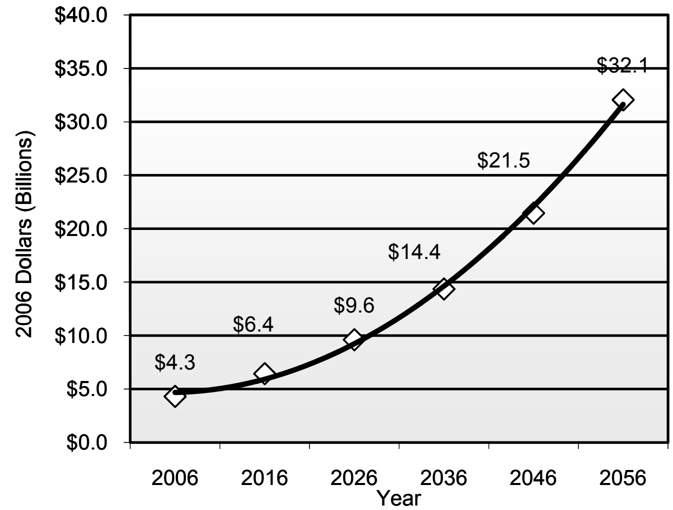
	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	74.6	74.6	71.2	78.3	86.6
Health Index	92.0	81.1	75.6	75.2	83.2	91.6
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	96.0%	94.1%	91.5%	97.8%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	94.3%	87.0%	83.1%	92.6%	98.1%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	81.6%	42.5%	51.0%	72.2%	97.8%

Source: National Bridge Investment Analysis System.

The maximum percent increase under this approach was 4.1 percent compounded per year. The funding level at which all available funds per year would be allocated was $704.9 billion (2006 dollars) over the 50-year period. *Exhibit 11-15* shows that yearly funding ranged from approximately $4.5 billion in 2007 to a maximum of slightly less than $32.1 billion in 2056.

Exhibit 11-15

Annual Funding Levels—HI 85 Driven Strategy: Maximum Ramped Funding Alternative



Source: National Bridge Investment Analysis System.

Age Equals 50 Management Strategy

The effect of the age of structures on the Nation's highways has been an issue of concern. With the surge in construction starting in the late 1950s and continuing through the 1970s, approximately 68.8 percent of NHS bridges were 30 years old or older in 2006. Also in 2006 the average age of bridges on the NHS was approximately 44 years. The useful life of many of these bridges is perceived to be around 50 years. Because of this perception, concerns have been expressed by the public and by members of the engineering community that many of the Nation's bridges may be reaching the end of their useful service life.

This management strategy analyses the effect on budget needs and the performance of the NHS bridge network if structures are selected for replacement when they reach 50 years of age. In addition to any other actions to be taken as indicated by NBIAS for bridges on the NHS, any NHS bridge having or reaching an age of 50 years will be replaced following this strategy.

Maximum Flat Funding Alternative

The maximum annual level of funding based on the parameters of the Age 50 management strategy was $11.3 billion per year, totaling $565.0 billion (2006 dollars) in 50 years.

Exhibit 11-16 shows the projected health index declined steadily from 92.0 in 2006 to 73.7 in 2056. The sufficiency rating also decreased steadily from 85.8 in 2006 to 74.1 in 2036 and 70.2 in 2056. The shares of structures with deck and superstructure ratings of 5 or greater declined to 93.8 percent and 82.4 percent, respectively, in 2056. The share of bridges with substructure ratings of 5 or greater is projected to decline significantly to 46.9 percent in 2056.

Maximum Ramped Funding Alternative

Exhibit 11-17 shows the trends for the five metrics using the Age 50 management strategy with MRF alternative spending. The share of structures with substructure ratings of 5 or greater is projected to drop to 59.7 percent in 2026 and 66.4 percent in 2036 before rising to 80.2 percent in 2046 and to 94.5 percent in 2056. The average sufficiency rating is projected to reach a low of 77.2 in 2016 and 2026 and then increase for the remainder of the analysis period and finish at 83.8 in 2056. The health index is projected to decline

Exhibit 11-16

Performance Projections—Age 50 Driven Strategy: Maximum Flat Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	82.5	82.5	74.1	71.8	70.2
Health Index	92.0	87.3	82.5	79.1	76.1	73.7
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.5%	98.5%	97.6%	95.8%	93.8%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.2%	94.6%	90.3%	86.9%	82.4%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	98.1%	78.7%	64.7%	53.2%	46.9%

Source: National Bridge Investment Analysis System.

Exhibit 11-17

Performance Projections—Age 50 Driven Strategy: Maximum Ramped Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	77.2	77.2	74.8	79.1	83.8
Health Index	92.0	82.9	78.7	79.3	84.3	90.5
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	97.2%	96.5%	95.5%	97.4%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	95.5%	90.0%	88.9%	93.6%	96.8%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	90.5%	59.7%	66.4%	80.2%	94.5%

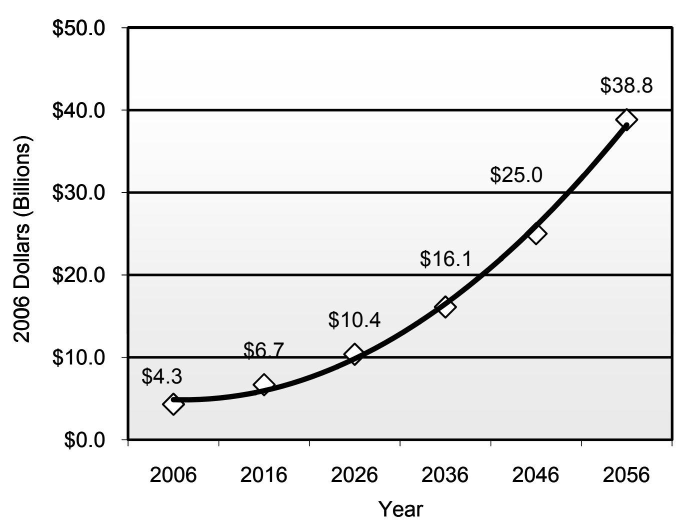
Source: National Bridge Investment Analysis System.

from 92.0 in 2006 to 78.7 by 2026 and then increase to 90.5 by 2056.

The maximum percent increase in funding under the MRF alternative was 4.5 percent compounded per year. The funding level at which all available funds per year would be allocated was $802.1 billion (2006 dollars) over the 50-year period. *Exhibit 11-18* shows that yearly funding ranged from approximately $4.5 billion in 2007 to a maximum slightly greater than $38.8 billion in 2056.

Exhibit 11-18

Annual Funding Levels—Age 50 Driven Strategy: Maximum Ramped Funding Alternative



Source: National Bridge Investment Analysis System.

Unconstrained Funding Alternative

This alternative combines the unconstrained funding alternative and the Age 50 management strategy. No limits were placed on annual budgets; therefore, work was selected based on the most economically beneficial time to schedule it. This alternative results in very high expenditures during the initial years. The budget required for 2007, the first year, is approximately $40.4 billion (2006 dollars). The total funds projected for the analysis period is $1.13 trillion (2006 dollars).

Exhibits 11-19 and *11-20* show the metric and financial trends for this alternative. All metrics are projected to remain at high performance levels during the analysis period. The share of structures with substructure ratings of 5 or greater will fall from 98.1 percent in 2006 to 92.2 percent by 2056. The average sufficiency rating remains fairly stable, ending at 82.8 in 2056. The average health index decreases moderately from 92.0 in 2006 to 89.6 by 2056.

Exhibit 11-19

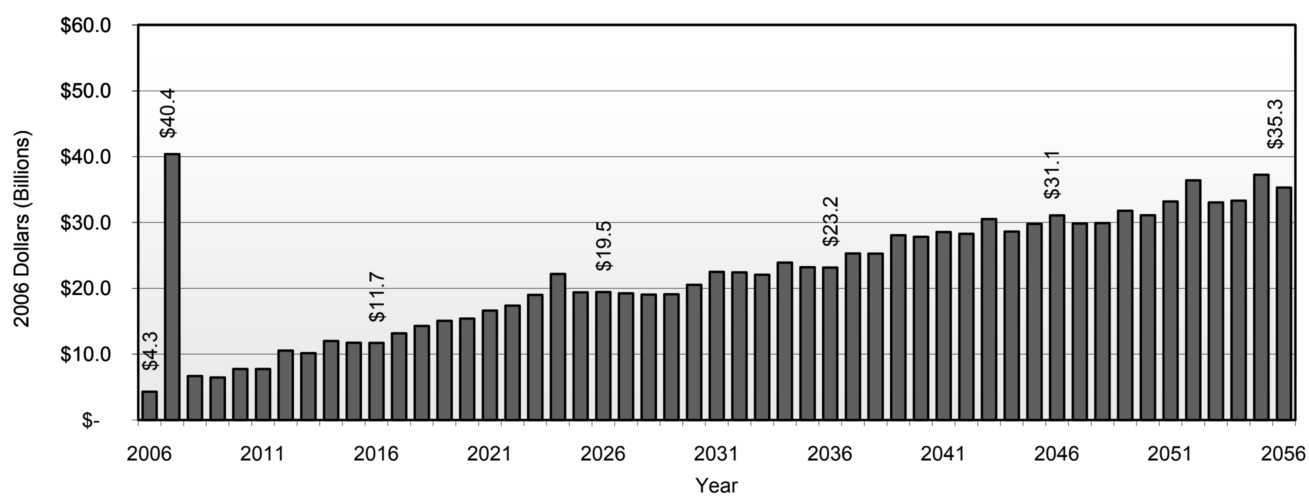
Performance Projections—Age 50 Driven Strategy: Unconstrained Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	82.4	82.4	80.6	82.0	82.8
Health Index	92.0	87.2	85.6	85.8	87.8	89.6
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.5%	98.6%	98.7%	98.7%	98.7%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.2%	97.1%	96.8%	96.8%	96.8%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	98.0%	88.2%	88.8%	91.0%	92.2%

Source: National Bridge Investment Analysis System.

Exhibit 11-20

Annual Funding Levels—Age 50 Driven Strategy: Unconstrained Funding Alternative



Source: National Bridge Investment Analysis System.

Under this scenario, a large surge of work is projected in the initial years. The results should provide a high-performance bridge system on the NHS. However, it is highly unlikely that certain requirements necessary for this surge are available.

The initial funding required in 2007 of $40.4 billion is 9.4 times the amount now being allocated to the NHS bridge network for all work. Approximately 28.7 percent of the bridges on the NHS would be affected for an average of 2 to 5 years. Bridge use would be severely restricted during this time, thereby affecting the flow of freight transport and the traveling public at a national level. The average time that bridge use would be severely restricted, thereby affecting the flow of freight transport and the traveling public at a national level, would be between 2 and 5 years. The lack of qualified contractors, materials, and State support applies here as in the previous alternative. It would continue the spike effect discussed in the previous alternative.

It is also unlikely that a sufficient number of qualified contractors would be available to undertake such a large volume of work in the time frame suggested by this alternative. The vast qualities of materials needed to complete the required work also would not be available to allow completion in the suggested time frame. State agencies would be unable to support the projected work because of lack of available plans, matching funds, and staff. Such a surge in construction would continue to perpetuate project spikes at periodic intervals, creating the same problem at some future date—minimal amounts of work for a long time and then a large spike in demand for replacement

No Special Rules Management Strategy

Unconstrained Funding Alternative

This approach assumes that annual capital expenditures will be determined by a user-defined benefit-cost ratio and that there is no limit on annual or total expenditures.

This approach results in very high expenditures during the initial years. The budget required for 2007, the first year, is approximately $35.8 billion (2006 dollars). The total funds projected for the analysis period is $359.5 billion (2006 dollars).

Exhibits 11-21 and *11-22* show the metric and financial trends for this approach. All metrics are projected to remain at high performance levels for the duration of the analysis period. The share of structures with substructure ratings of 5 or greater will fall from 98.1 percent in 2006 to 76.9 percent by 2056. The sufficiency rating and health index values will decrease from 82.8 and 92.0, respectively, in 2006 to 75.5 and 79.2, respectively, by 2056.

Under this scenario, a large surge of work is projected in the initial years. The results should provide a high-performance bridge system on the NHS. However, it is highly unlikely that certain requirements necessary for this surge are available.

The caveats for this alternative are the same as those for the previous alternative. The funding required in 2007 of $35.8 billion is 8.3 times the amount now being allocated to the NHS bridge network for all work. Over 24 percent of the bridges on the NHS would be affected for an average of 2 to 5 years. Bridge use would be severely restricted during this time, thereby affecting the flow of freight transport and the traveling public at a national level.

Exhibit 11-21

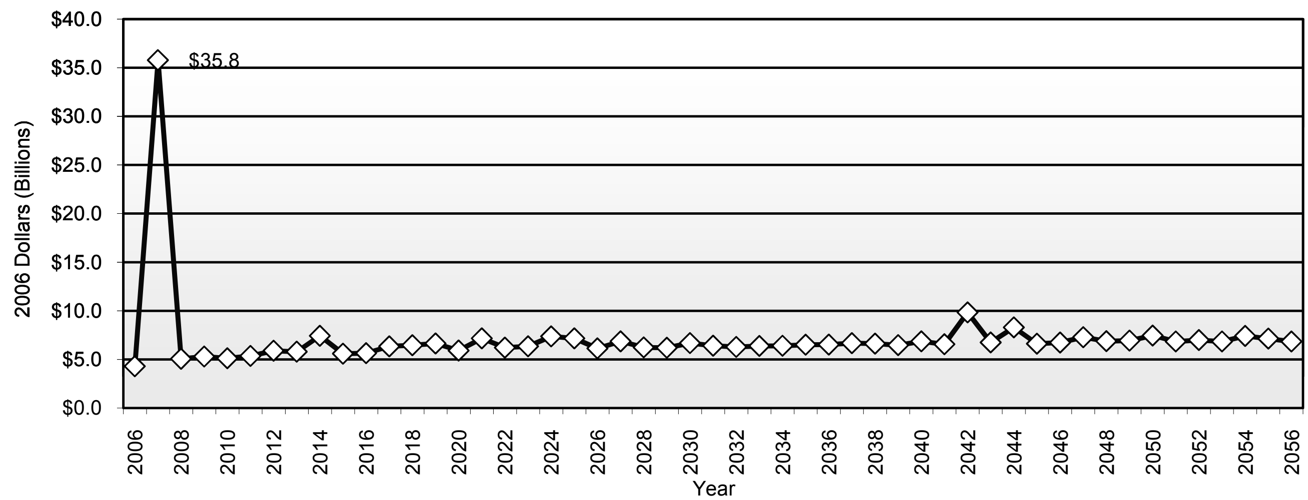
Performance Projections—No Special Rules Strategy: Unconstrained Funding Alternative

	Year					
Metric	**2006**	**2016**	**2026**	**2036**	**2046**	**2056**
Sufficiency Rating	82.8	81.3	81.3	76.7	76.6	75.5
Health Index	92.0	86.0	82.1	80.0	79.5	79.2
Percentage of Bridges With Deck Ratings of 5 or Greater	95.4%	98.4%	98.6%	98.6%	98.5%	98.6%
Percentage of Bridges With Superstructure Ratings of 5 or Greater	97.9%	98.2%	97.9%	97.8%	96.9%	97.1%
Percentage of Bridges With Substructure Ratings of 5 or Greater	98.1%	97.4%	85.5%	81.9%	80.7%	76.9%

Source: National Bridge Investment Analysis System.

Exhibit 11-22

Annual Funding Levels—No Special Rules Strategy: Unconstrained Funding Alternative



Source: National Bridge Investment Analysis System.

Conclusion

Several philosophies for managing the NHS bridge network have been presented in this chapter. They do not, by any means, constitute all possible alternatives and are intended only to illustrate potential strategies. The analysis of this limited number of options has been intended to provide some insight into the numerous possibilities available to maintain the performance and health of the NHS bridge network.

Each presented alternative has positive and negative aspects. In general, when comparing the various alternatives, those yielding the higher values of the individual metrics both over the long and short term will provide a more desirable system. In addition to high metric values, the overall cost must be considered. Some alternatives may require committing extremely high levels of funding initially and allocating physical resources most likely beyond the capabilities of the Nation.

When considering different criteria for selecting bridge projects and the possible funding options to support managing the NHS bridge network, certain items should be considered. Pertinent metrics are needed to measure system performance. Acceptable performance levels for these metrics need to be determined.

Exhibit 11-23 compares the final metrics for each evaluated alternative at the conclusion of the 50-year analysis period. The SR 50: Maintain Current Funding alternative yields the lowest values for all the metrics except for the percentage of bridges with substructure ratings of 5 or greater. The Age 50: Maximum Flat Funding alternative has the lowest substructure value in 2056. The remaining alternatives provide much higher metric levels in 2056 and, depending on the minimum acceptable performance levels selected, yield a much higher performance level for the total NHS bridge network than the SR 50: Maintain Current Funding and the Age 50: Maximum Flat Funding alternatives, even though the levels of all metrics are below those in 2006.

Exhibit 11-23

Projected 2056 Condition Ratings, Sufficiency Rating, And Health Index for Alternative Management Strategies and Funding Approaches

Management Strategy and Funding Approach	DECK [1]	SUPER [2]	SUB [3]	Sufficiency Rating	Health Index
SR 50: Maintain Current Funding	84.5%	72.4%	48.9%	67.1	66.8
SR 50: Maximum Flat Funding	98.2%	92.9%	75.7%	76.8	78.9
SR 50: Maximum Ramped Funding	98.4%	94.2%	77.3%	78.3	80.3
HI 75: Maximum Flat Funding	98.7%	97.7%	89.1%	79.2	82.7
HI 75: Maximum Ramped Funding	98.7%	98.4%	96.1%	83.8	87.5
HI 80: Maximum Flat Funding	98.6%	96.6%	88.0%	85.8	90.1
HI 80: Maximum Ramped Funding	98.7%	98.3%	98.0%	85.8	90.1
HI 85: Maximum Flat Funding	98.6%	95.0%	83.8%	80.9	85.5
HI 85: Maximum Ramped Funding	98.7%	98.1%	97.8%	86.6	91.6
Age 50: Maximum Flat Spending	93.8%	82.4%	46.9%	70.2	73.7
Age 50: Maximum Ramped Spending	98.7%	96.8%	94.5%	83.8	90.5
Age 50: Unconstrained Funding	98.7%	96.8%	92.2%	82.8	89.6
No Special Rules: Unconstrained Funding	98.6%	97.0%	76.9%	75.5	79.2

[1] *DECK = Percentage of bridges with deck ratings of 5 or greater.*

[2] *SUPER = Percentage of bridges with superstructure ratings of 5 or greater.*

[3] *SUB = Percentage of bridges with substructure ratings of 5 or greater.*

Source: National Bridge Investment Analysis System.

Some alternatives provide more consistent or higher performance levels than others. When evaluating an alternative, consideration should be given to the projected performance during the analysis period in addition to the final results predicted. A management alternative may yield acceptable final results; but, at certain points during the analysis period, performance may decline to unacceptable levels for certain metrics.

Exhibit 11-24 shows projected low points for each of the evaluated metrics and year of occurrence. Low performance metrics do not necessarily exclude the associated alternative; but, they should be considered when choosing the management alternative in order to understand all factors and possible results.

Exhibit 11-24

Projected Year within the 2006 to 2056 Analysis Period with Lowest Conditon Ratings, Sufficiency Rating, and Health Index Values for Different Management Strategies and Funding Alternatives

Management Strategies and Funding Approaches	DECK [1]		SUPER [2]		SUB [3]		Sufficiency Rating		Health Index	
	Value	Year	Value	Year	Value	Year	Value	Year	Value	Year
SR 50: Maintain Current Funding	**84.5%**	2056	**72.4%**	2056	**48.9%**	2056	**67.1**	2056	**66.8**	2056
SR 50: Maximum Flat Funding	**95.4%**	2006	**92.9%**	2056	**73.7%**	2026	**76.5**	2026	**78.9**	2056
SR 50: Maximum Ramped Funding	**92.3%**	2036	**86.4%**	2036	**57.1%**	2026	**71.4**	2026	**75.7**	2036
HI 75: Maximum Flat Funding	**95.4%**	2006	**97.7%**	2056	**89.1%**	2056	**79.2**	2056	**82.7**	2056
HI 75: Maximum Ramped Funding	**95.4%**	2006	**90.3%**	2036	**57.7%**	2026	**71.3**	2026	**77.7**	2026
HI 80: Maximum Flat Funding	**95.4%**	2006	**96.6%**	2056	**88.0%**	2056	**80.4**	2056	**84.2**	2056
HI 80: Maximum Ramped Funding	**93.8%**	2036	**87.7%**	2036	**48.5%**	2026	**70.1**	2026	**76.7**	2036
HI 85: Maximum Flat Funding	**95.4%**	2006	**95.0%**	2056	**83.8%**	2056	**80.9**	2056	**85.5**	2056
HI 85: Maximum Ramped Funding	**91.5%**	2036	**83.1%**	2036	**42.5%**	2026	**68.6**	2026	**75.2**	2036
Age 50: Maximum Flat Spending	**93.8%**	2056	**82.4%**	2056	**46.9%**	2056	**70.2**	2056	**73.7**	2056
Age 50: Maximum Ramped Spending	**95.4%**	2006	**88.9%**	2036	**59.7%**	2026	**72.6**	2026	**78.7**	2026
Age 50: Unconstrained Funding	**95.4%**	2006	**96.8%**	2036	**88.2%**	2026	**80.6**	2026	**85.6**	2026
No Special Rules: Unconstrained Funding	**95.4%**	2006	**96.9%**	2046	**76.9%**	2056	**75.5**	2056	**79.2**	2056

[1] *DECK = Percentage of bridges with deck ratings of 5 or greater.*

[2] *SUPER = Percentage of bridges with superstructure ratings of 5 or greater.*

[3] *SUB = Percentage of bridges with substructure ratings of 5 or greater.*

Source: National Bridge Investment Analysis System.

Understanding the funding stream required to implement any of the alternatives is just as important, and in some situations more important, as the total funds required for an alternative (*Exhibit 11-25*). Gradually increasing allocated funds, the ramped spending alternative, reduces the tendency to create "peak demand spikes" by addressing a few more bridge needs each year. This alternative reduces the backlog of needs in a gradually increasing manner.

Allocating a set amount of funding in the flat spending alternative may not provide sufficient funds to reduce the backlog, thereby potentially increasing the backlog. The No Special Rules: Unconstrained Funding alternative projects a large influx of funding in 2007, followed by relatively flat funding. This alternative has the third-lowest total cost but a high initial year cost. The Age 50: Unconstrained Funding alternative also has a very high cost in 2007 and requires increased yearly funding for the remainder of the analysis period, resulting in the highest total cost.

An alternative to manage the NHS bridge network, whether it is one of those presented in this chapter or another, should be evaluated on the final goals desired, the performance provided during the implementation period (10 years, 25 years, 50 years, etc.), the total cost and return on investment, and the necessary funding stream. All aspects, both positive and negative, of each proposed alternative should be evaluated and compared against those in other alternatives before a selection is made.

Exhibit 11-25

Annual and Total Allocated Funds Based on Management Strategies and Funding Alternatives

Approach	Annual Allocated Funds			Total Funds Allocated 50 Years (Billions)
	Initial 2007 Budget (Billions)	Increase per Year (Percent)	Final 2056 Budget (Billions)	
SR 50: Maintain Current Funding	$4.3	-	$4.3	$215.0
SR 50: Maximum Flat Funding	$7.5	-	$7.5	$375.0
SR 50: Maximum Ramped Funding	$4.4	1.8%	$10.5	$349.7
HI 75: Maximum Flat Funding	$11.0	-	$11.0	$550.0
HI 75: Maximum Ramped Funding	$4.4	3.1%	$19.8	$515.1
HI 80: Maximum Flat Funding	$14.4	-	$14.4	$720.0
HI 80: Maximum Ramped Funding	$4.5	3.7%	$26.4	$620.8
HI 85: Maximum Flat Funding	$18.5	-	$18.5	$925.0
HI 85: Maximum Ramped Funding	$4.5	4.1%	$32.1	$704.9
Age 50: Maximum Flat Spending	$11.3	-	$11.3	$565.0
Age 50: Maximum Ramped Spending	$4.5	4.5%	$38.8	$802.1
Age 50: Unconstrained Funding	$40.4	-	$35.3	$1,126.8
No Special Rules: Unconstrained Funding	$35.8	-	$6.8	$359.5

Source: National Bridge Investment Analysis System.

Chapter 12

Transportation Serving Federal and Indian Lands

Condition and Performance of Transportation Serving Federal and Indian Lands

Acronyms

AASHTO	American Association of State and Highway Transportation Officials	FWS	Fish and Wildlife Service
ATPPL	Alternative Transportation in Parks and Public Lands	IRR	Indian Reservation Roads Program
ATS	alternative transportation system	LMHS	Land Management Highway System
BIA	Bureau of Indian Affairs	MIR	Military Installation Roads
BLM	Bureau of Land Management	NFSR	National Forest System Roads
BOR	Bureau of Reclamation	NPS	National Park Service
DAR	Defense Access Road Program	PCR	Pavement Condition Rating
DoD	Department of Defense	PLDR	Public Lands Development Roads
DOI	Department of the Interior	PLH	Public Lands Highways
ERFO	Emergency Relief for Federally Owned Roads	PRP	Park Roads and Parkways
FH	Forest Highways Program	RR	Refuge Roads Program
FHWA	Federal Highway Administration	RVD	recreation visitor days
FLH	Federal Lands Highway	SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
FLHP	Federal Lands Highway Program	SDDC	Military Surface Deployment and Distribution Command
FLMA	Federal Lands Management Agency	USACE	U.S. Army Corps of Engineers
FLREA	Federal Lands Recreation Enhancement Act	USDA	U.S. Department of Agriculture
FTA	Federal Transit Administration	USFS	U.S. Forest Service
		VMT	vehicle miles traveled

Types of Federal Lands

Federal and Indian lands are managed by various Federal Land Management Agencies (FLMAs) within the Departments of the Interior, Agriculture, and Defense. *Exhibit 12-1* highlights resources managed by eight FLMAs.

Resources Served Within Federal and Indian Lands

Each site managed by FLMAs has a unique mission for preserving and protecting its resources while providing access to those resources in varying degrees for the enjoyment of the public. Most FLMAs are charged with managing the resources for present generations without impairing them for future generations. Resource management includes preserving and protecting natural, cultural, historical, and wildlife areas; many of these sites have multiple uses, while others have very limited, specific uses.

Approximately half of the Federal lands are managed under multiple use and sustained yield policy, which relies on transportation. The remaining lands are managed under protected use management policies; however, transportation systems are essential to their resource management, development, recreational use, and protection.

> The growing mission of many of the individual sites includes providing access to resources for the enjoyment of the public.

Exhibit 12-1

Resources Managed by Eight FLMAs

Federal Land Management Agency	Federal Lands Served
Department of Agriculture	
U.S. Forest Service	155 National Forests and 22 National Grasslands
Department of the Interior	
National Park Service	391 National Parks and Monuments
Bureau of Indian Affairs	560 Federally recognized Tribes and Indian and Alaskan Native villages
Fish and Wildlife Service	548 National Wildlife Refuges, 37 Wetland Management Districts, 70 National Fish Hatcheries, and 42 administrative sites
Bureau of Land Management	258 million acres of public lands, 3,496 recreation sites
Bureau of Reclamation	479 dams, 348 reservoirs, 308 recreation sites, and 59 power plants
Department of Defense	
Military Installations	500 military installations
U.S. Army Corps of Engineers	423 lakes

Source: Federal Highway Administration.

Federal and Indian lands have many uses, including recreation, range and grazing, timber, minerals, watersheds, fish and wildlife, and wilderness. Indian reservations and trust land are home to Indian tribal governments and thousands of residents, both tribal members and nontribal members. Roads on Indian lands provide access and mobility for residents and provide access to regional and national transportation systems. Tribal roads are essential for economic development and community development on reservations. These lands are also managed to protect natural, scenic, scientific, and cultural values. In recent years, resource extraction and cutting of timber have been significantly reduced, while recreational use has significantly increased.

Recreation on Federal lands is measured in recreation visitor days (RVDs), a measure of time spent on Federal lands. This standard, however, is defined differently by each agency. *Exhibit 12-2* summarizes recreational use and other uses of Federal and Indian lands.

Exhibit 12-2

Federal and Indian Land Use

	Other Land Uses									
Federal Agency	**Recreation**	**Timber**	**Minerals & Oil**	**Grazing & Farming**	**Water Resource**	**Wildlife**	**Energy**	**National Defense**	**Housing**	**Industry**
Department of Agriculture										
U.S. Forest Service	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Department of Interior										
National Park Service	✓				✓	✓			✓	
Bureau of Indian Affairs	✓	✓	✓	✓	✓	✓	✓		✓	✓
Fish and Wildlife Service	✓	✓	✓	✓	✓	✓	✓			✓
Bureau of Land Management	✓	✓	✓	✓	✓	✓	✓			✓
Bureau of Reclamation	✓				✓	✓	✓			
Department of Defense										
Military Installations	✓				✓	✓		✓		
U.S. Army Corps of Engineers	✓	✓	✓	✓	✓	✓	✓			

Source: Federal Highway Administration.

Condition and Performance of Roads Serving Federal and Indian Lands

Use of roads by private vehicles and tour buses continues to be the primary method of travel to and within Federal and Indian lands. *Exhibit 12-3* summarizes the number of total roadway miles, paved roadway miles, and bridges on Federal and Indian lands.

The transportation systems serving various Federal and Indian lands are discussed below, including bridge and roadway deficiencies. Roadways are generally rated as "good," "fair," or "poor" according to the Pavement Condition Rating standard, although rating definitions may vary among the FLMAs.

The Office of Federal Lands Highway within the Federal Highway Administration (FHWA) works with a number of FLMAs. Twenty-five years ago, FLHP was created by the 1982 Surface Transportation Assistance Act, signed by the President on January 6, 1983; however, the work of the Office of Federal Lands Highway, i.e., Accessing America's Treasures on Federal lands, is not new to FHWA. For close to 100 years, FHWA and its predecessors like the Bureau of Public Roads have been doing this work.

The four FLMAs that have Federal Lands Highway (FLH) programs and that are known as core partners are the U.S. Forest Service (USFS), National Park Service (NPS), Bureau of Indian Affairs (BIA), and U.S. Fish and Wildlife Service (FWS). Other FLMAs meet their roadway needs from outside the FLHP.

Exhibit 12-3

Summary of Public Roads and Bridges

Federal Lands	Length Miles	Paved Miles	Number of Bridges
Department of Agriculture			
USFS, State and Local	99,100	31,400	4,526*
Department of the Interior			
National Park Service	9,550	5,450	1,414
BIA, Tribe, State, & Local	90,731	36,883	8,082
Fish and Wildlife Service	4,900	415	265
Bureau of Land Management	68,880	N/A	776
Bureau of Reclamation	1,863	1,082	900
Department of Defense			
Military Installations	14,400	14,400	TBD
U.S. Army Corps of Engineers	12,164	6,996	252

* *Bridges used by the public.*

Source: Agency Data.

Q&A

Are the road mileage and bridge numbers presented in this chapter fully consistent with those reported in the National Bridge Inventory (NBI) and the Highway Performance Monitoring System (HPMS)?

The numbers in this chapter are supplied by the individual FLMA. Due to differences in definitions, these figures may not match those from NBI and HPMS. FHWA is working with its Federal partners to reconcile the differences.

U.S. Forest Service—Forest Highway Program

The 155 National Forests and 22 National Grasslands offer a wide spectrum of recreation opportunities. For instance, the 191 million acres of National Forest System lands contain 128,000 miles of fishing streams and rivers; over 2.2 million acres of lakes, ponds, and reservoirs; and 12,500 miles of coast and shoreline.[1]

There are almost 99,100 miles of National Forest System Roads (NFSR) and 4,526 bridges used by the public. Approximately 29,500 miles of the roads are paved and the remainder is gravel surface. The condition ratings of paved roads for all 99,100 miles of NFSR are 39 percent good, 29 percent fair, and 32 percent poor.

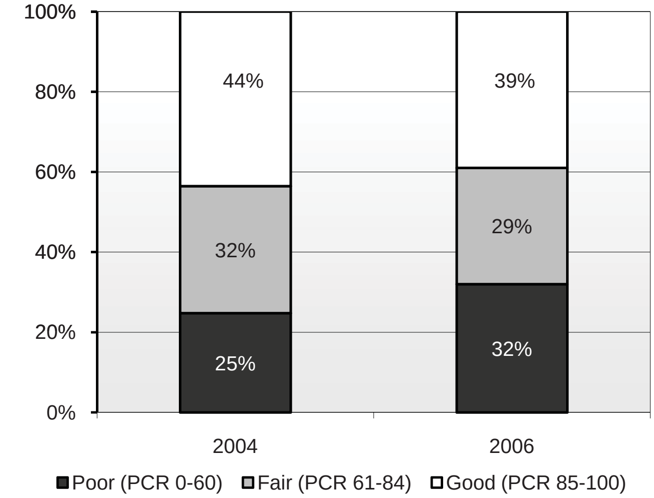
Approximately 29,200 miles of NFSR are State and local roads designated as Forest Highways, of which only 2,000 are under USFS jurisdiction. The Forest Highway Program is funded under the FLHP. The other 69,900 miles of NFSR are considered "Public Forest Roads," and do not receive FLHP funding. The condition of Forest Highway roads is shown in *Exhibit 12-4*.

There are approximately 4,526 bridges on NFSR used by the public, combined between Forest Highways and Public Forest Roads. The condition of Forest Highway bridges from 2002 through 2006 is shown in *Exhibit 12-5*. In 2006, approximately 77 percent were not deficient, nearly 13 percent were functionally obsolete, and slightly less than 10 percent were structurally deficient.

The composition of NFSR is summarized in *Exhibit 12-6*.

Exhibit 12-4

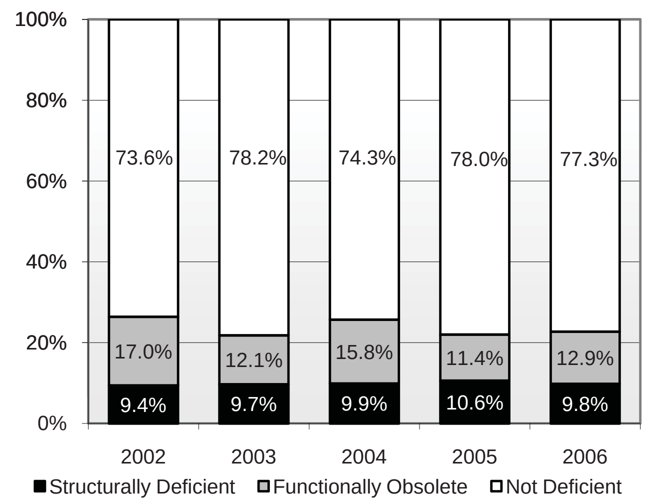
Condition of Forest Highway Roads



Source: Agency Data.

Exhibit 12-5

Condition of Forest Highway Bridges



Source: Agency Data.

Exhibit 12-6

National Forest System Roads and Bridges

Road Type	Road Miles: Unimproved Earth	Road Miles: Graded Earth Template	Road Miles: Gravel	Road Miles: Paved	Road Miles: Total	Bridges
Forest Highway	N/A	600	7,100	21,500	29,200	-
Public Forest Roads (USFS jurisdiction)	N/A	5,000	56,900	8,000	69,900	-
Total	**N/A**	**5,600**	**64,000**	**29,500**	**99,100**	**4,526** [1]

[1] Includes FH and NFSR - Public

Source: Agency Data.

National Park Service—Park Roads and Parkways Program

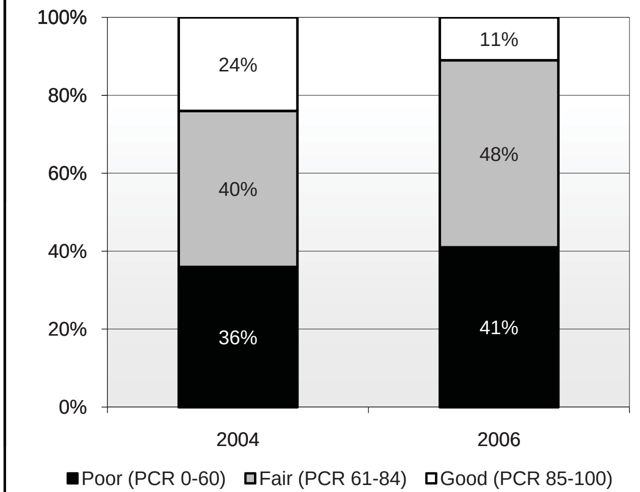
The NPS system includes 391 national park units containing more than 84 million acres. This system includes parks, parkways, monuments, historic sites, military parks, battlefields, memorials, recreational areas, and scenic waterways.

There are about 9,550 miles of Park Roads and Parkways (PRP), of which about 5,450 miles are paved. As shown in *Exhibit 12-7*, approximately 11 percent of pavement road mileage in 2006 was rated as good, while 48 percent was identified as fair and 41 percent was considered poor.

The annual vehicle miles traveled (VMT) on PRP roads is 2.4 billion, based upon a subset of 33 parks representing 63 percent of paved road miles for which VMT figures are available. PRP roads have a total of approximately 1,414 public bridges and 63 tunnels; less than 2 percent of the bridges are structurally deficient. Bridge conditions for 2002 through 2006 are shown in *Exhibit 12-8*.

Exhibit 12-7

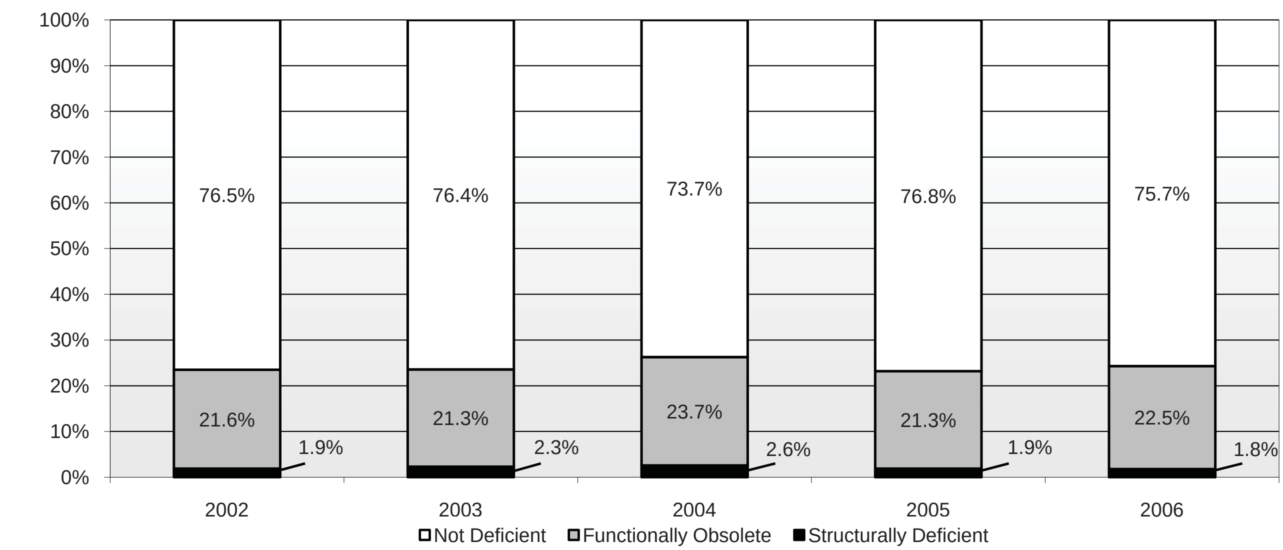
Condition of PRP Highway Roads



Source: Agency Data.

Exhibit 12-8

Condition of PRP Highway Bridges



Source: Agency Data.

The road system serving National Parks is summarized in *Exhibit 12-9*.

Exhibit 12-9

PRP Roads and Bridges

Road Type	Road Miles: Unimproved Earth	Road Miles: Graded Earth Template	Road Miles: Gravel	Road Miles: Paved	Road Miles: Total	Bridges
Public Roads	N/A	N/A	4,100	5,450	9,550	1,414

Source: Agency Data.

Retaining Wall Inventory Program

The NPS has also requested that the FHWA develop a strategy and procedure for a retaining wall inventory program that, in the same manner as the existing Road Inventory Program and the NBI Program, supports the NPS Facility Management Software System asset management program. As of February 2008, inventories have been conducted in all 26 parks selected for the Phase 1 field effort. Approximately 2,000 walls have been inventoried thus far, with nearly 2,500 walls anticipated to be investigated by the conclusion of the Phase 1 effort. Thus far in Phase 1, 23 different wall types have been inventoried, with the vast majority being culturally sensitive mortared/nonmortared stone masonry structures—wall assets common to the vast majority of National Parks. Of the approximately 2,000 walls, over 87 percent have received relatively high condition ratings and have been found to require little or no maintenance for continued serviceability.

Bureau of Indian Affairs—Indian Reservation Roads and Bridges Programs

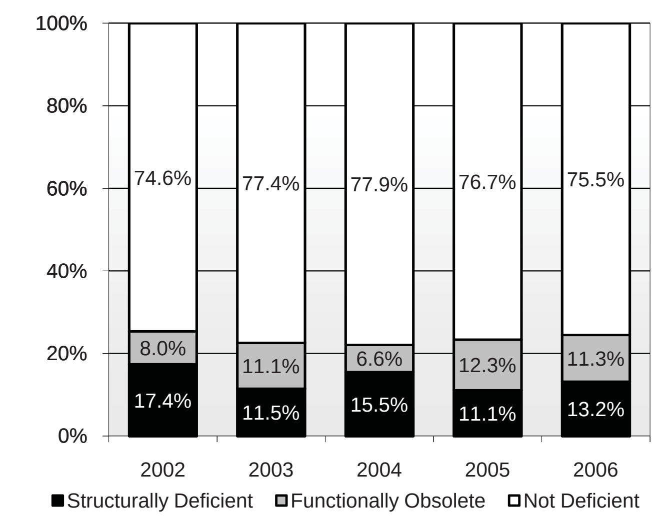
The BIA manages 56 million acres and has stewardship and trust responsibility for programs that serve the more than 560 Federally recognized American Indian and Alaskan Native tribes, villages, groups, and communities. In many instances, American Indian and Alaskan Native villages are in isolated locations with little arable land and few known natural resources. Isolation is also a result of geologic features such as islands, lakes, rivers, and difficult terrain and can be perpetuated by lack of transportation facilities.

The IRR system provides access to and within American Indian and Alaskan Native reservations, lands, communities, and villages. There are two categories of IRR roads. The first consists of approximately 32,996 miles of public roads that are owned and maintained by the BIA and tribal governments. These are referred to as BIA system roads. The second category consists of about 57,735 miles of State and local public roads, and other Federal roads. These roads provide access to American Indian reservations and Alaska Native villages or, in some instances, are located within reservations or American Indian lands. Over 55 percent of the IRR system is unimproved, earth, and/or gravel. The annual VMT on these roads is 2 billion. The annual fatal accidents on IRR exceed four times the national average.

The condition ratings of IRR roads are 16 percent good, 39 percent fair, and 45 percent poor. Nearly 37,000 miles of the IRR roads are paved. About 25 percent of the BIA-owned unpaved roads are constructed to nationally recognizable standards. There are 8,045 bridges within the entire IRR system, of which 940 are tribally or BIA-owned. *Exhibit 12-10* describes the condition of IRR Highway Bridges from 2002 through 2006. Currently, approximately 24.5 percent of all IRR bridges are either functionally obsolete and/or structurally deficient.

Exhibit 12-10

Condition of IRR Highway Bridges



Source: Agency Data.

The IRR system is summarized in *Exhibit 12-11*.

Exhibit 12-11

IRR Roads and Bridges

	Unimproved Earth [1]	Graded Earth Template [1]	Gravel	Paved	Total	Bridges
BIA	N/A	N/A	21,278	6,817	28,095	940
Tribes	N/A	N/A	4,532	369	4,901	N/A[2]
State	N/A	N/A	593	13,014	13,607	2,310
Local	N/A	N/A	27,567	16,561	44,128	4,795
Total	**N/A**	**N/A**	**53,970**	**36,761**	**90,731**	**8,045**

[1] *Included in Gravel.*

[2] *BIA Bridge data includes data for Tribes.*

Source: Agency Data.

Average annual authorizations in the Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) of FLHP funding for IRR are $356 million per year. Two percent of this is reserved for transportation planning. In addition, $14 million of funding is received annually for the national IRR Bridge Program. This program replaces or rehabilitates functionally obsolete or structurally deficient IRR bridges identified in the FHWA NBI System.

U.S. Fish and Wildlife Service—Refuge Roads Program

The FWS manages the National Wildlife Refuge System. This system consists of 585 wildlife refuges and wetland management districts encompassing 96 million acres of land in the 50 States, Puerto Rico, the Virgin Islands, American Samoa, Guam, and the Caribbean and Pacific insular possessions of the United States. FWS receives about 40 million recreation visits per year and has a variety of roads, trails, boat ramps, access points, bicycle trails, and viewing areas. FWS also operates 70 National Fish Hatcheries that are open to the public for visits and tours.

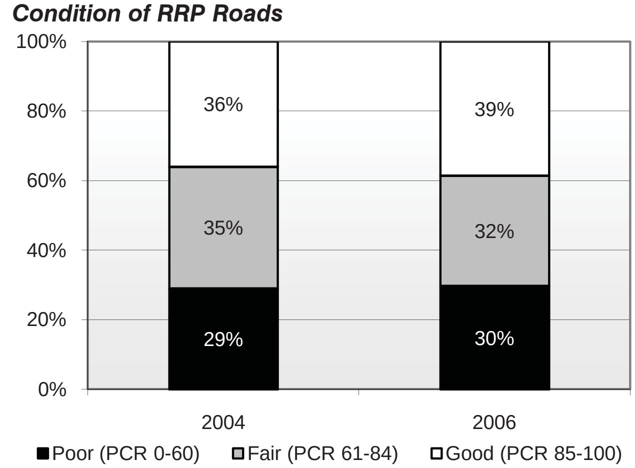
FWS administers 4,900 miles of public roads. Four hundred fifteen miles of public FWS roads are paved; the remaining miles consist of gravel and native surfaced roads. *Exhibit 12-12* shows pavement condition ratings for Refuge Roads Program (RRP) roads between 2004 and 2006.

The National Wildlife Refuge System contains 265 public bridges and 5,153 public parking lots. About 24 percent of RRP bridges were functionally obsolete in 2006, while 11 percent were structurally deficient. Bridge conditions from 2002 through 2006 are shown in *Exhibit 12-13.*

The road system serving FWS lands is summarized in *Exhibit 12-14.*

Exhibit 12-12

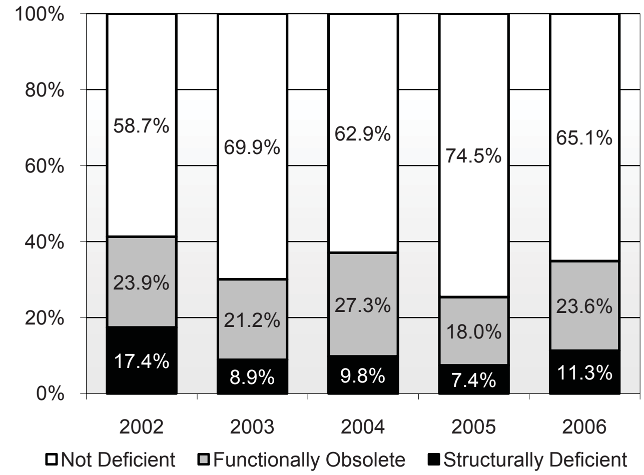
Condition of RRP Roads



Source: Agency Data.

Exhibit 12-13

Condition of RRP Highway Bridges



Source: Agency Data.

Exhibit 12-14

FWS Roads and Bridges

	Road Miles					
Road Type	Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Bridges
Public Roads	N/A	1,800	2,685	415	4,900	265

Source: Agency Data.

Funds from RRP were authorized at $29 million beginning in FY 2005. The funds are used for improving the existing roads within the National Wildlife Refuge System and may not be used to fund new construction.

Non-FLH Core Partners

The following transportation systems do not have a dedicated funding program through SAFETEA-LU. However, many of these agencies' roads are open for public use. For the purposes of this report, FHWA elected to include transportation condition and performance data of all major FLMAs.

Many National Parks and National Forests have become more visited and an increasing number of people are using facilities on Bureau of Land Management (BLM)–managed lands, Corps of Engineers (USACE) facilities, and Department of Defense (DoD) installations. On BLM lands in 2006 alone, more than 69 million visitor days took place, an increase of 7 million since 2001. Annual visits to BLM lands increased nearly 5 million, or 9 percent, between 1999 and 2005.

Bureau of Land Management—Public Lands Development Roads

The BLM manages 258 million acres, about 13 percent of the surface area of the United States, and is the largest manager of Federal lands (42 percent overall). The BLM lands are concentrated primarily in 11 Western States and Alaska.

Public areas managed by BLM include 17 National Conservation Areas, 15 National Monuments, 375 National Recreation Areas, 12 National Scenic and Historic Trails, 45 National Landmarks, and 3,496 Recreation Sites. BLM is responsible for the balanced management of lands and resources. This includes resource protection, recreation, range and grazing, timber harvesting, mineral and oil extraction, watersheds, fish and wildlife, and wilderness. Management is based on the principles of multiple use and sustained yield. BLM is responsible for maintaining the land and minerals records and the U.S. Public Land Survey System.

The BLM manages a network of 68,880 miles of Public Lands Development Roads (PLDR). Many of the roads serve public-use and special purposes, such as those that serve recreational development areas. The BLM has constructed new roads over the last 25 years to meet recreation and other resource access needs. The system also has 776 bridges and major culverts. As of 2001, the most recent year for which data are available, the condition ratings of roads were 10 percent good, 46 percent fair, and 44 percent poor. Data for BLM roads and bridges are given in *Exhibit 12-15*.

Exhibit 12-15

BLM Roads and Bridges

	Road Miles					
Road Type	**Unimproved Earth**	**Graded Earth Template**	**Gravel**	**Paved**	**Total**	**Bridges**
PLDR	N/A	N/A	N/A	N/A	68,880	776

Source: Agency Data.

Bureau of Reclamation

The Bureau of Reclamation (BOR) administers 472 dams and 348 reservoirs in 17 Western States and manages 308 recreation sites. One of the most notable reservoirs is Lake Mead, created by Hoover Dam. BOR is the ninth-largest electric utility and second-largest producer of hydropower in the United States, with 58 powerplants producing an average of 44 billion kilowatt-hours annually. BOR is also the Nation's largest wholesale water supplier, delivering 10 trillion gallons of water to more than 31 million people each year and providing one out of five western farmers with irrigation water.

The BOR owns approximately 1,863 miles of public roads and an estimated 900 bridges that are open for use by the general public. The road system serving BOR lands is summarized in *Exhibit 12-16*.

Exhibit 12-16

BOR Roads and Bridges

	Road Miles					
Road Type	**Unimproved Earth**	**Graded Earth Template**	**Gravel**	**Paved**	**Total**	**Bridges**
Public Roads	N/A	N/A	781	1,082	1,863	900

Source: Agency Data.

Department of Defense—Military Installation Roads

There are approximately 500 major military reservations in the United States encompassing about 24 million acres of land. DoD roads are open to use by dependents, visitors, and other members of the public, even though they may be required to stop at a gate area. Roads on military installations serve housing, offices, commissaries, base exchanges, recreation facilities, unrestricted training facilities, hospitals, and through-traffic. This public street system is similar to street systems in urban areas; in many cases, military streets are an integral part of the local community's street system, and motorists may not even realize they are on a military street.

DoD regulations allow public access to recreational facilities such as lakes, beaches, and wooded areas for bases within the continental United States. The public may access these areas for fishing, swimming, hunting, and other natural resource enjoyment except where an overriding military mission specifically requires a temporary or permanent suspension of such use. Improved recreational facilities such as baseball, football, and soccer fields; gymnasiums; golf courses; swimming pools; and bowling alleys are also available. These facilities attract an estimated 15 million visitors annually. Also, there are 244 man-made lakes open to public recreational use on military installations.

About 14,400 miles of paved public roads, referred to as Military Installation Roads (MIR), are under the jurisdiction of the DoD. Of these, approximately 590 miles (4 percent) are classified as principal arterial roads, 2,550 miles (18 percent) as collector roads, and 11,260 miles (78 percent) as local roads. These roads accommodate approximately 5.8 billion vehicle miles traveled annually, with approximately 50 percent on the principal arterial and collector roads.

The conditions of public base roads are 17 percent good, 12 percent fair, and 71 percent poor. Roads serving military installations are summarized in *Exhibit 12-17.*

Exhibit 12-17

Military Installation Roads and Bridges

	Road Miles					
Road Type	**Unimproved Earth**	**Graded Earth Template**	**Gravel**	**Paved**	**Total**	**Bridges**
Roads	N/A	N/A	N/A	14,400	14,400	TBD

Source: Agency Data.

U.S. Army Corps of Engineers

The USACE is the largest provider of water-based recreation. The USACE currently administers approximately 12.7 million acres of land and water at 423 lakes and waterways reporting recreational use throughout the United States. USACE lakes and waterways have 4,479 recreation areas, including 970 campgrounds, 4,666 miles of trails, 3,430 launching ramps, and 829 swimming beaches available for public use. The USACE directly manages 2,615 recreation areas. The remainder is managed by other Federal agencies (53 areas), States (583 areas), local governments (556 areas), concessionaires (380 areas), and quasi-public agencies (287 areas). USACE recreation facilities are located in all but seven States.

Most of the USACE lakes and waterways are in locations in reasonable proximity to the public. More than 80 percent are within 50 miles of a major metropolitan area, and 94 percent are within a 2-hour drive. The majority of USACE resources are located east of the Rocky Mountains, where the majority of the U.S. population resides.

There are 12,164 miles of roads on USACE lands, of which 6,996 miles are paved. Of total roads, 9,860 miles are public USACE operations and maintenance roads, and 2,304 miles of public roads are out-granted to partners for operations and maintenance. Fifty-three percent of USACE public roads are rated in good condition, 29 percent in fair condition, and 18 percent in poor condition. The USACE owns 252 bridges; bridge conditions have not been assessed. The road system serving USACE facilities is summarized in *Exhibit 12-18.*

Exhibit 12-18

USACE Roads and Bridges

	Road Miles					
Road Type	**Unimproved Earth**	**Graded Earth Template**	**Gravel**	**Paved**	**Total**	**Bridges**
Public/USACE[1]	N/A	N/A	4,172	5,688	9,860	252
Public/Leased	N/A	N/A	996	1,308	2,304	N/A
Total	**N/A**	**N/A**	**5,168**	**6,996**	**12,164**	**252**

[1] Includes Service Roads.

Source: Agency Data.

U.S. Forest Service—Public Forest System Roads

As noted earlier, of the 99,100 miles of NFSR, 69,900 are considered Public Forest Roads, and do not receive FLHP funding. Only the 29,200 miles of Forest Highways receive FLHP funding.

Summary of Road and Bridge Conditions

E*xhibit 12-19* presents a summary of the condition of all roads and bridges serving Federal lands.

Transportation Funding for Federal and Indian Lands

The FLHP SAFETEA-LU authorizations for 2005 through 2009 total over $4.5 billion for the Public Lands Highways (PLH) (Discretionary and Forest Highways), PRP, IRR, and RRP. FLHP funds can be used for transportation planning, research, engineering, and construction of highways, roads, parkways, and transit facilities within public lands, National Parks, and Indian reservations. In addition, FLHP funds can also be used as the State/local match for most types of Federal-aid highway funded projects.

During the past five fiscal years, the FLHP has improved, on average, about 1,000 miles of roads and 35 to 40 bridges per year.

Exhibit 12-20 outlines FLHP funding under SAFETEA-LU for 2005 through 2009. These programs result in “core partners.”

Exhibit 12-19

Summary of Condition of Roads and Bridges Serving Federal Lands

Federal Lands	Road Category	Owner	Length Miles	Paved Miles	Condition of Paved Roads: % Good	% Fair	% Poor	Bridges: Number	% Deficient
Department of Agriculture									
U.S. Forest Service	FH	State/ Local	27,200	21,400	N/A	N/A	N/A	4,526 [1]	13%
	FH	USFS	2,000	N/A	N/A	N/A	N/A	N/A	TBD
	NFSR - Public	USFS	69,900	8,000	20% [2]	61%	19%	N/A	TBD
Department of the Interior									
National Park Service	PRP	NPS	9,550	5,450	11%	48%	41%	1,414	2
Bureau of Indian Affairs	IRR	BIA/ Tribal	32,996	7,186	16%	39%	45%	940	24%
	IRR	State/ Local	57,735	29,575	N/A	N/A	N/A	7,142	0
U.S. Fish and Wildlife Service	Public Roads	FWS	4,900	415	46%	44%	24%	265	11%
Bureau of Land Management	LMHS	Local	7,208	3,608	N/A	N/A	N/A	N/A	TBD
	PLDR	BLM	76,383		10%	46%	44%	776	6%
Bureau of Reclamation	Public Roads	BOR	1,863	1,082	65%	25%	10%	900	12% [3]
Department of Defense									
Military Installations	MIR	DoD	14,400	14,400	17%	12%	71%	N/A	TBD
U.S. Army Corps of Engineers	Public Roads	USACE	7,808	5,152	53%	29%	18%	252	TBD
	Roads	USACE	2,052	536	69%	24%	8%	N/A	TBD

[1] *Includes all bridges.*

[2] *Condition is for paved roads only.*

[3] *Based on a sample of 218 bridges inspected.*

Key:

BIA: Bureau of Indian Affairs
BLM: Bureau of Land Management
BOR: Bureau of Reclamation
DoD: Department of Defense
FH: Forest Highways Program
FWS: Fish and Wildlife Service
IRR: Indian Reservation Roads
LMHS: Land Management Highway System
MIR: Military Installation Roads
NFSR: National Forest System Roads
NPS: National Park Service
PLDR: Public Lands Development Roads
PRP: Park Roads and Parkways
USACE: U.S. Army Corps of Engineers
USFS: U.S. Forest Service

Source: Agency Data.

Other FLMAs that work with FLH on a more limited basis are as follows:

- BLM—Public Lands Development Roads
- BOR
- DoD—Military Installation Roads
- USACE
- USFS—Public Forest System Roads.

Exhibit 12-20

SAFETEA-LU FLHP Funding, 2005–2009 (Millions of Dollars)

	SAFETEA-LU					
Category	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
PLH-FH	173	187	187	193	200	**940**
PLH-D	87	93	93	97	100	**470**
IRR	300	330	370	410	450	**1,860**
IRR - Bridges	14	14	14	14	14	**70**
PRP	180	195	210	225	240	**1,050**
RRP	29	29	29	29	29	**145**
Total	**783**	**848**	**903**	**968**	**1,033**	**4,535**

Source: Office of Federal Lands Highway.

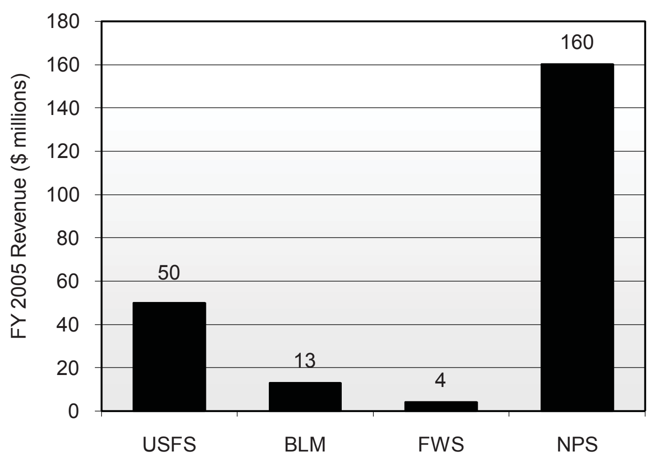
These FLMAs each receive between $500,000 and $1 million from the PLH program for transportation planning activities only. The FLMAs rely on their own appropriations or other sources of funding for additional transportation planning, research, engineering, and construction of highways, roads, parkways, and transit facilities within their jurisdiction.

Often, FLMA lands are located either adjacent to or very near each other. This situation presents an opportunity to create seamless transportation systems and leverage Federal funds within and between these lands through integrated transportation planning.

In addition to FLHP funds, certain National Parks, Forests, and Wildlife Refuges collect recreation fees that help maintain those areas. Recreation fees (collected under the Federal Lands Recreation Enhancement Act [FLREA, also known as REA]) supplement FLMAs' transportation programs, but the Highway Trust Fund and Title 23 appropriations continue to be the primary source of funds. *Exhibit 12-21* shows the recreation fees collected by selected FLMAs, which generated a total of $228 million in FY 2005.[2] A portion of the fees collected are distributed back to transportation either directly by the FLMAs or indirectly through the county and/or State.

Exhibit 12-21

Recreation Fees Collected by Selected Partner Agencies (Millions of Dollars)



Source: First Triennial Report to Congress Fiscal Year 2006, Department of the Interior.

Role of Transportation in the Use of Federal and Indian Lands

Transportation plays a key role in the way people access and enjoy Federal lands and provides access to resources. Federal lands possess approximately 329,000 miles of public roads of which about 93,000 miles are State and local roads that provide access to and within these lands. Transportation is also critical to the quality of life in Indian communities, providing access between American Indian and Alaskan Native housing and education, emergency centers, and places of employment. The transportation system is vital to encouraging economic development on Indian lands.

Many FLHP roads are also designated by State and Federal governments as Scenic Byways. Under the FHWA National Scenic Byways Program, FLMAs have had numerous designations; NPS units have over 73 National Scenic Byways and All American Road designations, the USFS has 69, the FWS has 24, BLM has 4, and BIA has 9 that share a geographic location crossing Federal partners' lands or, in some instances, that are the attraction itself, like the Blue Ridge Parkway or the Natchez Trace Parkway. The USFS began designating National Forest Scenic Byways in 1988, and today there are 136 routes over 9,126 miles in 34 states. Similarly, in 1989, the BLM began designating routes as Back Country Byways, and today these constitute more than 60 routes over 3,100 miles in 11 States. There are also over 3,000 miles of NPS roads and parkways that meet the criteria for Scenic Byways. Finally, the BIA has identified 1,000 miles of IRR with the potential for Scenic Byways designation.

Roads serving Federal and Indian lands are summarized in *Exhibit 12-22*.

Exhibit 12-22

Summary of Federal Roads

Federal Lands Served	Road Category	Owner	Length Miles
Department of Agriculture			
National Forest	Forest Highways	State/Local/USFS	29,200
	Public Forest System Roads	U.S. Forest Service	69,900
Department of Interior			
National Parks	Park Roads and Parkways	National Park Service	9,550
Indian Lands	Indian Reservation Roads	Bureau of Indian Affairs/Tribal*	32,996
	Indian Reservation Roads	State/Local/Other	57,735
Wildlife Refuges	Wildlife Refuge Roads	Fish and Wildlife Service	4,900
Public Lands (BLM Lands)	Public Lands Development Roads	Bureau of Land Management	76,000
Reclamation Projects	Use)	Bureau of Reclamation	1,980
Department of Defense			
Military Installations	Military Installation Roads	DoD	14,400
U.S. Army Corps of	Corps Recreation Roads	USACE	7,808
Engineers	Leased Roads to States	USACE	2,304
Total			**306,773**

* *Does not include proposed roads in the IRR inventory that are not yet funded or scheduled for construction.*

Endnotes

[1] http://www.fs.fed.us/biology/fish/fish.html, accessed February 2008.

[2] *Federal Lands Recreation Enhancement Act: First Triennial Report to Congress Fiscal Year 2006.* Department of the Interior. NPS includes $128 million from REA fees, National Park Pass revenues, Transportation Revenue, etc.

Alternative Transportation in Parks and Public Lands Program

The Alternative Transportation in Parks and Public Lands (ATPPL) program was established in 2005 under Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU). The ATPPL program provides a total $97 million of Federal funding to help develop transportation alternatives for enjoying our parks and public lands while protecting resources. The new program's goals are to conserve natural, historical and cultural resources; reduce congestion and pollution; improve visitor mobility and accessibility; enhance the visitors' experience; and ensure access to all, including persons with disabilities.

Federal agencies that manage parks, refuges, or recreational areas that are open to the general public are eligible to apply for funds. This includes the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Forest Service, the Bureau of Land Management and the Bureau of Reclamation. Also eligible to apply are State, tribal, or local governmental authorities with jurisdiction over land in the vicinity of an eligible area, acting with the consent of the Federal land management agency. The program is administered by the Federal Transit Administration (FTA) in cooperation with the Department of the Interior and the Department of Agriculture.

An interagency working group was established to guide the program. Members include the FTA, the Department of the Interior, the National Park Service (NPS), the U.S. Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM), and the U.S. Department of Agriculture's Forest Service. The working group jointly developed program structure, selection criteria, a solicitation and evaluation process for applications, and grant and reimbursable agreement funding mechanisms. In cooperation with inter-agency partners, FTA staff developed program requirements and an oversight program to ensure proper use of Federal funds. Finally, FTA staff, working with inter-agency partners, developed initial technical assistance, research, and planning activities to support the program.

In 2006, a total of 78 proposals were received totaling $40.5 million, approximately twice the amount available for projects, indicating high competition for funds. In 2007, proposals totaled $55.0 million, while in 2008 proposals totaled $55.2 million. *Exhibit 12-23* shows funding that has been made available for the program.

Exhibit 12-23

Alternative Transportation in Parks and Public Lands Program Funding

(Millions of Dollars)

	Funds Appropriated	Funds Authorized	Proposals Received
2006	21.8	22.0	40.5
2007	23.0	23.0	55.0
2008	25.0	25.0	55.2
2009	27.0	27.0	
Total	**96.8**	**97.0**	

** Appropriations not yet decided.*

As such, FTA's planning and policy staff worked closely with Federal land management agency representatives to develop a process that would select the most meritorious projects – those that were both strong transportation projects and best met the unique needs of Federal lands. An interagency technical review committee carefully evaluated the project proposals based on the considerations defined in the program's legislation. The main categories of evaluation criteria used were demonstration of need, visitor mobility and experience benefits, environmental benefits, and operational efficiency and financial sustainability. Then, as specified in the program's legislation, the Department of Interior determined the final selection of projects after consultation with and in cooperation with the Department of Transportation.

In 2006, the program funded 42 alternative transportation projects. In 2007, the program funded 46 projects. The alternative transportation projects selected for funding represent a diverse set of capital and planning projects across the country.

SAFETEA-LU allows a broad range of projects under this new program. The types of projects selected include purchase of buses for new transit service, replacement of old buses and trams, construction of a bicycle and pedestrian pathway, ferry dock replacement, intelligent transportation system components, and planning studies.

Fifty of the projects (totaling $32 million) funded in 2006 and 2007 are capital projects and 38 (totaling $7.5 million) are planning projects. As such, the bulk of the program dollars are used to fund capital investments with a smaller amount devoted to planning for future projects.

As predicted by the August 2001 Department of Transportation (DOT) – Department of Interior (DOI) study on alternative transportation needs in public lands, the National Park Service had the highest need for alternative transportation. In 2007, 70 percent of project funds were allocated towards projects serving National Parks, 15 percent are for projects serving National Forests, 11 percent are for projects serving Fish and Wildlife Refuges, and four percent are for projects serving Bureau of Land Management areas.

The awards include funding for both existing alternative transportation systems – through projects such as purchasing replacement buses – and funding for brand new systems. This enables the program to support the continued quality of existing alternative transportation systems such as those in Acadia National Park and Zion National Park, which were earlier pilot projects for DOT and DOI collaboration on alternative transportation. It also enables the program to fund brand new systems – such as a new trolley bus system to serve Gettysburg National Park to a new bicycle and pedestrian pathway that will allow visitors to access sites in the National Elk Refuge by bicycle and foot rather than by car.

The projects are located in 27 different States. There are projects in all major geographic regions – northeast, south, midwest, and west. The list includes projects in both rural and urban areas. Projects also vary by size from $50,000 planning studies to million dollar fleet purchases.

An example serves to illustrate the program's impact within just one of the Federal land management units receiving funding through the ATPPL program. The program is funding a new shuttle service from the San Joaquin Valley to the popular Sequoia National Park in California. The shuttle service will allow the thousands of visitors who pass through the valley on their way to the park to take public transportation rather than use private automobiles. Financial assistance through the program is also funding the lease of ten shuttle buses connecting key sites within Sequoia National Park – lodging, camping, food service facilities, popular day use trails, and features of the world-famous Giant Forest Sequoia grove. Shuttle ridership is estimated to reduce vehicular traffic by up to 925 cars daily, easing congestion in Level of Service D areas, and up to 47 percent within the popular Giant Forest/Generals Highway/Lodgepole area. An estimated 3,703 daily visitors (35% of the visitors) will use the Giant Forest shuttle, removing 50.3 tons of pollutants per day from the air in this air quality non-attainment area.

An additional 52 alternative transportation projects were awarded in 2008. A list of the projects funded is available on the program's website: www.fta.dot.gov/atppl.

Chapter 13

Freight Transportation

Freight Transportation

The economy of the United States depends on freight transportation to link businesses with suppliers and markets throughout the Nation and the world. Freight impacts nearly every American business and household in some way. American farms and mines use inexpensive transportation to compete against their counterparts around the world. Domestic manufacturers rely on remote sources of raw materials to produce goods. Wholesalers and retailers, meanwhile, depend on fast and reliable transportation to obtain inexpensive or specialized goods. In the expanding world of e-commerce, households and small businesses increasingly depend on freight transportation to deliver purchases directly to them. Service providers, public utilities, construction companies, and government agencies rely on freight transportation to obtain needed equipment and supplies from distant sources.

The U.S. economy requires effective freight transportation to operate at minimum cost and respond quickly to demands for goods. As the economy grows, over the next several decades, the demand for goods and the volume of freight transportation activity will only increase. Current volumes of freight are straining the capacity of the transportation system to deliver goods quickly, reliably, and cheaply. Anticipated growth of freight could overwhelm the system's ability to meet the needs of the American economy unless public agencies and private industry work together to improve the system's performance.

All statistics presented in this chapter are from the Freight Analysis Framework (FAF) release 2.2 unless otherwise noted. FAF estimates cover all freight flows to, from, and within the United States, excluding shipments through the United States between foreign countries. Shipments to and from Puerto Rico are counted with Latin America. See www.ops.fhwa.dot.gov/freight/freight_analysis/faf.

Statistics from the FAF and other sources are published in U.S. Department of Transportation, Federal Highway Administration, Freight Facts and Figures 2007, at www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/07factsfigures. Many statistics are based on the Economic Census and Commodity Flow Survey (CFS) both conducted once every 5 years. The most recently published data from the Economic Census and CFS are for 2002.

The CFS is conducted in partnership between the U.S. DOT and U.S. Department of Commerce, Bureau of Census. CFS is a component of the Economic Census that measures movement of goods in the United States and is a major input to the FAF.

The Large and Growing Demand for Freight Transportation

According to estimates based on the most recently available Economic Census, the transportation system in the United States moved an average of 53 million tons of freight worth $36 billion per day in 2002. This network served 109 million households, 24.8 million business establishments, and almost 88,000 units of government.[1] More than half the tonnage moved within local areas, and less than 10 percent was an import from, or export to, another country. Close to 60 percent of the weight and two-thirds of the value of shipments moved by truck, as shown in *Exhibit 13-1*. Shipments traveling by more than one mode of transportation accounted for only 1 percent of domestic tons, but 60 percent of the weight of exports and almost 70 percent of imports.

Over the next several decades, the volume of freight that will need to be moved will increase as the economy expands and, in some cases, at a much greater rate. Between 1999 and 2004, container traffic increased 44 percent while Gross Domestic Product increased 13 percent.[2] Over the next three decades, the U.S. economy is expected to grow almost 3 percent per year in gross domestic product (GDP), driven in part by a population increase from 300 million people today to almost 380 million in 2035.[3] The resulting tonnage of goods to be moved is forecast to increase 2.0 percent each year, almost doubling between now and 2035, as shown in *Exhibit 13-2*. International trade is expected to increase even faster.

Exhibit 13-1

Goods Movement by Mode, 2002

Mode	Tons (Millions)	Percent	Value (Billions of Dollars)	Percent
Truck	11,539	59.70%	8,856	67%
Rail	1,879	9.70%	382	2.90%
Water	701	3.60%	103	0.80%
Air	11	0.10%	771	5.80%
Intermodal	1,292	6.70%	1,967	14.90%
Pipeline	3,905	20.20%	1,149	8.70%
Total	**19,328**	**100%**	**13,228**	**100%**

Source: Freight Analysis Framework 2.2.

Note: In the Freight Analysis Framework, air includes shipments over 100 pounds moving by air or by air and truck. Intermodal includes all other shipments moving by more than one mode, ranging from bulk products moving by water and pipeline, to mixed cargo moving by truck and rail, to courier and postal shipments weighing less than 100 pounds moving by air and truck or by rail and truck. Pipeline includes a small quantity of shipments with unknown modes.

The value of commodities moved is greater than the gross domestic product (GDP) because many products counted once for GDP move multiple times during the year. For example, grain moved initially from farm to grain elevator, then from grain elevator to processing plant, and finally as cereal or bread from processing plant to the store is counted three times in freight statistics and only once in GDP as the food being purchased by households.

In addition to moving larger volumes of freight, the transportation system is transporting goods over greater distances. During the past decade, domestic tons increased by slightly more than 20 percent while ton-miles increased by almost 30 percent.[4] This growth in the weighted average distance of shipments may result from several factors. A growing number of consumers in the eastern United States are purchasing Asian products that are reshipped through the West Coast. Export of agricultural goods is growing. Midwestern power plants are shifting from local sources of coal, to coal that is extracted from the Powder River Basin in Montana and Wyoming.

Exhibit 13-2

Goods Movement by Mode, 2002 and 2035

Mode	2002 (Millions of Tons)	Percent	2035 (Millions of Tons)	Percent	Percent Change, 2002/ 2035
Domestic	17,670	91.4%	33,668	90.6%	90.5%
Imports Plus Exports	1,657	8.6%	3,509	9.4%	111.8%
Total	**19,326**	**100%**	**37,178**	**100%**	**92.4%**

Source: Freight Analysis Framework 2.2.

Demands on the Transportation System

Much of the Nation's freight transportation infrastructure was developed before 1960 to provide national connectivity, move goods from farm to market and from fort to port, and serve industrial and population centers concentrated in the Northeast and the Midwest. Since 1960, however, there have been fundamental changes in the American economy. Population and manufacturing have grown in the South and West Coast. There has been a restructuring of the economy as heavy industries such as steel have given away to services such as health care. International trade has placed new demands on the freight system; ports, airports, and border crossings handle dramatically increasing volumes of traffic. Railroads and steamship companies accommodate enormous numbers of containers, a technological novelty five decades ago. Trucks serve new inland distribution centers beyond the urban fringe and air carriers deliver parcels between any location in the country overnight. The freight system must serve an economy that is increasingly organized around just-in-time delivery.

Pressures that existing and anticipated volumes of freight place on the transportation system vary by the type of goods being moved. Routes, facilities, volumes, and service demands differ between higher-valued goods moving at high velocities and lower-valued goods moving in bulk shipments, as shown in *Exhibit 13-3*.

Trucking handles a surprising share of lower-valued bulk tonnage. This share includes activities such as movement of agricultural products from farms, local distribution of gasoline, and pickup of municipal solid waste. The length of haul is typically very short.

Q&A

What is the National Network?

The National Network was authorized by the Surface Transportation Assistance Act of 1982 (P.L. 97-424) and specified in the Code of Federal Regulations (23 CFR 658) to require States to allow conventional combinations on "the Interstate System and those portions of the Federal-aid Primary System… serving to link principal cities and densely developed portions of the States…[on] high volume route[s] utilized extensively by large vehicles for interstate commerce…[which do] not have any unusual characteristics causing current or anticipated safety problems." Conventional combinations are tractors with one semitrailer up to 48 feet in length or with one 28-foot semitrailer and one 28-foot trailer, which can be up to 102 inches wide.

Although the National Network has significant overlap with the National Highway System, they differ in several respects. The National Network provides geographic access for interstate commerce through 210,000 miles of highways, while the National Highway System connects "major population centers, international border crossings, ports, airports, public transportation facilities, other intermodal transportation facilities and other major travel destinations" through a network that cannot exceed 178,250 miles in length (the current NHS mileage is 162,684). The National Network serves trucking on substantial miles of highway beyond the National Highway System, while parts of the National Highway System are designated solely for passenger travel and may exclude trucks (even on the Interstate System). The National Network was designated more than a decade before the National Highway System, which was created by the National Highway System Designation Act of 1995 (P.L. 104-59). The National Network supports interstate commerce through regulation, while the National Highway System supports interstate commerce by focusing Federal investments.

The National Network has not been significantly updated in more than two decades. It changes only if segments are added to the Interstate System or if States petition to have a segment beyond the Interstate System added or deleted. Petitions for modifications have not been received in years, even though the geography of interstate commerce has changed significantly with the growth of smaller places into principal cities and the emergence of new, densely developed areas. Consistency between the National Network and freight-related portions of the more recent National Highway System is not required.

The definition of conventional combinations is also unchanged, even though 48 feet is no longer the maximum length of a single trailer in the majority of States. Single 53-foot trailers are allowed in 25 States without special permits, and in an additional three states subject to limits on the distance between the trailer kingpin and the rearmost axle.

In addition to hauling bulk commodities, trucking moves our Nation's high-value, high-velocity goods. The value of goods that will be moved is forecast to grow in constant dollars by more than 190 percent between 2002 and 2035, nearly twice the growth rate forecast for tonnage. As the value of goods to be moved grows, the cost of holding inventory in warehouses or in transit also increases. Many industries have shifted to just-in-time delivery systems to minimize inventory costs and maximize responsiveness to rapidly changing markets. Just-in-time systems depend on fast and reliable transportation. According to one estimate, companies judged to be best-in-class for supply chain management have 40 percent higher profitability and 25 percent higher sales growth than median companies.[5]

Just-in-time delivery systems contribute to an increase in transportation activity per ton-mile and thus capacity requirements per ton. For many products, just-in-time logistical systems require greater numbers of vehicles hauling smaller payloads to meet market demands. This shift—more vehicles carrying less per vehicle—was a factor in the 71 percent growth in the number of trucks used in for-hire transportation and 115 percent growth in their vehicle miles of travel between 1998 and 2000.[6]

Because of this growth, trucks traffic is increasing on American highways. Trucks were 25 percent of the average daily traffic on almost 31,000 miles of the National Highway System in 2002, and are forecast to be on 37,000 miles in 2035. Freight-hauling vehicles are usually more than twice as long as passenger vehicles, so trucks become a dominant part of the traffic stream when they are every fourth vehicle on the road.

Long distance freight movements by truck are concentrated on the Interstate System (*Exhibit 13-4*). Approximately 25,500 miles of the Interstate System and 600 miles of other portions of the National Highway System serve

Exhibit 13-3

The Spectrum of Freight Moved in 2002

	High-Value, High-Velocity Goods	Bulk Goods
Top 5 Commodity Classes		
	Machinery	Natural gas
	Electronics	Gravel
	Mixed freight	Cereal grains
	Motorized vehicles	Crude petroleum
	Textiles and leather	Coal
Share of Total Tons		
	30%	70%
Share of Total Value		
	85%	15%
Key Performance Variables		
	Reliability	Reliability
	Speed	Cost
	Flexibility	
Share of Tons by Domestic Mode		
	88% truck	51% truck
	7% rail	12% rail
	5% all other	32% pipeline
		5% water
		<1% air and intermodal
Share of Value by Domestic Mode		
	83% truck	36% truck
	10% intermodal	5% rail
	3% rail	53% pipeline
	4% all other	4% water
		2% air and intermodal

Source: Freight Analysis Framework 2.2.

Exhibit 13-4

Freight Share of Vehicle Miles of Travel by Highway System

	Interstate Highways	Balance of National Highway System	Other Highways
All Vehicles	35%	30%	35%
All Trucks	49%	26%	25%
Freight-Hauling Trucks Serving Places at Least 50 Miles Apart	75%	20%	6%

Source: Freight Analysis Framework 2.2.

Note: Numbers do not add to 100 due to rounding.

corridors that carry at least 50 million tons of cargo by truck or by trailer-on-flatcar and container-on-flatcar services. Many locations of economic activity depend on segments on the 210,000-mile National Network to reach the major highway freight corridors.

Freight and Congestion

Congestion affects economic productivity when American businesses require more operators and equipment to deliver goods when movement takes longer, more inventory when deliveries become unreliable, and more distribution centers to reach markets quickly through a slow transportation network. Businesses and households are both affected by sluggish traffic on the ground and in the air, reducing the number of workers and places to work and consume within easy reach of any location. The growth in freight is a major contributor to congestion in urban areas and on intercity routes, and congestion in turn affects timeliness and reliability of freight transportation. Long distance freight movements are often a significant contributor to local congestion, and local congestion typically impedes both local and distant economic activity.

Highway Congestion

Trucks must contend with congested urban areas at some point during most intercity trips. The largest highway freight bottlenecks identified in a study for the Federal Highway Administration (FHWA) are intersections in large cities, where personal vehicles and trucks both clog the road.[7] Recurring peak-period congestion caused slowing on over 10,600 miles of the National Highway System in 2002, and stop-and-go conditions on an additional 6,700 miles.[8] Most of the affected mileage was in major metropolitan areas.

Congestion is forecast to spread from the larger urban areas and a few intercity routes to large stretches of intercity highways in urban and rural areas. Without operational improvements or additional capacity between now and 2035, recurring peak-period congestion is forecast to cause slowing on 20,000 miles of the National Highway System and stop-and-go conditions on an additional 45,000 miles.

Truck congestion occurs throughout the Nation's highways, but some local bottlenecks account for a substantial share of the total disruption. The top 10 highway-interchange bottlenecks cause an average of 1.5 million annual truck hours of delay each, compared to less than 250,000 annual hours of truck delay for other truck bottlenecks.[9]

Trucks are also a source of congestion when space and time for pickups and deliveries are limited. One estimate of urban congestion attributes 947,000 hours of vehicle delay to delivery trucks parked curbside in dense urban areas where office buildings and stores lack off-street loading facilities.[10] Limitations on delivery times place significant demands on highway rest areas as large numbers of trucks park outside major metropolitan areas each night waiting for their destination to open and accept their shipments.[11]

The aforementioned estimates of delay are based on recurring, predictable congestion, which is only part of the problem. Nonrecurring delay for often-unpredictable sources of temporary capacity loss such as incidents, weather, and work zones for maintenance and reconstruction may cause more delay than recurring congestion.[12]

Until recently, estimates of highway delay have been based on comparisons of traffic volumes to physical highway capacity. To supplement these estimates with direct measures, FHWA and the American Transportation Research Institute are working together to calculate average truck speeds and travel time reliability using automatic vehicle location and mapping technologies. Data are being collected for 25 of the most heavily traveled Interstate Highways and at major border crossings.[13] These data will identify congested locations from all sources of delay, including both recurring and non-recurring congestion.

Railroad Congestion

After decades of stagnant demand and a reduction of trackage by about 50 percent, Class 1 (large interregional) freight railroads are experiencing significant growth in tonnage to be moved.[14] Trailer-on flatcar and container-on-flatcar service, once a small market, is now a major source of traffic, with high-speed intermodal trains vying for space on the network with slower trains carrying bulk commodities. Seasonal surges in freight demand and disruptions from incidents and maintenance activities add to congestion as volumes reach capacity on the reduced mainline railroad network. Operational improvements mitigated the effects, at least in the short run, as the average speed of U.S. freight trains has improved from a range of 18 to 24 miles per hour at the beginning of 2006 to a range of 20 to 25 miles per hour in October 2006 depending on the railroad. Terminal dwell time for freight trains improved from a range of 28 to 35 hours down to 20 to 25 hours during the same period.[15] Additionally, Federal investment in the Alameda Corridor in Southern California improved freight flows through a local bottleneck to destinations well beyond the metropolitan area and the State. The project reduced congestion on the rail connections between the ports of Los Angeles and Long Beach and the rest of the Nation, as well as congestion on streets that formerly crossed the railroad at grade.

Congestion on the mainline railroad network is forecast to spread significantly. Using volume-to-capacity comparisons similar to highway calculations, the Association of American Railroads reports that rail lines with unstable flows and service break-down conditions will increase from 108 miles today to almost 16,000 miles (30 percent of the network) in 2035 if current capacity is not increased.[16] Rail routes with moderate to very limited capacity to accommodate maintenance without serious service disruptions and recover quickly from incidents will increase from 6,413 miles today to over 12,000 miles in 2035, affecting 25 percent of the network.[17]

The picture for short-line and regional railroads is far less clear. Very few statistics are collected on this portion of the industry, which included 34 regional railroads and 529 local railroads in 2001.[18] Some of these railroads provide links between port facilities and the Class 1 railroads, while others serve small communities and shippers in rural areas.

Waterway Congestion

Deep draft ports experience congestion as room for increasing volumes of import and export cargo is stagnated by factors such as waterside residential development and environmental and community concerns. Congestion also occurs when vessels arrive at the same time rather than spread through the week. Most ports must look to operational improvements to increase capacity and reduce congestion, such as reducing the amount of demurrage allowed for containers on the terminals, instituting chassis pools, and moving to stack operations.

Even when ports can berth and unload a ship quickly, the increasing size of container ships is moving congestion from peaks in demand to access roads and railroads. The number of the world's post-Panamax vessels, container ships that are too large to fit the Panama Canal, increased from 331 in 2001 to 561 in 2004, with another 426 on order.[19]

On the inland waterways, aging infrastructure and locks (some of which are a century old) are a continuous bottleneck: 39 percent of 539,000 passages of commercial vessels through Federal and State locks experienced delay in 2006.[20] Average delay for tows was 1 hour 19 minutes, and average processing time was almost 13 hours.[21] Inland waterways are especially susceptible to weather, sometimes closed by flooding, sometimes by droughts, and sometimes by ice or other obstructions related to storms.

The Economic Costs of Freight Transportation

Freight transportation has become cheaper for a given level of service over the past quarter century, contributing significantly to enhanced economic productivity and growth. Several forces, however, are conspiring to increase costs in the years ahead. These factors include market forces affecting railroads, environmental forces affecting waterways and fuel prices affecting all modes. These and other forces will increase the cost of moving bulk goods, while congestion and other factors will affect the long and often vulnerable supply chains of high-value, high-velocity commodities. If these forces are not mitigated, the increased cost of moving freight will be felt throughout the economy, affecting businesses and households alike.

Congestion results in enormous costs to shippers, carriers, and the economy. The 2,110 freight bottlenecks on highways throughout the United States cause more than 243 million hours of delay to truckers annually.[22] At a delay cost of $26.70 per hour, the conservative value used by FHWA's Highway Economic Requirements System model for estimating national highway costs and benefits, these bottlenecks cost truckers about $6.5 billion per year. Other examples illustrate the cost of gridlock on the Nation's individual employers.

When shipping delays require Nike to carry an extra 7 to 14 days of inventory, the company must spend an additional $4 million per week.[23] Just one day of delay in American President Line's eastbound trans-Pacific service requires a carrier to increase its use of containers and chassis by 1,300, adding $4 million in costs per year.[24] A week-long disruption to container movements through the Ports of Los Angeles and Long Beach could cost the national economy between $65 million and $150 million per day.[25]

Congestion costs are compounded by continuing increases in operating costs per mile and per hour. The cost of highway-use diesel fuel increased 126 percent over the decade ending in 2006.[26] Future labor costs, meanwhile, are projected to increase at a faster rate than in the past thanks to the growing shortage of truck drivers.[27] To attract and retain more drivers and adjust to new safety regulations, carriers may reduce the number of hours drivers are on the road, which will in turn increase operating costs. Railroads are also facing labor recruitment challenges.[28] Beyond fuel and labor, truck operating costs are also affected by repairs to equipment damage caused by deteriorated infrastructure; taxes and tolls to pay for repair of the deteriorating infrastructure; insurance; and additional equipment required to meet security, safety, and environmental requirements.

Increased costs to carriers are eventually reflected in increased prices paid for freight transportation. Over the 3 years ending in 2006, prices increased 13 percent for truck transportation, 27 percent for rail transportation, 8 percent for scheduled air freight, 11 percent for water transportation, 9 percent for port and harbor operations, 5 percent for marine cargo handling, 22 percent for pipeline transportation of crude petroleum, and 8 percent for pipeline transportation of refined petroleum products.[29]

When the entire economy is taken into account, transportation services contribute more than 5 percent to the production of GDP.[30] Over half this contribution is for-hire and in-house trucking. The importance of transportation varies by sector of the economy. A $1 increase in the final demand for agricultural products, for instance, requires 14.2 cents in transportation services, compared with 9.1 cents for manufactured goods and about 8 cents for mining products. An increase in transportation costs is more critical to lower margin bulk commodities than to the high-velocity, high-value commodities that have higher margins. In either case, an increase in the cost of transportation will ripple through all these industries to affect not only the cost of goods from all economic sectors consumed by the Nation, but those markets that may remain open for the goods.

The Freight Challenge

How can the Nation cheaply and reliably move the increasing volume of goods needed by U.S. businesses and households on an increasingly constrained infrastructure without safety concerns and environmental degradation? This challenge is enormous. Efficiency gains from economic deregulation have been largely achieved and absorbed by the system. Opportunities for operational improvements are still available and must be used; but, new physical capacity is limited by available financing, competition with other needs and uses, and environmental concerns. Traditional strategies aimed at passenger travel may not apply.

The freight challenge is different from other dimensions of the Nation's transportation system:

- While the majority of passenger travel is between local origins and destinations, half of freight involves moving long distances through localities, responding to distant economic demands, and often creating local problems without local benefit.
- Freight movements fluctuate more quickly and in greater relative amounts than passenger travel. While both passenger travel and freight respond to long-term demographic change, freight responds far more than passenger travel to short-term economic fluctuations. Fluctuations can be national or local. The addition or loss of a major business can dramatically change the level of freight activity in a locality.
- Freight movement is heterogeneous compared with passenger travel. Patterns of passenger travel tend to be very similar across metropolitan areas and among large economic and social strata. Freight demands of farms, steel mills, and clothing boutiques differ radically. Solutions aimed at average conditions are less likely to work because the freight demands of each economic sector vary widely.
- Improvements targeted at freight demand may be needed should freight's share of transportation system usage increase. Improvements targeted at general traffic or passenger travel are not certain to aid the flow of freight as an incidental by-product.

Local public action is difficult because freight traffic and the benefits of serving that traffic rarely stay within a single political jurisdiction. Two-thirds of the value and almost half the tonnage of freight move across a State or international boundary. Although metropolitan planning organizations (MPOs) were established by Federal legislation four decades ago to coordinate transportation planning and investment across jurisdictional lines, freight corridors extend well beyond even the largest metropolitan regions and usually involve several States. Creative and ad hoc arrangements are often required. These may involve pooled fund studies and multi-State coalitions that plan and invest in freight corridors that span regions and even the continent. Institutional arrangements to coordinate this type of activity are still relatively few.

Truck routes in urban areas are among the most localized sources of conflict between freight transportation and the surrounding communities.[31] Typically the purview of local officials, restrictions on truck routes can have significant effects on the local economy and its connections with domestic and foreign trading partners. While access for interstate commerce is ensured by Federal requirements to allow conventional combinations on the National Network, public demands for restrictions on trucks may increase as neighborhoods near ports and industrial areas evolve and as trucks become a larger share of the traffic on an increasing number of highways.

Beyond the challenges of intergovernmental coordination, freight transportation raises additional issues involving the relationships between the public and private sectors. Virtually all carriers and many freight facilities are privately owned: \$925 billion in equipment plus \$515 billion in private structures, compared with \$429 billion in transportation equipment plus \$2.1 trillion in highways owned by public agencies.[32] Freight railroad facilities and services are almost entirely private. Trucks in the private sector operate over public highways, air cargo services in the private sector operate in public airways and mostly public airports, and ships in the private sector operate over public waterways and both public and private port facilities. Pipelines are mostly in the private sector, though significantly controlled by public regulation. In the public sector, virtually all truck routes are owned by State or local governments, airports and harbors are typically owned by public authorities, air and water navigation is mostly Federal, and safety is regulated by all levels of government. As a consequence of this mixed ownership and management, most solutions to freight problems require joint action by the public and private sectors. Joint efforts by public agencies and private firms traditionally have been very limited, inhibiting effective measures to improve the performance and minimize the public costs of the freight transportation system.[33]

A Framework for Responding to the Freight Challenge

Freight has moved to the forefront of many policy debates and plans concerning transportation in recent years. Stakeholders increasingly express concern that piecemeal improvements to the freight transportation system are not enough. The freight challenge requires a wide range of activities by the private sector and all levels of government, organized formally or informally to pursue common objectives.

To establish a better understanding of the freight challenge and activities by the private sector and all levels of government, the Transportation Research Board convened individuals from transportation providers, shippers, State agencies, port authorities, and the U.S. Department of Transportation (DOT). These organizations formed a Freight Transportation Industry Roundtable. Members of the roundtable developed an initial Framework for a National Freight Policy to identify freight activities and focus those activities toward common objectives.

The Framework for a National Freight Policy continues to evolve as a joint effort of DOT and its partners in the public and private sectors. These groups are completing an inventory of existing and proposed strategies, tactics, and activities that can improve freight transportation. These are shown in *Exhibit 13-5.* The framework is national rather than Federal, reflecting the critical roles of the Federal government, States, localities, and the private sector. Each strategy has at least one tactic; each tactic has at least one activity; and each activity has "owners" responsible for articulating milestones and consequences for moving the activity forward. The Framework is structured to identify examples of good practice, actions that would benefit from increased collaboration, conflicts needing resolution, and issues needing more attention. It represents a common ground for discussion rather than a formal industry consensus or official views of DOT.

Freight Aspects of the Federal-Aid Highway Program

Freight emerged as a significant component of the Federal-Aid Highway Program in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: Legacy for Users (SAFETEA-LU).[34] SAFETEA-LU authorized $4.6 billion for the freight-oriented infrastructure investments in *Exhibit 13-6.* SAFETEA-LU also, expanded eligibility for financing freight projects under the Transportation Infrastructure Finance and Innovation Act (TIFIA) Program, extended the State Infrastructure Bank (SIB) Program, and modified the tax code to encourage up to $15 billion in investment in freight facilities through private activity bonds.

Beyond concrete and steel, SAFETEA-LU funds freight planning capacity building,[35] and supports freight analysis through the surface transportation congestion relief solutions research initiative.[36] Many State DOTs have established freight offices or designated freight coordinators and several have initiated statewide freight plans. Washington State goes beyond planning to include financing freight projects though its

Exhibit 13-5

Framework for a National Freight Policy

Vision: The U.S. freight transportation system will ensure the efficient, reliable, safe, and secure movement of goods and support the Nation's economic growth while improving environmental quality.

Objectives:	Strategies:
Improve the operations of the existing freight transportation system.	Improve management and operations of existing facilities. Maintain and preserve existing infrastructure. Explore opportunities for privatization. Ensure the availability of a skilled labor pool sufficient to meet transportation needs.
Add physical capacity to the freight transportation system in places where investment makes economic sense.	Facilitate regionally based solutions for freight gateways and projects of national or regional significance. Utilize and promote new/expanded financing tools to incentivize private sector investment in transportation projects. Explore opportunities for public-private partnerships and/or privatization.
Better align all costs and benefits between users and owners of the freight system.	Utilize public sector pricing tools. Utilize private sector pricing tools.
Reduce or remove statutory, regulatory, and institutional barriers to improved freight transportation performance.	Identify/inventory potential statutory, regulatory, and institutional changes. Provide pilot projects with temporary relief from unnecessarily-restrictive regulations and/or processes. Encourage regionally based intermodal gateway responses. Actively engage and support the establishment of international standards to facilitate freight movement.
Proactively identify and address emerging transportation needs.	Develop data and analytical capacity for making future investment decisions. Conduct freight-related research and development. Maintain dialogue between and among public and private sector freight stakeholders. Make public sector institutional arrangements more responsive.
Maximize the safety and security of the freight transportation system.	Ensure a balanced approach to security and efficiency in all freight initiatives. Preserve redundant capacity for security and reliability. Manage public exposure to hazardous materials.
Mitigate and better manage the environmental, health, energy, and community impacts of freight transportation.	Pursue pollution-reduction technologies and operations. Pursue investments to mitigate environmental, health, and community transportation impacts. Promote adaptive reuse of brownfields and dredge material. Prevent introduction of or control invasive species. Pursue energy-conservation strategies and alternative fuels in freight operations.

Source: U.S. Department of Transportation Working Group on Freight Transportation.

Freight Mobility Strategic Investment Board.[37] The Board was established to create a comprehensive and coordinated State program to facilitate freight movement and to find solutions that lessen the impact of freight on local communities. The Board has provided funding for freight mobility projects and technical assistance to eliminate chokepoints and grade crossings so that freight can move smoothly and communities experience fewer disruptions in local traffic. The Board is represented by high-level industry and regional stakeholders who direct the agency's activities.

Exhibit 13-6

Direct Expenditures for Freight Infrastructure in SAFETEA-LU

Projects of National/Regional Significance	$1.779 billion over 5 years
National Corridor Infrastructure Improvement	$1.948 billion over 5 years
Coordinated Border Infrastructure Program	$833 million over 5 years
Freight Intermodal Distribution Pilot Grant Program	$30 million over 5 years
Truck Parking	$25 million over 4 years
Total	**$4.615 billion**

Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations.

Many States realize that solutions to their freight problems require actions well beyond the State's borders, and have joined in corridor coalitions to develop and pursue those solutions. At least a dozen major corridor coalitions exist today.[38] Coalitions have sponsored research to better understand freight problems throughout their corridor, and several have developed specific plans through the Corridors of the Future Program. One group, the I-95 Corridor Coalition, is developing a Freight Academy to provide continued education to the region's freight transportation professionals.[39]

The MPOs in larger cities are undertaking freight plans and programs and are engaging the private sector stakeholders through Advisory Committees. For example, the Atlanta Regional Commission MPO and Georgia Department of Transportation have jointly undertaken the development of a Regional Freight Mobility Plan to address freight and goods movement needs and challenges in the region.[40] Similar efforts are underway in metropolitan areas such as Philadelphia, Chicago, and Los Angeles.

One of the more notable local initiatives is the PierPASS OffPeak program, created by the marine terminal operators at the Ports of Los Angeles and Long Beach to alleviate truck traffic congestion and improve air quality in the region.[41] Trucks with loaded containers entering or exiting marine terminals during peak hours are charged a Traffic Mitigation Fee, which encourages cargo owners and their carriers to move cargo at night and on weekends and defrays the additional costs of keeping the terminal open longer hours. Thus, congestion is reduced during peak daytime periods at port gates and on major highways around the ports, and air quality is improved.

Carriers, shippers, terminal operators, and other private sector players in the freight transportation industry deal with the freight challenge on a daily basis, either through the actions of individual businesses, collective action through associations, or cooperative ventures with public agencies. The Intermodal Freight Technology Working Group (IFTWG) is a an example of a public-private partnership focused on the identification and evaluation of technology-based options for improving the efficiency, safety, and security of intermodal freight movement. The IFTWG engages in efforts to marry industry and government priorities in a way that leverages collective experience and shared investment.[42] The IFTWG worked with FHWA to establish the Universal Electronic Freight Manifest (EFM) initiative, which provides all supply chain partners with timely access to shipment information to improve the operational efficiency, productivity, and security of the transportation system.[43]

Conclusion

To sustain the nation's economy in the face of global competition, collective action of all stakeholders is needed to maintain and enhance the freight transportation system within environmental and other constraints. Key actions could be initiated through reauthorization of the Federal-aid highway program. Among likely questions to be considered:

- What kinds of investment programs, financial incentives, changes in eligibility, and performance requirements should be targeted in nationally significant freight corridors?
- Should the National Network be updated or changed to provide geographic access by conventional combination trucks to all locations of economic activity?
- Should targeted investments and/or minimum condition and performance standards be established for freight intermodal connectors?
- Should trucks be given special consideration in air quality requirements and greenhouse gas reduction strategies?
- Should new finance mechanisms be established for freight projects?
- Are new institutional arrangements needed to plan, design, finance, build, and operate interrelated projects in a freight corridor that spans several states?
- How do we maintain the flow of information needed to plan and hold accountable improvements in the freight transportation system?

Endnotes

[1] The number of households is from table 57 (07s0057.xls) of the 2007 *Statistical Abstract of the United States* at www.census.gov/compendia/statab. The number of business establishments combines establishments with payrolls from table 738 (07s0738.xls) and nonemployer establishments from table 737 (07s0737.xls). Units of government are from table 415 (07s0415.xls).

[2] Containers in 20-foot equivalent units (TEUs) are from exhibit 7 in *Containership Market Indicators*, Office of Statistical and Economic Analysis, Maritime Administration, U.S. Department of Transportation, August 2005, at www.marad.dot.gov/marad_statistics. Gross domestic product in constant dollars is from the *Economic Report of the President* at www.gpoaccess.gov/eop/2008/B2.xls.

[3] "Forecasts of Economic Variables that Impact Passenger and Freight Demand and the Implication of Alternative Economic Assumptions on Modal Travel Demand." 2007. Battelle for the National Surface Transportation Policy and Revenue Study Commission, Briefing Paper 4B-06, p. 1, at www.transportationfortomorrow.org/final_report/pdf/volume_3/technical_issue_papers/paper4b_06.pdf. And "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin." 2004. U.S. Census, March, Detail file, at www.census.gov/ipc/www/usinterimproj.

Endnotes, continued

[4] Freight in America: A New National Picture. 2006. Bureau of Transportation Statistics, U.S. Department of Transportation, table 10, page 24, January.

[5] Hermans, Mark. 2006. "Supply Chain Benchmarking." Presentation to the TRB Freight Roundtable, October 23, at www.trb.org/conferences/FDM/Hermans.pdf.

[6] "Vehicle Inventory and Use Survey, 2002." U.S. Bureau of the Census, United States Summary, table 2A, and "Truck Inventory and Use Survey, 1992." U.S. Bureau of the Census, United States Summary, table 2A.

[7] U.S. Department of Transportation, Federal Highway Administration, *An Initial Assessment of Freight Bottlenecks on Highways*, prepared by Cambridge Systematics, October 2005, at www.fhwa.dot.gov/policy/otps/bottlenecks.

[8] U.S. Department of Transportation, Federal Highway Administration, *Freight Facts and Figures 2008*, p. 30.

[9] U.S. Department of Transportation, Federal Highway Administration, *An Initial Assessment of Freight Bottlenecks on Highways*, *op. cit.*

[10] Oak Ridge National Laboratory, *Temporary Losses of Highway Capacity and Impacts on Performance: Phase 2*, ORNL/TM-2004/209, table 36, at www-cta.ornl.gov/cta/Publications/tlc/tlc2_title.shtml.

[11] Truck parking facility demand is analyzed in FHWA, *Study of Adequacy of Commercial Truck Parking Facilities*, www.tfhrc.gov/safety/pubs/01158/.

[12] Incidents, work zones, and weather cause between 50 and 61 percent of all highway delay according to composite estimates from national studies in Oak Ridge National Laboratory, *op. cit.*, p. 101.

[13] Results of the freight performance measurement initiative are available at www.ops.fhwa.dot.gov/freight/freight_analysis/perform_meas.htm.

[14] Rail mileage between 1960 and 2000 in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 2000*, table 1-1, at http://www.bts.gov/publications/national_transportation_statistics/html/table_01_01.html.

[15] Class 1 railroad average speed and dwell time data from www.railroadpm.org.

[16] Association of American Railroads, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared by Cambridge Systematics, Inc., September 2007, p. 4-10, at http://www.aar.org/~/media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx.

[17] Association of American Railroads, *op. cit.*, p. 5-6.

[18] Annual Data Profile of the American Short Line and Regional Railroad Association, published by the Upper Great Plains Transportation Institute at shortline.ugpti.org/profiles/downloads.Profile2001.pdf.

[19] U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Analysis, "Containership Market Indicators," August 2005, exhibit 9.

Endnotes, continued

[20] U.S. Army Corps of Engineers, Lock Performance Monitoring System, www.iwr.usace.army.mil/ndc/lpms/lock2006web.HTM.

[21] *Ibid*.

[22] *An Initial Assessment of Freight Bottlenecks on Highways.* 2005. Federal Highway Administration, U.S. Department of Transportation, prepared by Cambridge Systematics, October, p. ES-2, at www.fhwa.dot.gov/policy/otps/bottlenecks/bottlenecks.pdf.

[23] Isbell, John. 2006. "Maritime and Infrastructure Impact on Nike's Inbound Delivery Supply Chain." Presentation to the TRB Freight Roundtable, October 23, at www.trb.org/conferences/FDM/Isbell.pdf.

[24] Bowe, John. 2006. "The High Cost of Congestion." Presentation to the TRB Freight Roundtable, October 24, www.trb.org/conferences/FDM/Bowe.pdf.

[25] *The Economic Costs of Disruptions in Container Shipments.* 2006. U.S. Congressional Budget Office, March 29, at www.cbo.gov/ftpdocs/71xx/doc7106/03-29-Container_Shipments.pdf.

[26] "Table 5.24: Retail Motor Gasoline and On-Highway Diesel Fuel Prices, 1946-2006." Energy Information Administration, U.S. Department of Transportation, at www.eia.doe.gov/emeu/aer/txt/ptb0524.html.

[27] *The U.S. Truck Driver Shortage: Analysis and Forecasts.* 2005. Global Insight, prepared for the American Trucking Associations, May, at www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/ATADriverShortageStudy05_R25-c-d_0Z5RDZ-i34K-pR.pdf.

[28] Reinach, Stephen, and Alex Viale. 2007. *An Examination of Employee Recruitment and Retention in the U.S. Railroad Industry*. Prepared for the Federal Railroad Administration, DOT/FRA/RRP-07/01, August, at www.fra.dot.gov/us/content/1891.

[29] Producer Price Index Data. Bureau of Labor Statistics, U.S. Department of Labor, extracted October 17, 2007, from www.bls.gov/ppi.

[30] *The Economic Importance of Transportation Services: Highlights of the Transportation Satellite Accounts.* 1998. Bureau of Transportation Statistics, U.S. Department of Transportation, BTS/98-TS/4R, April, at www.bts.gov/publications/transportation_statistics_newsletter/issue_04.

[31] Anne Strauss-Wieder, *Integrating Freight Facilities and Operations with Community Goals*, NCHRP Synthesis 320, Transportation Research Board, 2003, at onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_320.pdf.

[32] Fixed assets are for 2005 and include both passenger and freight transportation. See Bureau of Economic Analysis at http://www.bea.gov/national/FA2004/index.asp.

[33] Coordination issues are discussed on Web sites throughout the U.S. Department of Transportation at www.dot.gov/freight.

[34] SAFETEA-LU, Public Law (PL) 109-059.

[35] Section 5204 of SAFETEA-LU, PL 109-059.

Endnotes, continued

[36] Section 5502 of SAFETEA-LU, PL 109-059.

[37] See www.fmsib.wa.gov.

[38] One list of major corridor coalitions is published at http://ops.fhwa.dot.gov/freight/corridor_coal.htm.

[39] See www.freightacademy.org.

[40] See http://www.atlantaregional.com/documents/tp_ARFMP_final_report_2-6-08.pdf.

[41] See www.pierpass.org.

[42] See http://www.intermodal.org/iftwg_files/index.shtml.

[43] See http://ops.fhwa.dot.gov/freight/intermodal/efm_program_plan.htm.

Chapter 14

Congestion Reduction Strategies

Congestion Reduction Strategies

All road users have experienced traffic congestion, some more than others. Most probably have an intuitive sense of what congestion is and what causes it. Americans know it makes a difference in their lives because it makes them wait in their cars, losing the opportunity to do other things. Congestion also influences where people choose to live and where they work, often limiting the range of feasible choices to households and workers.

The business community also understands congestion. Retailers, manufacturers, and shippers have to adjust their operating practices to compensate for time wasted in traffic. Because of congestion, transporting goods and services to their destinations takes longer.

Allowing for unexpected delays makes congestion even more problematic. Individuals must allow more time to arrive at important appointments. When calculating the time to travel to a given location, they must add a "buffer factor." Often, this means that they arrive early and, once again, must wait. Unreliable travel times can also affect businesses, forcing them to carry larger inventories to guard against delays in deliveries.

Chapter 4 describes the dimensions and magnitude of the congestion problem in U.S. cities, which has grown over time in both its depth and reach across the country. Chapter 13 includes a discussion of the impact that congestion has on freight movement. This chapter describes several strategies and approaches that can be used to reduce congestion on our Nation's highways.

Causes of Congestion

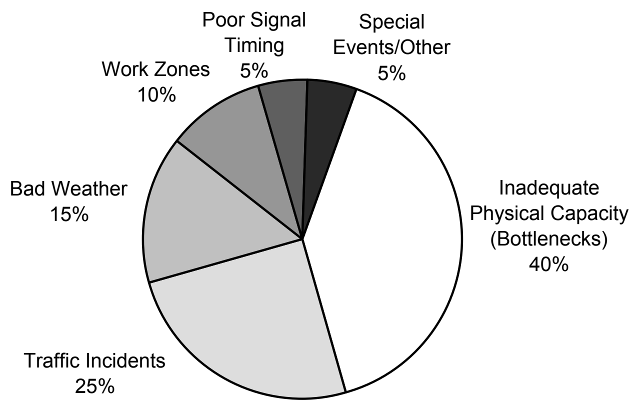
The root causes of congestion have long been understood, and there is now broad consensus that congestion generally reflects a fundamental imbalance of supply and demand. During hours of peak usage of the transportation facilities most desirable to motorists, the supply of roadway capacity is insufficient to meet the demand for those facilities. Economists have long understood that such an imbalance stems from inefficient pricing, where the true costs of usage are not reflected in prices paid by the users. For example, travelers are not generally charged for the impact their trip will have on others using the same facility (e.g., increased levels of congestion) or on other members of society (e.g., increased air pollution). In fact, in this country, access to highway travel, for the most part, is rationed by traveler delay.

The imbalance of supply and demand leading to congestion is also impacted by the absolute volume of traffic (e.g., demand) on a given facility relative to its physical capacity (e.g., supply). Looking at traffic congestion from a demand perspective means considering how many vehicles compete for space on a particular facility at a given time. The demand for a facility is a function of individual decisions as to when, where, how, and even whether highway travel will take place.

On the supply side, congestion is primarily a function of the physical characteristics of the facility and events that limit the availability of this capacity. Congestion driven by supply-side considerations is characterized as either "recurring" or "nonrecurring." This distinction is useful in helping transportation professionals devise strategies that will either mitigate or reduce congestion. Recurring congestion happens in roughly the same time and place on the same days of the week. It results when physical capacity is simply not adequate to accommodate demand during peak periods. On the other hand, nonrecurring congestion is caused by events such as work zones, traffic incidents, and bad weather. Obviously, when these nonrecurring events occur on an already congested facility, the impacts are magnified. *Exhibit 14-1* shows the factors that cause on-the-road congestion.

Exhibit 14-1

Sources of Congestion



Source: Federal Highway Administration.

In considering solutions to the congestion problem, it might be useful to think of transportation as a resource that is incrementally distributed to customers. At present, the resource is limited; there is not enough to meet everyone's requirements. Society has several options: make more of it (add new capacity), use it more productively (operate the system at peak condition and performance), provide alternatives to highway travel (encourage travel demand management strategies), and create an efficient transportation market (use congestion pricing to balance supply and demand).

Making More of It: Strategic Addition of Capacity

The traditional approach to dealing with congestion is to expand the capacity of the road network. At the beginning of the Interstate era, Federal funding provided incentives to build new highways that offered significant improvements in speed, safety, and traffic-carrying capabilities. As traffic levels increased over time, many of these roads have been widened or rebuilt with higher capacity. Today, however, concerns about air pollution, noise, and urban sprawl often stand in the way of capacity additions. Equally significant, adding new capacity can be enormously expensive and physically challenging.

The demand for new highway capacity is not only increasing but also is dynamic in nature and location. For example, locations that were rural communities in the early 1960s are now major metropolitan areas. Increases and shifts in international trade have created new trade routes and have expanded freight access requirements at seaports and major cargo hubs. The investment analyses of Part II of this report include significant discussion of future system expansion and performance.

Many capacity expansion projects are aimed at relieving bottlenecks. Traffic bottlenecks are specific roadway locations that routinely and predictably experience congestion because traffic volumes exceed capacity during periods of heavy demand. Bottlenecks are characterized by queues upstream and freely flowing traffic downstream. They may be compared to a storm pipe that can carry only so much water—during floods the excess water just backs up behind it, much the same as traffic at bottleneck locations. However, the situation is even worse for traffic. Once the traffic flow breaks down to stop-and-go conditions, capacity is actually reduced—fewer cars can get through the bottleneck because of the extra turbulence.

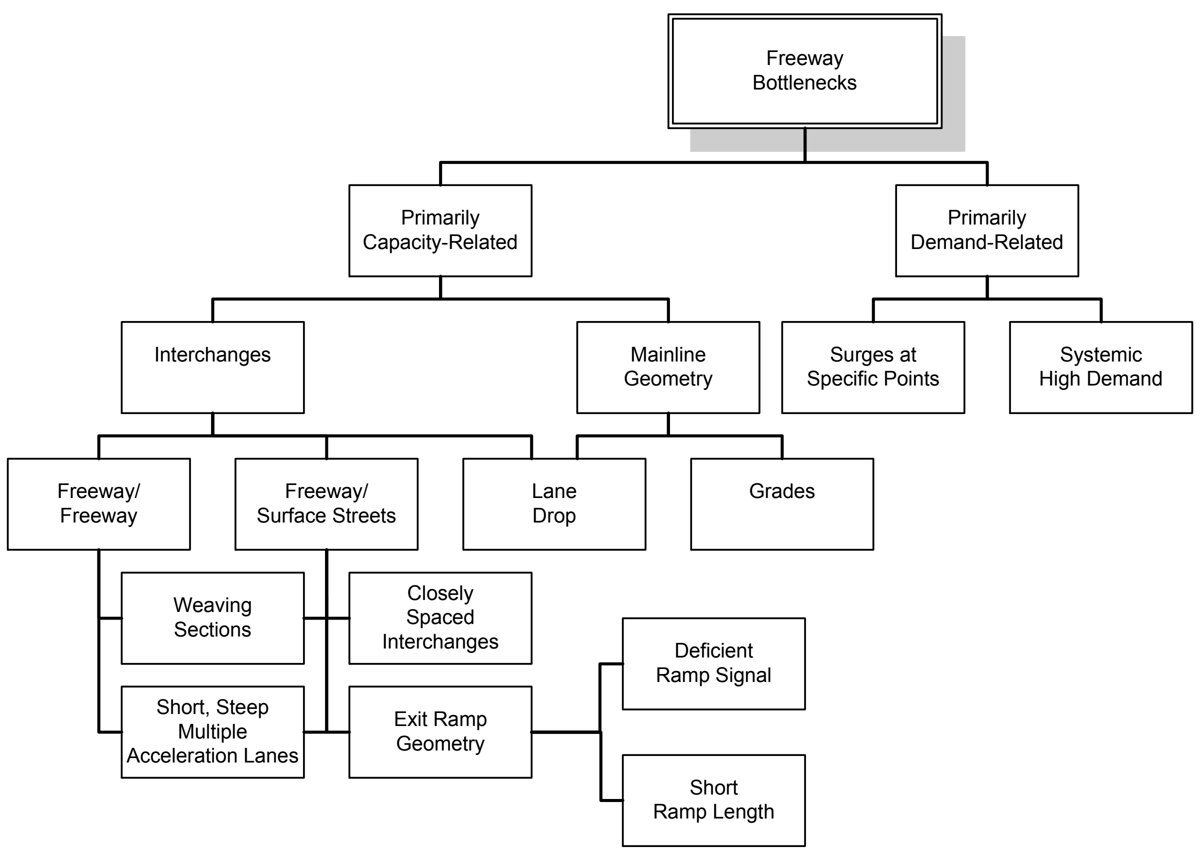
The severity of congestion at a bottleneck is related to its physical design. Some bottlenecks were originally constructed many years ago using designs that are now considered to be antiquated. Others that have been built to extremely high design specifications are simply overwhelmed by high traffic volumes. Whatever the root cause, operational conflicts can occur at lane drops (where one or more traffic lanes are lost), weaving areas (where traffic must merge across one or more lanes to access entry or exit ramps), freeway on-ramps, freeway-to-freeway interchanges, and abrupt changes in highway alignment (such as sharp curves and hills).

Exhibit 14-2 summarizes various root causes of freeway bottlenecks by category. Factors contributing to bottlenecks can be classified as being primarily demand-related or primarily capacity-related. Demand-related causes include both localized surges in traffic volumes at specific points and systemic high demand across an entire facility, corridor, or region. Capacity-related causes include items associated with mainline roadway geometry (grades, lane drops) and interchange design (lane drops, weaving sections, acceleration lanes, interchange spacing, ramp geometry, ramp signals, and ramp lengths). Multiple factors may contribute to causing a bottleneck at a particular location.

Bottlenecks have been the focus of transportation improvements—and of travelers' concerns—for many years. On much of the urban highway system, there are specific points that are notorious for causing congestion on a daily basis. These locations—which can be a single interchange (usually freeway-to-

Exhibit 14-2

Fault Tree for Freeway Bottlenecks



Source: Federal Highway Administration.

freeway), a series of closely spaced interchanges, or lane drops—are focal points for congestion in corridors. Major bottlenecks tend to dominate congestion in corridors where they exist. Many bottlenecks have become so notorious that they have acquired colorful nicknames from local motorists, such as the Mixing Bowl, the Hillside Strangler, or Malfunction Junction.

Some of these major bottlenecks, particularly those involving large freeway-to-freeway interchanges, can be addressed through major multiyear construction projects. While costly, such projects can provide congestion relief to motorists. For most other bottlenecks, however, applying operational and low-cost infrastructure solutions also may relieve congestion at much lower cost. Such strategies may include the following:

- Using a short section of shoulder as an additional travel lane during peak periods
- Restriping merge or diverge areas to better match demand
- Reducing lane widths to add a travel and/or auxiliary lane through restriping
- Modifying weaving areas (e.g., adding collector/distributor or through lanes)
- Metering or closing entrance ramps
- Adjusting speed limits when congestion thresholds are exceeded and congestion and queue formation is impending (known as "speed harmonization")
- Encouraging "zippering" to promote fair and smooth merges
- Designating reversible lanes to accommodate the prevailing direction of traffic flow during morning and evening peaks

Using It More Productively: System Operations and Management

Capacity constraints arise when physical capacity is insufficient and when capacity is temporarily reduced due to traffic incidents, work zones, inclement weather, or special events. As traffic volumes have grown over time relative to physical capacity, the system has become less able to absorb "surprise"—or nonrecurring—

Q&A

How are transportation agencies transitioning to focus on operational considerations?

The transportation community is exploring approaches for bringing management and operations (M&O) into the planning process. Underscoring the move to link planning and operations are provisions in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) calling for both the congestion management process and the long-range transportation plan to reflect consideration of M&O strategies. The Federal Highway Administration (FHWA) is advancing a comprehensive program that assists State departments of transportation and metropolitan planning organizations in implementing SAFETEA-LU provisions. The program lays out a path for transportation agencies to move from the traditional project-oriented planning approach to an outcome-based approach.

The FHWA has established a robust program providing guidance, technical assistance, and training in performance measurement. Just as outcome-based performance measures provide the means for linking planning and operations, so too can they link transportation agencies directly to their customers. Performance information explains not only an agency's performance in providing transportation services, but also helps guide agencies (and stakeholders) toward investments and strategies with the highest payoffs for reducing congestion. An emphasis on performance outcomes will provide a common platform for transportation agencies to communicate with their customers. When the customer understands the value of M&O strategies (and the associated investment trade-offs), the project-oriented business model can change to one that is more service-oriented.

events. In the realm of managing the highway system, the margin for error is very small and continues to decline. By operating the system to maximize system performance in the first place, and being prepared to take actions to recover as quickly as possible when disruptions occur, operational strategies can make a major contribution to effective performance of the highway system at a much lower cost than capacity expansion.

Such strategies include managing temporary disruptions in a way that will return the system to full capacity quickly; ensuring more effective day-to-day operations through coordinated and up-to-date traffic signal timing and operational improvements to relieve bottlenecks; and providing real-time information about the system so that travelers can decide immediately when, where, and how to travel and transportation agencies can adjust immediately to improve system operations.

Real-Time Traveler Information

Real-time traveler information enables travelers to decide how they will use (or not use) the transportation system, influencing the choices that people make about how, when, where, whether, and which way they travel to their destinations. Real-time information enables motorists to manage the uncertainty of travel during congested conditions by leaving earlier or later, taking an alternative route, or even postponing discretionary trips. Transportation agencies also can use the information to better manage and improve the system. Traveler information on traffic conditions, transit service, parking availability, and weather conditions is being delivered through various means, including Web sites, dynamic message signs, e-mail and text message alerts, and highway advisory radio.

The development and establishment of 511 Traveler Information Systems to provide access to highway and travel conditions information in all parts of the Nation have been identified as key elements in implementing a successful national operations strategy. Such systems use the 511 telephone number dedicated by the Federal Communications Commission for relaying information to travelers. As of early 2008, there were 41 active systems in 33 States, providing access to nearly 136 million people, or about 47 percent of the U.S. population.

Real-Time System Management Information Program

Section 1201 of SAFETEA-LU requires the U.S. DOT to "establish a real-time system management information program to provide, in all States, the capability to monitor, in real time, the traffic and travel conditions of the major highways of the United States and to share that information to improve the security of the surface transportation system, to address congestion problems, to support improved response to weather events and surface transportation incidents, and to facilitate national and regional highway traveler information."

Through the Section 1201 program, agencies will be able to anticipate changes and events and take remedial actions, and provide road users with information to make better travel-related decisions. The specific goal of the program is to establish in all States the capability of sharing data on system performance nationwide. Significant opportunities exist for private sector involvement or partnering in implementing this program, including information gathering, data processing, and information dissemination. Toward this end, the FHWA published an interim guidance on data-sharing specifications and data exchange formats in 2007.

In May 2006, FHWA issued a notice in the *Federal Register* requesting comments on the proposed program goals, definitions for various parameters, the current status of related activities in the States, and implementation issues to guide development of the Real-Time System Management Information Program. Based on comments received from State DOTs and other representatives of the private sector and national associations, FHWA is developing a rule to implement the Real-Time System Management Information Program. The FHWA published a notice of proposed rulemaking in the *Federal Register* in January 2009 and anticipates issuing a final rule in late 2009 or early 2010.

Traffic Incident Management

Traffic incidents cause approximately 25 percent of all congestion, and each minute of lane blockage creates 4 minutes of congestion after the incident is cleared. Traffic incident management is a planned and coordinated process to detect, respond to, and remove traffic incidents and restore capacity as safely and quickly as possible. Effectively managing traffic incidents requires cooperation among organizations that often have conflicting on-scene priorities and operating cultures. For example, transportation agencies must interact with a variety of public and private sector partners, including law enforcement, fire and rescue, emergency medical services, public safety communications, emergency management, towing and recovery, hazardous materials contractors, traffic information media, and traffic management centers (TMCs). Promoting more aggressive and widespread traffic incident management is an important strategy to lessen the effects of nonrecurring congestion as well as provide a safer driving environment.

Real-time information is particularly critical for effective incident management. Information is necessary for locating and clearing crashes, stalled vehicles, spilled loads, and other highway debris. Efficient and rapid response, effective management of resources at the incident, and area-wide traffic control all depend on the rapid exchange of accurate and clear information among the responding parties. This exchange requires communications standards and institutional coordination among all the parties involved in responding to and clearing traffic incidents.

Work Zone Mobility

Work zones are second only to incidents as a source of delay from temporary capacity loss. Effective work zone management requires fundamental changes in the way reconstruction and maintenance projects are planned, estimated, designed, bid, and implemented. A comprehensive approach to work zone management requires minimizing work zone consequences, serving the customer around the clock, making use of real-time information, and aggressively pursuing public information and outreach.

Road Weather Management

Adverse weather is the third most common source of delay from temporary capacity loss. Although the weather cannot be changed, its effects on highway safety and operations can be reduced. Today, it is possible to predict weather changes and identify threats to the highway system with much greater precision through the use of roadside weather-monitoring equipment linked to TMCs. More precise weather information can be used to adjust speed limits and traffic signal timing; pretreat roads with anti-icing materials; pre-position trucks for deicing, sanding, or plowing; and inform travelers of changing roadway conditions.

Traffic Signal Timing and Coordination

Another source of congestion is outdated or poor signal timing at intersections. When signal timing is not updated to accommodate changes in traffic patterns, drivers may be subjected to unnecessary stops and delays. Outdated signal timing accounts for an estimated 10 percent of the total delay on major roadways, and a far greater percentage on local roadways.

Signal timing can be improved in several ways, with varying levels of complexity. At the most basic level, old signal timing plans can be updated based on more recent traffic counts. Signal controls can be upgraded, from simple signals actuated by traffic to sophisticated adaptive or even predictive computer-based controls. Interconnecting and coordinating traffic signals through a central master control can achieve the maximum benefits from traffic signal optimization.

How does technology support the efficient operation and management of the transportation system?

Q&A

Highway system operations and management strategies often depend on technology to be effective. Advanced technologies can provide system managers with the necessary information about traffic conditions to make decisions, both in responding to real-time events and in devising longer term operations and investment strategies. Technology can also provide managers with the means to control the operations of the system and to convey important information to system users.

The range of technologies used to advance highway system operations are often referred to collectively as Intelligent Transportation Systems (ITS). They include such technologies as electronic toll payment, roadway surveillance systems, and advanced traveler information systems. Such systems are being used around the country to improve the operational efficiency and safety of the transportation system. The impetus to employ ITS is growing as technology improves, congestion increases, and building new roads and bridges becomes more difficult and expensive. Many of these technologies are discussed in the highway investment analyses of Part II.

Freeway and Arterial Management Technologies. ITS technologies are being deployed to actively manage freeways and arterials in many places around the country. For instance, ramp metering on freeways is used to regulate the flow of traffic entering a facility to increase vehicle throughput and speeds. In the Minneapolis-St. Paul region, ramp metering increased vehicle throughput by 30 percent and average speeds in the peak period by 60 percent. Adaptive signal control is another type of ITS that adjusts traffic signal timing based on current traffic demand. In Los Angeles, where nearly 2,500 of the more than 4,000 traffic signals use adaptive signal control, delay at intersections with these systems is reduced by an average of 10 percent.

Traveler Information Systems. Traveler information systems use a wide variety of ITS technologies to improve highway mobility and safety. These applications are currently being used in many different situations, including road weather information systems and in work zones and during special events. A traveler information system involving traffic cameras, remote traffic microwave sensors, dynamic message signs (DMS), and highway advisory radio is used in work zones on I-30 and I-40 in central Arkansas. In Montana, weather sensors and DMS are being used to warn motorists of high winds on portions of I-90.

Transportation Management Centers. In many places, a TMC coordinates the use of ITS. A TMC is typically a central location for bringing together multiple agencies, jurisdictions, and control systems for managing traffic and transit, incident and emergency response, and traveler information. Transportation management technology includes closed-circuit television cameras, DMS, synchronized traffic signals, vehicle-flow sensors, highway advisory radio, and other high-tech devices. To manage emergencies, Houston TranStar uses a host of technologies in its Road Flood Warning Systems and the Regional Incident Management System.

Integrated Corridor Management. Transportation corridors often contain unused capacity in the form of parallel routes, the counter-peak direction on freeways and arterials, single-occupant vehicles, and transit services that could be leveraged to help reduce congestion. Traffic information is often fragmented, outdated, or not completely useful. Networks are often independently operated, and efforts to date to reduce congestion have focused on optimizing individual networks.

The combined application of technologies and a commitment of network partners to work together may transform the way corridors are operated and managed. Thanks to recent advancements in ITS technologies, a tremendous opportunity exists to integrate operations to manage total corridor capacity.

With integrated corridor management (ICM), the various institutional partner agencies manage the transportation corridor as a system—rather than the more traditional approach of managing individual assets. They manage the corridor as an integrated asset in order to improve travel time reliability and predictability, help manage congestion, and empower travelers through better information and more choices.

In an ICM corridor, because of proactive multimodal management of infrastructure assets by institutional partners, travelers could receive information that encompasses the entire transportation network. They could dynamically shift to alternative transportation options—even during a trip—in response to changing traffic conditions. For example, while driving in a future ICM corridor, a traveler could be informed of congestion ahead on that route and of alternative transportation options such as a nearby transit facility's location, timing of departures, and parking availability.

Vehicle Infrastructure Integration. In the future, vehicle-infrastructure integration (VII) may offer significant crash prevention and congestion relief that could be facilitated through vehicle-vehicle and vehicle-roadside communication. VII envisions a nationwide deployment of a communications infrastructure on the roadways and in all vehicles. Under VII, data transmitted from the roadside to the vehicle could warn a driver that it is not safe to enter an intersection. Vehicles could serve as data collectors and anonymously transmit traffic and road condition information from every major road within the transportation network. Such data would provide transportation agencies with the information needed to implement active strategies to relieve traffic congestion. A VII consortium of public agencies and private companies has been established to determine the feasibility of widespread deployment and to form an implementation strategy.

Providing Better Transportation Choices: Travel Demand Management

In addition to managing the supply of highways, agencies can affect travel demand. One way to reduce the level of demand for highway use is to ensure the availability of high-quality alternatives that meet travelers' transportation needs. Travel demand management (TDM) increases the use of travel alternatives; spreads the timing of travel to less-congested periods; reduces the need for travel; and shifts the routing of vehicles, including trucks and single-occupant vehicles, to less-congested facilities. TDM can provide travelers with choices of location, route, time, and mode.

A robust public transportation system can provide the backbone for such choices. Providing exclusive lanes for high occupancy vehicles (HOVs) during peak hours is another means of providing incentives for transportation system users to reduce their use of scarce highway capacity by sharing rides in carpools, vanpools, or buses. Bike lanes and streetscape improvements can encourage the use of non-motorized travel modes. Other tools for enhancing the attractiveness and efficiency of travel alternatives include park-and-ride facilities, guaranteed ride home programs, tax-advantaged transit benefit programs, and transit-supportive local land use controls.

Other TDM strategies are focused on shifting the times of travel or reducing the frequency and distance of trip-making altogether. Flexible work schedules, compressed workweeks, telecommuting, satellite work centers, and encouragement of mixed-use development (combining residential, commercial, and office uses in a single development) are among several options available to employers and public agencies in achieving such goals.

Traveler information systems are increasingly seen as an important tool for encouraging efficient travel choices by consumers. Online travel planning tools can help system users choose the routes and combination of modes that will best meet their travel needs. Online tools can also be used to match carpool drivers and passengers. Real time travel information can be used to notify travelers of parking availability at remote transit stations or even expected travel times on alternative modes.

Creating an Efficient Transportation Market: Road Pricing

Building new facilities and better management and operation of existing roads do not address one of congestion's root causes: that most travelers do not pay the full cost of receiving transportation services. As discussed in the introduction to Part II, when making travel decisions, travelers consider only their own travel times and vehicle operating costs; they do not consider the effects that their trips will have on others using the same facilities. For this reason, congestion often returns to newly constructed facilities, and facilities with state-of-the-art operating practices remain congested as users respond to increases in road supply and efficiency by simply making more trips. In the absence of road pricing mechanisms, highway travel—a notably inefficient market—is distributed according to the amount of time users are willing to wait.

Congestion pricing—charging a cash toll price during peak hours in order to bring supply and demand back into balance—relies on market forces and recognizes that trip values vary by individual, depending on time, location, destination, and cost, and more broadly among individuals, depending on personal preference and access to alternative travel options.

Congestion pricing incorporates both the direct cost to the traveler and the cost of delay that the traveler imposes on others. Travelers are encouraged to eliminate some lower value trips or take them at different times, or to choose alternate routes or modes of transportation, such as transit or carpooling.

Congestion pricing can take many forms. Presently, variable pricing is typically applied on a limited access facility (such as a bridge or freeway) or in a congestion charging zone around a central business district (such as in Singapore or London). In the future, charging systems using global positioning system or dedicated short-range communication technologies may make it feasible to efficiently price entire road networks.

Variable pricing can also be used to make more efficient use of existing transportation infrastructure. This provides users with the benefits of reduced congestion but at a much lower cost than adding new capacity or new technologies. For example, HOV facilities often operate at volumes well below the traffic carrying capacity of such facilities, even during peak hours. Allowing vehicles that fall below the occupancy threshold to use the facility by paying a toll (which may vary to reflect changing levels of demand) enables better use of the facility as a whole without the costly addition of new capacity. Such policies retain the incentive for carpool and transit use while also reducing traffic levels in the general purpose lanesCongestion pricing concepts can also be applied to parking. When parking is made available too cheaply, it can encourage inefficiently high levels of auto use. Underpriced parking can also contribute to localized congestion during high demand periods as motorists search for available parking spaces. Variable pricing of parking can address both of these contributors to congestion.

Conclusion

Various tools are available to policy makers and public agencies to reduce congestion on the Nation's highways. The problems caused by congested roadways call for a more thoughtful and hands-on approach to operating the transportation system to get the most out of existing investments; the United States cannot afford to underutilize the capacity already in place. The challenge to reduce congestion and increase mobility requires public agencies to think and act differently, incorporating proven operational strategies and technologies to provide congestion relief. Through the cooperative efforts of Federal, State, and local transportation agencies, the most beneficial approaches to congestion relief can be identified and adopted, significantly improving the quality of the Nation's surface transportation system.

.

Chapter 15

National Household Travel Survey

National Household Travel Survey

The transportation system in the United States plays a vital role in maintaining the vigor of the economy and quality of life for the people who live here. By connecting people and places, transportation provides the American public with access to a wide array of economic, social, and cultural opportunities that allow for daily commerce, enrich and enliven leisure, and strengthen the fabric of society. This chapter describes some of the new trends in travel by the American public and the ways in which understanding travel behavior trends and forecasts is critical in the development of sound national transportation policy and programs.

The primary source of national information on the travel of people in the United States is the National Household Travel Survey (NHTS). Previously called the Nationwide Personal Transportation Survey or NPTS, with studies conducted since 1969, the NHTS is a fundamental intermodal program that provides statistical measures of system use and travel behavior of the American public. In addition to broad indicators of travel demand such as vehicle and person miles of travel (VMT and PMT), mode share, vehicle occupancy rates, travel time and distance, and trip purpose distributions, the NHTS provides detailed data on the characteristics of travelers, trips, and vehicles.[1] As such, the NHTS is a critical data source for sound national transportation policy making.

The topics presented in this chapter are based on data from the 2001 NHTS and other sources. Each topic was originally discussed in a separately issued *NHTS Brief* as follows:

- "Long-Distance Travel" – March 2006
- "Older Drivers: Safety Implications" – May 2006
- "Rising Fuel Cost—A Big Impact" – June 2006
- "Travel Characteristics of New Immigrants" – August 2006
- "Commuting for Life" – November 2006
- "Congestion: Non-Work Trips in Peak Travel Times" – April 2007
- "Congestion: Who is Traveling in the Peak?" – August 2007
- "Travel to School: The Distance Factor" – January 2008.

Data collection for the 2008 NHTS began in March 2008 and will continue for 1 year. Data from the 2008 NHTS will be available in Summer 2009. New data topics for the 2008 NHTS include travel to school, Interstate use, tolling, work schedule flexibility, hybrid/alternative fuel vehicles, residential deliveries, and additional information on walking and biking.

In addition to understanding trends in travel behavior and developing national policy initiatives, the NHTS is used by State and local planning agencies as a vehicle for collecting robust travel data for local planning. The 2008 NHTS has local participation from 19 areas. Together with the national sample, the survey will yield travel behavior data on approximately 150,000 households—the largest sample ever.

Beyond the 2008 survey, consideration is being given to adopting a continuous survey design beginning in 2010 to support the integration with other Department of Transportation (DOT) programs such as the Fatality Analysis Reporting System (FARS) and the required annual performance measurement and reporting to Congress and the Administration.

Long-Distance Travel

Overall, there were about 2.6 billion long-distance trips taken by U.S. residents in 2001, the last year of the NHTS survey. These were trips of 50 miles or more away from home (100 miles in round-trip distance) for people of all ages, for a wide range of purposes: commuting, business, pleasure, or personal business; and by all modes of travel: personal vehicle, air, bus, and train. Ninety percent of these long-distance trips were taken by personal vehicle, followed by trips by air at 7 percent. Many people never traveled that far from home—169 million people (61 percent of the population) did not make any long-distance trips. In fact, just 5 percent of the population took 25 percent of the long-distance trips.

Census Regions

- New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
- Mid-Atlantic: New Jersey, New York, Pennsylvania
- East North Central: Illinois, Indiana, Michigan, Ohio, Wisconsin
- West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
- South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
- East South Central: Alabama, Kentucky, Mississippi, Tennessee
- West South Central: Arkansas, Louisiana, Oklahoma, Texas
- Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
- Pacific: Alaska, California, Hawaii, Oregon, Washington.

Of the nine U.S. Census regions, people in the Mid-Atlantic region had the lowest per capita trip rates and people in the West North Central region the highest. *Exhibit 15-1* shows the annual per capita trip rates for each of the Census regions.

Higher-income people in rural areas took more trips of 50 miles or more than all others (nearly 20 per year), while low-income people in large cities took the fewest long-distance trips (less than four each year).

Those living in the largest metropolitan areas (3 million or more in population) were twice as likely to take a trip of 1,000 miles or more than people in small towns or rural areas. However, the majority of the long-distance trips were not that long—58 percent were less than 250 miles in round-trip distance. The average long-distance trip by privately owned vehicle (POV) was 220 miles one way. Bus or train trips averaged 400 miles, and air trips nearly 1,500 miles.

Exhibit 15-1

Annual Per Capita Trip Rates by Census Region, 2001

Census Regions of the United States	Average Number of Long-Distance Trips Per Capita, Per Year*
New England	10.3
Mid-Atlantic	8.4
East North Central	9.3
West North Central	11.2
South Atlantic	9.3
East South Central	10.4
West South Central	10.0
Mountain	9.3
Pacific	8.7
All	9.4

** Includes trips 50 miles or more from the respondent's home by all modes for all purposes.*

Weighted to represent the average annual travel.

Source: 2001 NHTS.

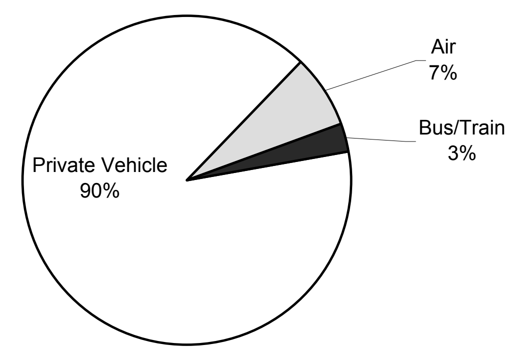
The vast majority of long-distance travel was on the highway, as shown in *Exhibit 15-2,* but the choice of means was dependent on income and trip distance.

People in low-income households were more dependent on private vehicles to make long-distance trips than people in high-income households, and the gap widened as the trip length increased. For people with an annual income of $100,000 per year, air travel became a significant option for trips of 600 miles (round trip) or 300 miles away from home. For lower-income people, air travel became a significant option only when round-trip distances approached 1,000 miles. *Exhibit 15-3* describes the distribution of vehicle trips for low-income and high-income Americans.

The reasons people travel vary as much as the people themselves; the data include trips for business, family vacations, weddings, or shopping. In 2001, business trips (including long commutes, conferences and meetings, and combined business and pleasure) comprised nearly 30 percent of the long-distance trips; visiting friends and relatives just over 25 percent; and leisure trips, sightseeing, and vacations nearly another 25 percent. For people who make long-distance trips, the average annual trips by purpose are shown in *Exhibit 15-4*.

Exhibit 15-2

Distribution of Long-Distance Trips by Mode, 2001*

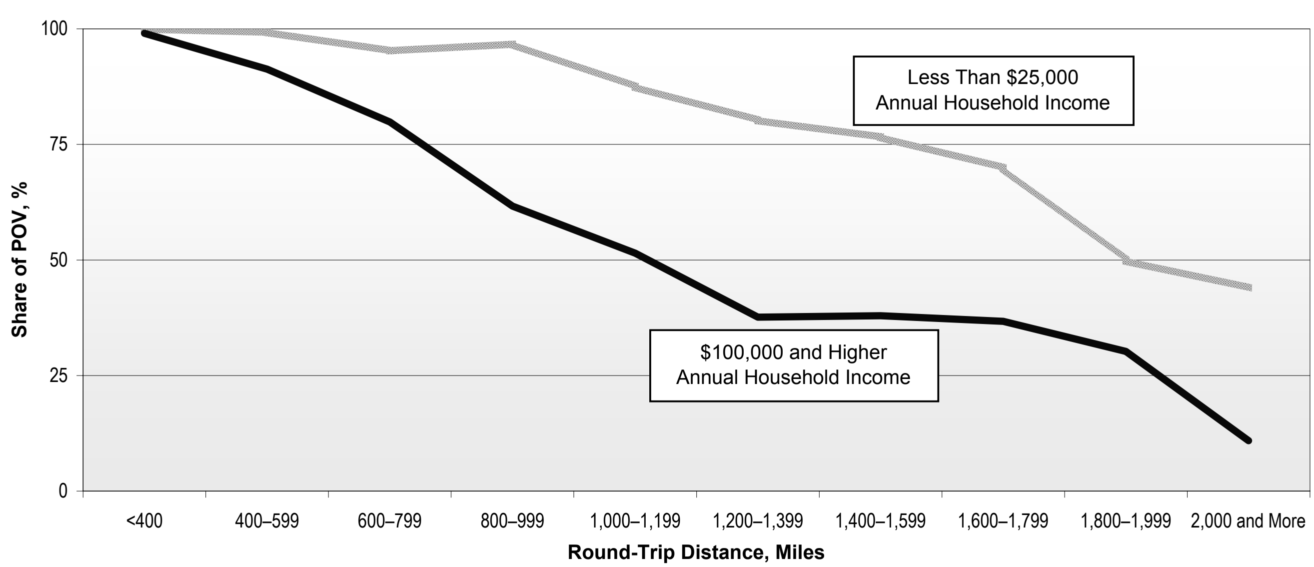


** Includes all trips of 50 miles or more from home.*

Source: 2001 NHTS.

Exhibit 15-3

Distribution of Privately Owned Vehicle Trips by Distance for Low-Income and High-Income Groups, 2001



Source: 2001 NHTS.

Exhibit 15-4

Average Annual Number of Trips by Purpose for People Who Make Long-Distance Trips, 2001*

	Mean Trips/Year
Business and Business/Pleasure	3.8
Visit Friends and Relatives	1.5
Vacation/Leisure	1.4
Personal Business, including Shopping and Medical	1.7
Other Reasons	1.8

** Includes trips 50 miles or more from the respondent's home by all modes for all purposes.*

Weighted to represent the average annual travel.

Source: 2001 NHTS.

Older Drivers: Safety Implications

Older Americans (age 65 or over) are the fastest-growing segment of the U.S. population—in the next decades, the baby boomers will swell the ranks of the older population to one in five of all Americans.

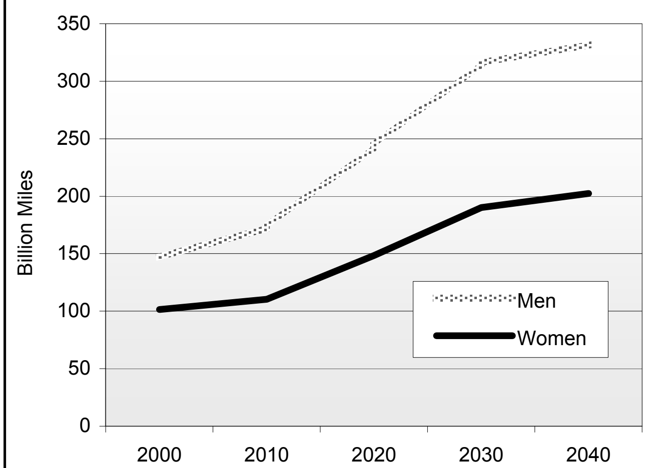
The aging of the U.S. population has profound implications for the transportation system. As the unique source of data on travel by different population groups, the NHTS survey shows that the percentage of older people who continue to drive is growing, and the growth rate of older drivers is especially marked among older women.

Even if baby boomer men and women drive at the same (modest) rates as the current older population, their sheer numbers mean that total miles driven by those 65 and or older will increase by 50 percent by 2020 and more than double by 2040. *Exhibit 15-5* shows these projections.

Likewise, the American vehicle fleet is aging—and older drivers are more likely to drive older cars than younger age groups. The age of a vehicle may indicate the types of safety features available. For example, in 1988 automatic seat belts became standard equipment, but 26 percent of drivers over the age of 80 are driving pre-1988 vehicles, compared with 16 percent of drivers under 60. Women are more likely than men to keep an older vehicle as they themselves get older. *Exhibit 15-6* describes the distribution of older Americans who operate vehicles manufactured before 1988.

Exhibit 15-5

Projected Annual Vehicle Miles of Travel for Men and Women Age 65 and Older, Using 2001 Driving Rates

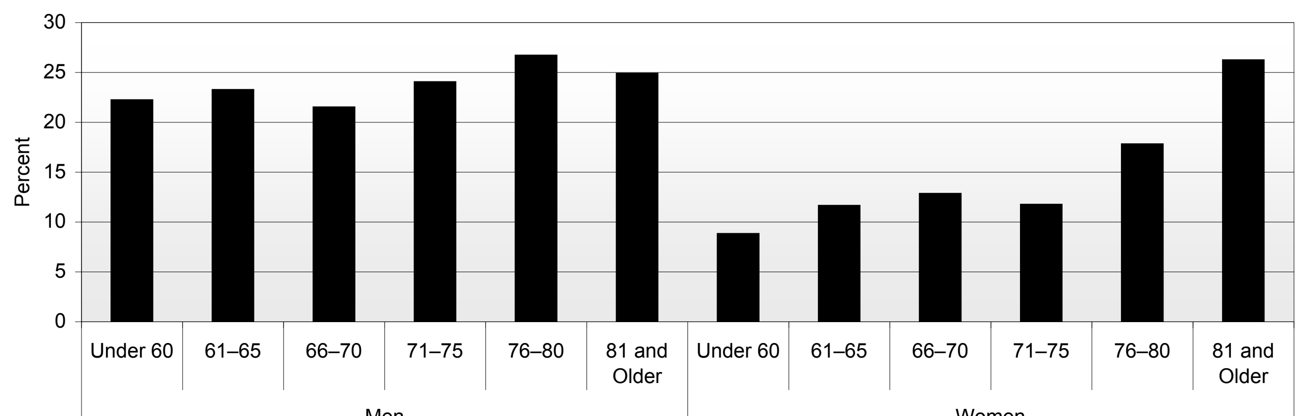


Source: 2001 NHTS.

Per mile driven, elderly drivers (those over 80 years old) were more likely to die in a crash than any other age group. The importance of calculating the crash rate by miles driven, rather than by population or percentage of licensed drivers, is that it puts accidents and fatalities into the context of the amount of driving done.

Exhibit 15-6

Distribution of Older Drivers Who Operate Vehicles Manufactured Before 1988, in 2001



Source: 2001 NHTS.

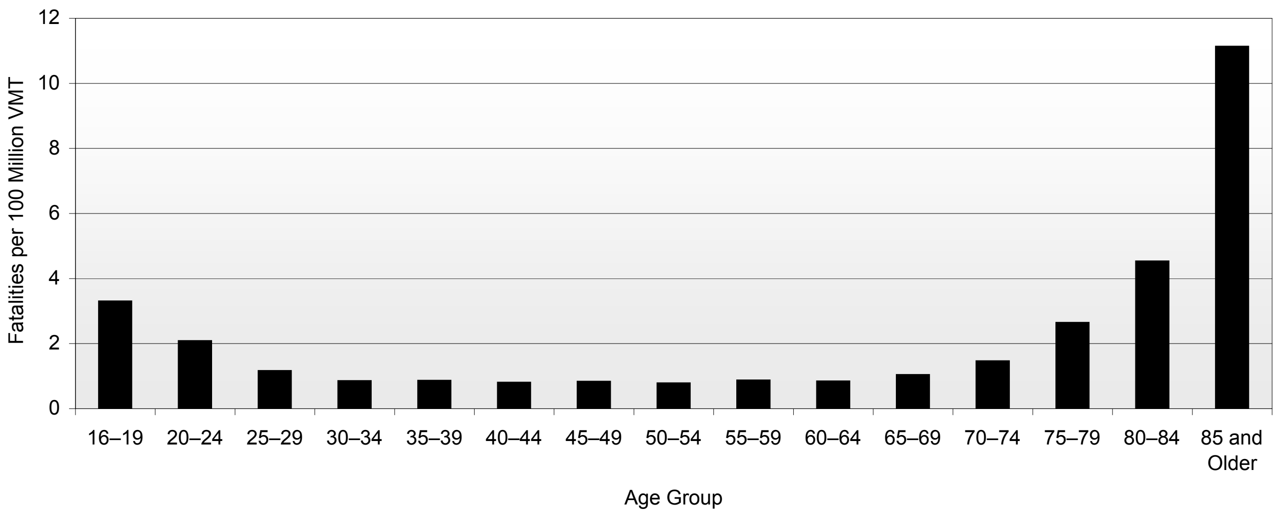
Older drivers drive far fewer miles than younger drivers but are more likely to be injured or die in a crash of the same severity.

As a proportion of all crashes, only about 8.4% involve drivers age 65 and older. However, as a proportion of total vehicle miles of travel, older drivers have the greatest risk of fatality due to decline in driving skill levels and greater vulnerability to severe injury in a collision. Safety concerns will be important as the driving public includes more and more older drivers.

Exhibit 15-7 breaks down, by age group, the number of fatalities per 100 million VMT.

Exhibit 15-7

Fatalities per 100 Million Vehicle Miles of Travel, 2001



Source: 2001 NHTS.

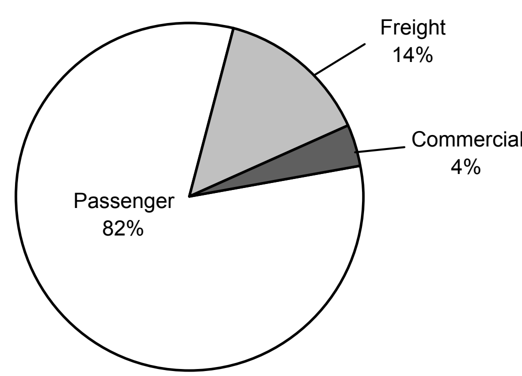
Rising Fuel Cost—A Big Impact

Transportation accounts for almost 70 percent of all petroleum used in the United States, and private (passenger) vehicle travel accounts for 82 percent of all vehicle miles traveled (VMT), as shown in *Exhibit 15-8*. Recent increases in the cost of motor fuel are raising questions about the impact of higher fuel prices on the economy and the daily travel of Americans.

Assuming that U.S. households continued to drive at the same rates, they paid more than double in annual motor fuel expenditures in 2006 compared with 2001. The average household's $1,461 expenditure on motor fuel in 2001 became $3,261 in 2006. If prices remain high, changes in daily travel and vehicle choice could result. In the long term, fuel cost may also affect work and housing location choices.

Exhibit 15-8

Distribution of Vehicle Miles of Travel by Type of Traveler, 2001



Source: Highway Statistics 2001.

Household spending for motor fuel depends on the number and kinds of vehicles the household has, the number of miles those vehicles are driven, and local fuel costs. In 2001, private vehicle fuel cost averaged 7.0 cents per mile of travel. As shown in *Exhibit 15-9*, this cost grew to 15.6 cents per mile in 2006.

The type of vehicle driven has a significant impact on the amount of money paid at the pump. Fuel expenditures for the average passenger car are approximately 24 percent less than the average sports utility vehicle (SUV) or pickup truck. Pickups and SUVs are less fuel-efficient and are driven more miles on average.

The introduction of SUVs, in particular, has changed the vehicle fleet. Only 12.5 percent of the total vehicle fleet is SUVs. However, SUVs make up about 20 percent of all newer vehicles (less than 2 years old).

Exhibit 15-9

Cost per Mile for Different Vehicle Types, 2001 and 2006

	Percent of Household Vehicles	Annual Miles	Average MPG	Cost per Mile in 2001	Cost per Mile in 2006
Car	59.9%	11,678	22.4	6.3 cents	14.1 cents
Van	9.4%	13,417	18.4	7.5 cents	16.6 cents
SUV	12.5%	13,941	16.7	8.2 cents	18.4 cents
Pickup	18.2%	12,552	16.9	8.3 cents	18.3 cents
Overall	100.0%	12,291	20.3	7.0 cents	15.6 cents

Sources: 2001 NHTS and Energy Information Agency.

How Much Will This Trip Cost?

Costs vary considerably across trip purpose due to differences in trip distance and vehicle types.

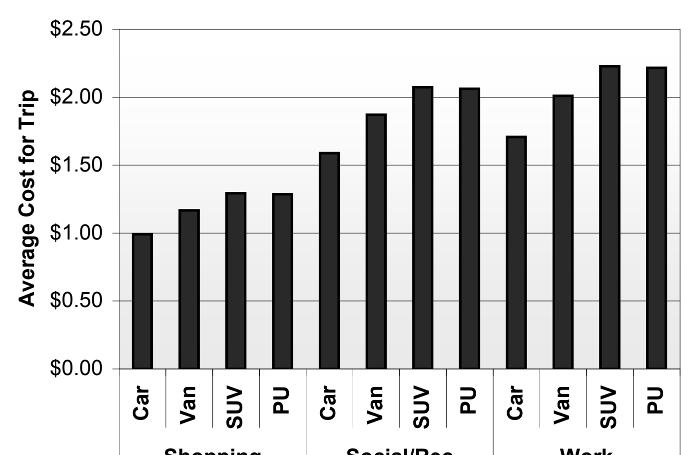
The most expensive single trip of the day is the longest trip for most people—the work trip. An average work trip is more than 12.1 miles, compared with 7.0 miles for the average shopping trip. On average, total fuel cost for a one-way trip to work is $1.87 per trip. As shown in *Exhibit 15-10*, this cost ranges from $1.71 per trip for a passenger car to $2.23 per trip for an SUV.

Current fuel prices put the cost of shopping trips at over $1 each way ($1.09 per trip on average). The average trip costs just under $1 ($0.99) for a passenger car and $1.30 for an SUV or pickup. *Exhibit 15-10* depicts the average cost for various trips by vehicle type.

Social and recreational trips, such as to visit friends and relatives or go to a concert, ball game, or park, rival the work trip in length and therefore cost more. These types of trips often include a family or a group of friends traveling together, which may reduce the cost per traveler. The 2001 survey showed that four out of five workers drive alone to work, but the average vehicle occupancy for social and recreational trips is 2.3 people.

Exhibit 15-10

Average Cost for Various Trips by Vehicle Type, 2001



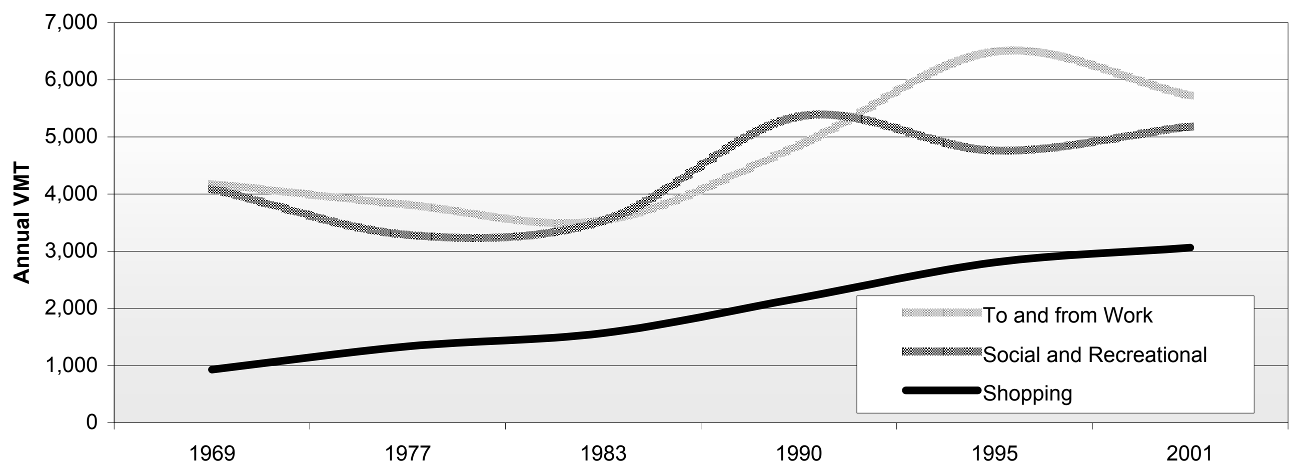
Source: 2001 NHTS.

Many factors have contributed to the continuing growth in passenger travel on the Nation's highways—the growth in the number of people and workers (both baby boomers and immigrants); increased purchase power of U.S. households for vehicle ownership; and the continued dispersion of housing, workplace, and recreational locations.

Since 1969, the average annual vehicle miles generated by American households increased from 12,423 to 21,187, a 59 percent increase. During the same time period, the increase in miles traveled for shopping nearly tripled, while miles for commuting and social/recreational travel rose by a third, as shown in *Exhibit 15-11*.

Exhibit 15-11

Vehicle Miles Traveled (VMT), 1969 –2001



Source: 2001 NHTS.

Who is Impacted the Most?

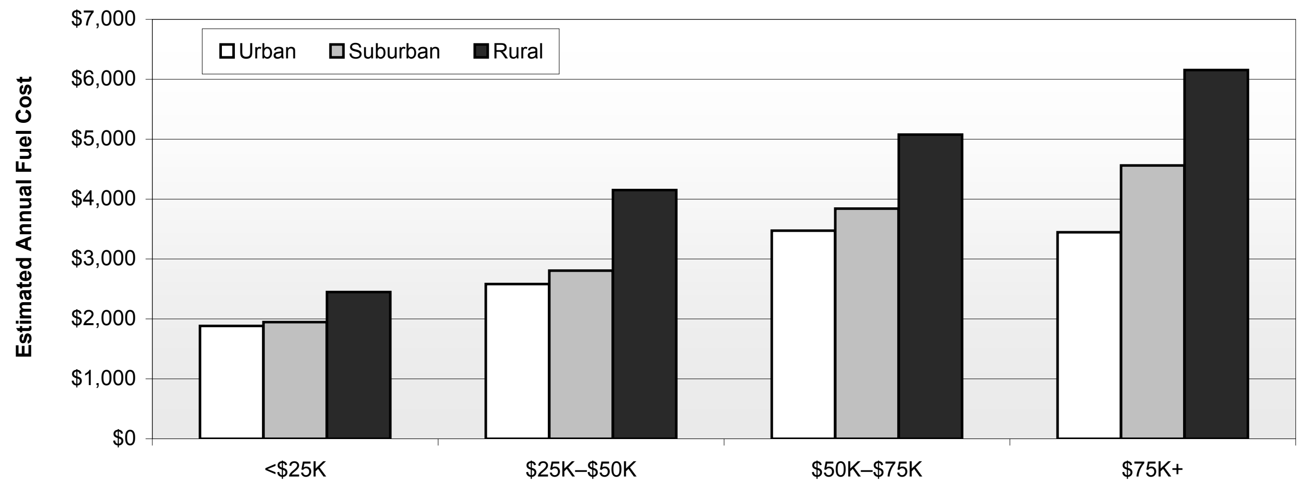
Rural families own twice as many vehicles as urban households—often less-efficient vehicles like pickup trucks. In fact, in 2001, 37 percent of rural households owned or leased a pickup truck compared with 17 percent of households overall. Rural families also drive more miles than suburban and urban households with average annual VMT of 28,238, well above the average of 21,187 annual vehicle miles. The lower fuel efficiency of pickups (18.3 cents per mile from *Exhibit 15-9*) combined with a greater VMT translates into a greater annual fuel cost for rural families, regardless of income, as shown in *Exhibit 15-12*.

Exhibit 15-13 shows the total annual fuel cost for different types of households. Higher-income rural families have the greatest annual motor fuel cost at $6,150. However, this is a smaller percentage of their total income as compared with lower-income rural households. The 6 million households in rural areas that have incomes less than $25,000 per year average $2,500 per year in fuel costs. This represents 10 percent or more of their total household income. Compared with low-income urban households, low-income rural households travel 13 percent more miles and spend 30 percent more in fuel costs. The average annual fuel cost for all households with vehicles was $3,261 in 2006.

The highway system provides important access to airports, rail stations, and transit. According to the NHTS, more than 3.4 billion vehicle trips are made annually to access other modes of transportation for both business and leisure purposes. It is important to remember this intermodal interdependence of the transportation system, which allows it to be flexible to changing user needs.

Exhibit 15-12

Fuel Cost Distribution Across Residential Areas for Selected Income Ranges, 2001

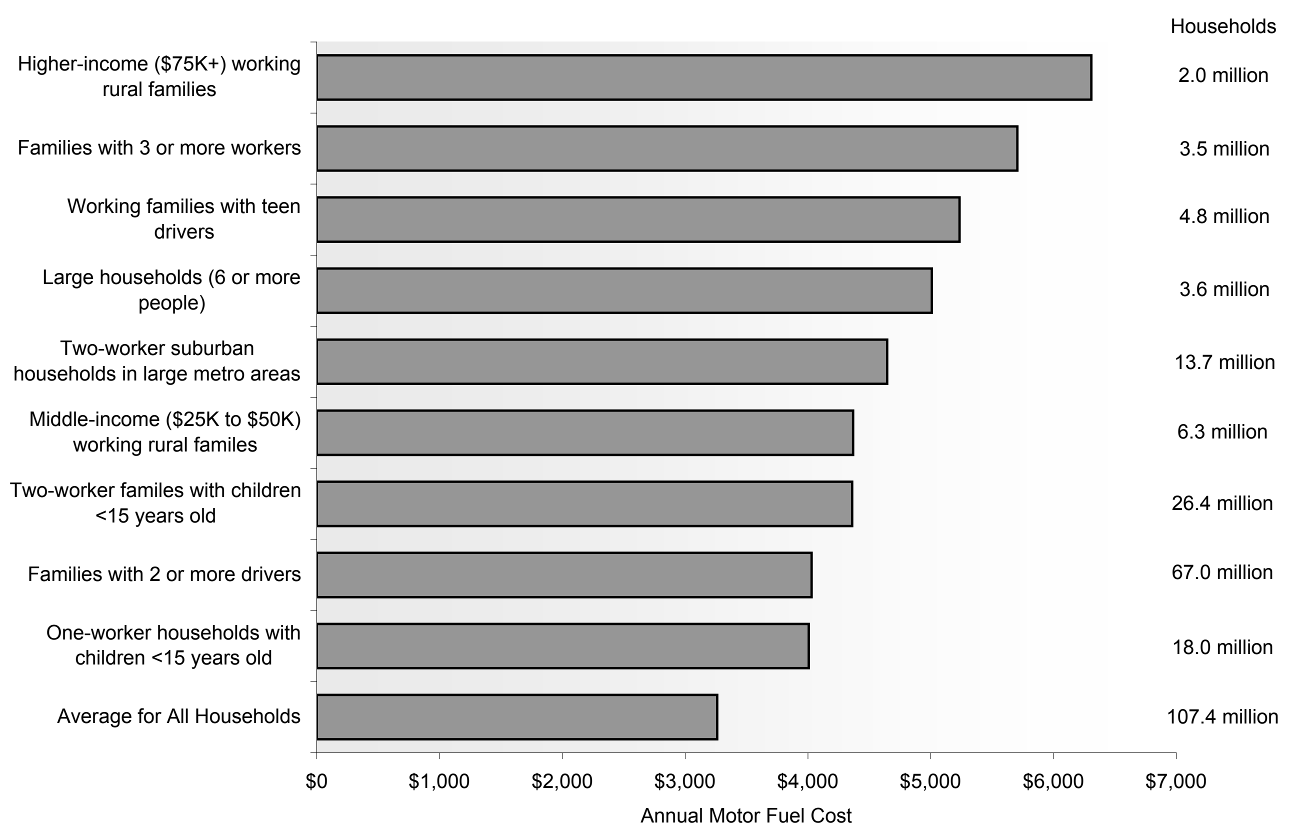


Source: 2001 NHTS and Energy Information Agency.

Current counts on the roadways show a decline in the rate of growth in VMT, especially on urban highways. However, the effect of the recent rise in fuel prices on travel behavior will not be known until new detailed travel data are collected and made available.

Exhibit 15-13

Annual Fuel Costs for Various Categories of Households, 2001



Source: 2001 NHTS and Energy Information Agency.

Note: Households can fall into more than one category.

Q&A

What Makes a Difference?

Sharing a ride. Each day American workers commute 166 million miles. If every worker in a two-worker family shared a ride to work, the Nation would save 3.1 million gallons of gas and $9.7 million in fuel costs every day.

Walking or biking. Overall, American adults travel 25 million miles a day in trips of a half mile or less, of which nearly 60 percent are vehicle trips. If people walked instead of drove for these short trips, the Nation would save 1.2 million gallons of gas and $3.9 million of motor fuel cost a day.

Linking trips together. Being efficient about planning travel also can save money. Every time workers link a shopping or errand stop to their commute instead of going home and going out again, they save over $1 in fuel cost.

Taking transit. Less than one out of 10 workers who live and work near transit actually take transit to work. For those who do, the motor fuel savings is substantial. Households with workers who take transit save $32 a week ($1,670 per year) on fuel costs compared with similar households whose workers drive to work.

Choosing the most fuel-efficient vehicle. The average American household has more than one vehicle. Drivers could save hundreds of dollars a year by driving a car instead of an SUV ($492 per year), pickup truck ($417 per year), or van ($193 per year).

Travel Characteristics of New Immigrants

Immigration promises to make the United States a more heterogeneous nation. For the first time since the early 1900s, immigrants comprise more than 10 percent of the U.S. population, a total of 32 million people.[2] The national origins of immigrants have changed over the past few decades—with a significant increase in the number of Hispanic immigrants. According to the 2000 census, nearly half (49.8 percent) of recent immigrants, those who have been in the United States for 3 years or less, are Hispanic.

Predicting future growth in travel has traditionally depended on key characteristics: household income, family size, autos owned, driving ability, and employment. With the aging population (baby boomers) and a sizable influx of new immigrants into the United States, the normal distribution of key population characteristics used to forecast travel demand is changing.

Although the data shown in *Exhibits 15-14* through *15-18* are for the Nation, immigration is concentrated both regionally and in major metropolitan areas. New immigrants tend to be most heavily concentrated in the West and Northeast, and least heavily in the Midwest.[3] For example, 26 percent of California residents are foreign-born as compared with only 3 percent in Ohio.

Along with the rich cultures, foreign languages, and exotic cuisines, immigrants bring different habits, constraints, and needs when it comes to travel. In 2001, the NHTS collected information on place of birth and year of entry to the United States. These data allow for the analysis of travel behavior trends among the immigrant population so transportation agencies can incorporate this analysis into planning and policy activities.

In the analysis of immigrant travel data, several important differences in key travel indicators, such as household size, emerge. This is illustrated by *Exhibit 15-14*. While the national average household size is 2.6, immigrant households have an average size of 3.6. In areas with high concentrations of immigrant households, this difference could have a significant impact on travel demand forecasts.

The slow acquisition of vehicles and the larger household sizes may reflect the lower socioeconomic status of new immigrants in the United States. According to the 2000 census, a higher proportion of new immigrants (15 percent) live in poverty as compared with U.S.-born residents (12.5 percent).

Exhibit 15-14

Key Demographic and Travel Characteristics of New Immigrants, 2001

	New Immigrants*	United States
Average Household Size	3.6	2.6
Average Workers per Household	2.0	1.4
Average Vehicles per Household	1.3	1.7
Percentage of 16+ Who Drive	60.6	91.5
Percentage of 16+ in Labor Force	65.2	69.8
Percentage of Part-time Workers	22.7	18.7
Usual Distance to Work	9.5	13.2
Usual Time to Work	24.6	25.5
Percentage of Homeowners	16.1	72.3
Percentage of Renters	82.8	27.2
Average Daily Trips per Household	10.2	9.6

** New immigrants are defined as foreign-born persons living in the United States for 3 years or less.*

Source: 2001 NHTS.

Daily Travel Differences

The travel differences of new immigrants go beyond higher average workers per household, longer distances to work, and lower rates of vehicle ownership. While total household trip rates are higher for new immigrants due to higher household size, individually, new immigrants make fewer trips—about five trips a week less than U.S.-born residents.

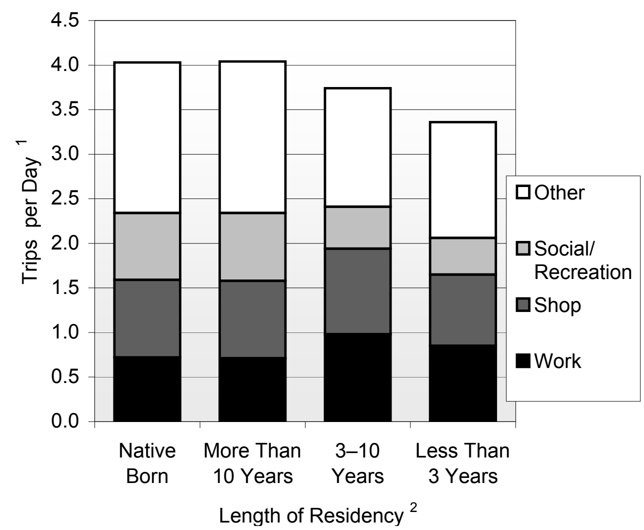
In addition, a higher proportion of their travel is work and work-related. *Exhibit 15-15* illustrates this phenomenon. While immigrants who have been in the United States more than 10 years show similar trip distributions to native-born residents, new immigrants take about 50 percent fewer trips for social and recreational purposes.

As compared with the U.S.-born population, new immigrants are also more dependent on transit and walking for all their daily travel and much less likely to drive alone. This difference in travel mode may be related to the acquisition of vehicles and driving skills. Non-Hispanic immigrants acquire vehicles faster than Hispanic immigrants, as shown in *Exhibit 15-16*. Even U.S.-born Hispanics are more likely to live in zero-vehicle households than other native-born residents.

One important reason for the slow acquisition of vehicles is that only about half of new immigrants

Exhibit 15-15

Distribution of Trips per Day in the United States by Purpose for Selected Categories of Length of Residency, 2001



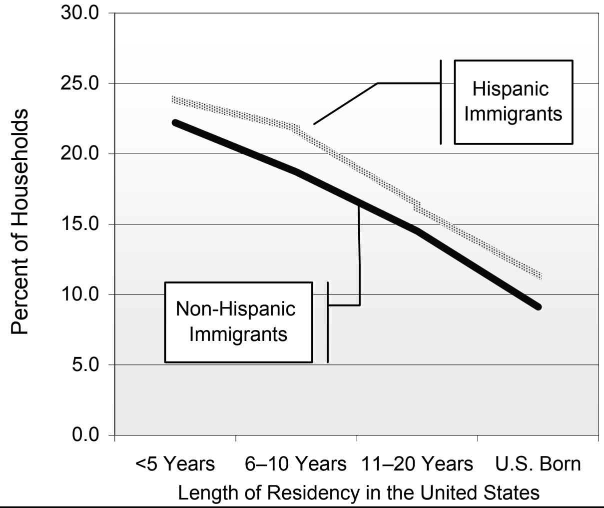
[1] Unweighted trips.

[2] More Than 10 Years n = 652,548; 3–10 Years n = 6,717; Less Than 3 Years n = 2,870.

Source: 2001 NHTS.

Exhibit 15-16

Distribution of Immigrant Households With No Vehicle Availability for Selected Categories of Length of Residency, 2000

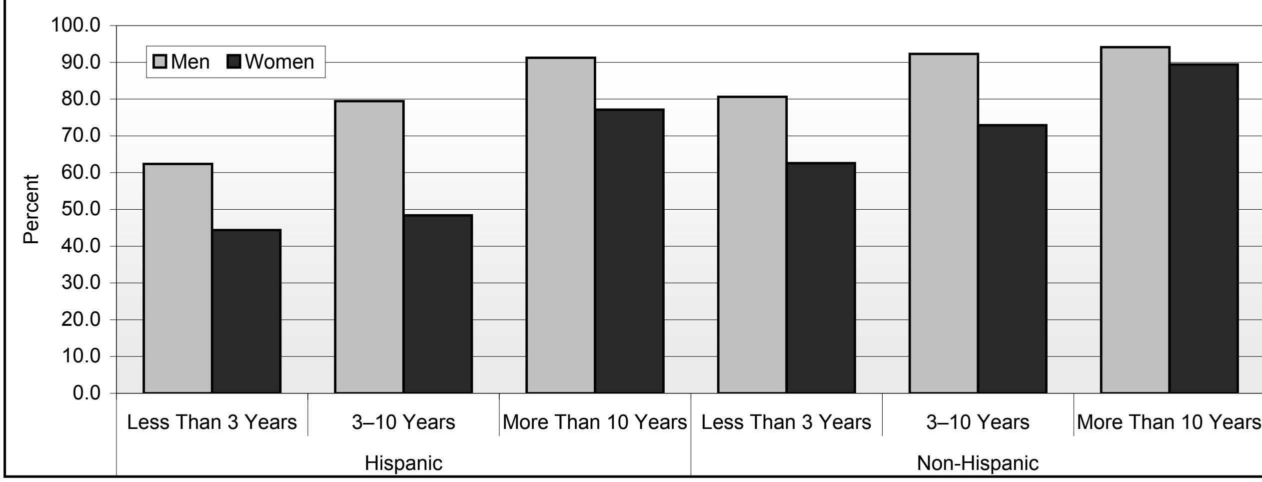


Source: Census 2000, U.S. Census Bureau.

are drivers, compared with 92 percent of adults in the United States. *Exhibit 15-17* shows the varied rates of drivers between Hispanic and non-Hispanic immigrants. In 2001, while non-Hispanic immigrant men reached U.S. driving rates after 3 years, Hispanic women were less likely to drive than other immigrants, even after 10 years in the United States.

Exhibit 15-17

Distribution of Hispanic and Non-Hispanic Immigrant Drivers for Selected Categories of Length of Residency, 2001



Source: 2001 NHTS.

Commuting

Work trips are the central focus of local transportation modeling and planning activities. In addition, congestion has become an important policy initiative at the national level. For these reasons, understanding commute patterns across population groups is important. Of great significance is the transit dependency of new immigrants. Immigrants are five times more likely to take transit to work than native–born residents. In some local areas, recent immigrants are a critical market for transit service.

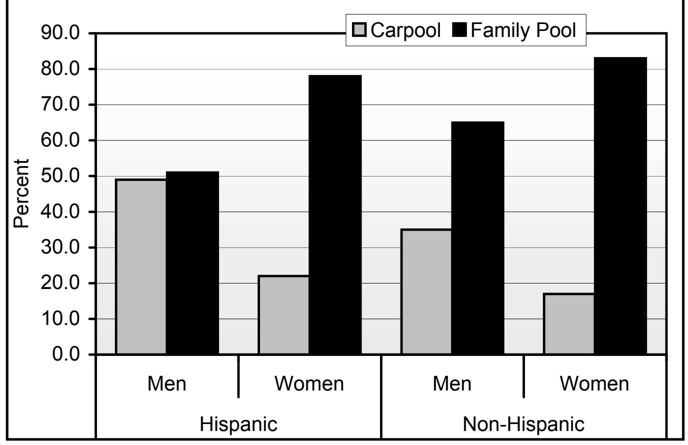
Another important insight about differences in commute patterns is the high use of carpools by Hispanic commuters, especially men. In many places, there are "formal" carpools, such as rideshares arranged through local programs consisting of workers from different households traveling together to a central location. Other arrangements include family carpools (fam-pools) that consist of people from the same household or family sharing a ride to work. Because the NHTS questionnaire specifically asks who was in the vehicle, fam-pools can be distinguished from other carpools. This differentiation is not possible with Census data.

These data shed light on the dynamics of vehicle sharing within a household. The NHTS shows that, of all multi-occupant trips to and from work, 68 percent were made up of two or more members of the same family or household. Women were more likely to be in fam-pools than men, often as part of couples traveling together.

However, as shown in *Exhibit 15-18*, marked differences existed between Hispanic and non-Hispanic commuters. Hispanic men are much more likely than non-Hispanic men or all women to share a ride to work.

Exhibit 15-18

Distribution of Commutes by Hispanic and Non-Hispanic Immigrants Using Carpools vs. Family Pools, 2001



Source: 2001 NHTS.

Policy and Planning Implications

America has always been a melting pot and, if current trends continue, immigrants will be a large portion of travelers on the Nation's roads and highways. The ethnicity of new immigrants has changed, adding a strong cultural influence to the traditional assimilation process. In addition, the location of first entry has shifted from center cities to the suburbs, potentially shifting demand for nonmotorized transportation services such as transit.

In 2001, the strong economy continued to create both high-paid and low-paid jobs. Immigrants from Latin America and Asia have been drawn to fill the demand for highly qualified technicians as well as low-skilled service workers. Based on recent trends, some economists project that both highly skilled and unskilled immigrants will be providing a larger share of the labor force in the future.

Especially for travel demand forecasting, growing immigration has both policy and planning implications as states and local areas develop travel forecasts and plan new transportation programs.

For example, the increase in immigration has created diverging trends in some key indicators of travel behavior. Forecasting based on mean indicators can mask these very different patterns. For instance, overall household size is declining, but new immigrants have significantly larger households than the aging white population.

Since immigrants are more transit-dependent and have higher auto occupancies, transportation initiatives focused on high occupancy vehicle (HOV) lanes and transit development can also benefit from understanding the travel behavior of this growing portion of the U.S. population.

As the U.S. society becomes more diverse, growth in travel demand will undoubtedly come from new immigrants. Therefore, the differences in travel behavior by immigrants have wide-reaching consequences for short-term and long-term policy development, planning, and travel demand forecasting.

Commuting for Life

All across the United States, more and more workers, in large metropolitan areas and in small towns, are spending an hour or more each way in their daily commute. One in 12 U.S. workers made these long commutes in 2001 (5.3 million workers). This is a significant increase from 1995 when one in 20 (3.4 million workers) commuted to work an hour or more each way. The distance of these long commutes is not always in the 50-mile range. In large cities, one out of 10 workers spends an hour or more each way to get to work, traveling at an average speed of just 27 miles per hour to go a distance of under 38 miles. *Exhibit 15-19* breaks down key characteristics for those workers with hour-long commutes.

Exhibit 15-19

Comparison of Characteristics of Workers With Hour-Long Commutes in Small and Large Cities

	Small Cities	Large Cities[1]
Average Percentage of All Workers with Hour-Long Commutes	4.3%	9.9%
Men	6.4%	11.4%
Women	1.8%	8.0%
Average Commute Length[2]	52.2 miles	37.7 miles
Average Commute Speed[2]	34.6 mph	26.9 mph

[1] Large cities are metropolitan statistical areas of 1 million in population or more; there are 49 of them in the United States.

[2] One-way trip.

Source: 2001 NHTS.

The number of hour-long commutes has skyrocketed, not because workers are taking jobs farther from home, but because the same commutes are taking longer. Commutes of 25 to 30 miles one way took 5 minutes more each day in 2001 than in 1995, adding up to 20 hours more commuting time over the course of a work year.

The men and women who travel at least an hour one way to work on average spent 2 hours and 48 minutes a day, or 14 hours per week, just traveling to and from work in 2001. This translates into significant time away from family, personal, community, and recreational activities for these workers.

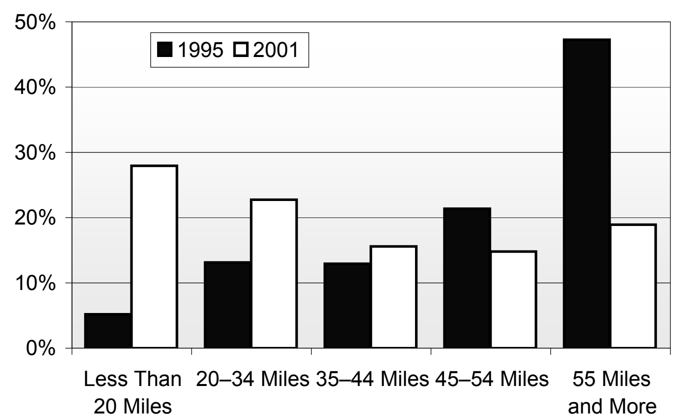
Urban Commutes

The number of workers in large cities who spend an hour or more for their commute is increasing at a faster rate than in non-urban areas. This is because the same commutes in large cities are taking significantly longer. As shown in *Exhibit 15-20*, change in travel distance for all commuters in large cities increased between 1995 and 2001, and trips of 55 miles or more increased from just over 80 minutes in 1995 to just over 100 minutes in 2001.

In addition, the distribution of hour-long commutes by the distance traveled has changed dramatically, as shown in *Exhibit 15-21*. In 1995, only 18.4 percent of hour-long commutes were less than 35 miles; but, by 2001, 50.7 percent of commutes of an hour or longer were less than 35 miles. At the same time, the proportion of hour-long commutes that are over 55 miles shrunk from 47.3 to 19 percent.

Exhibit 15-20

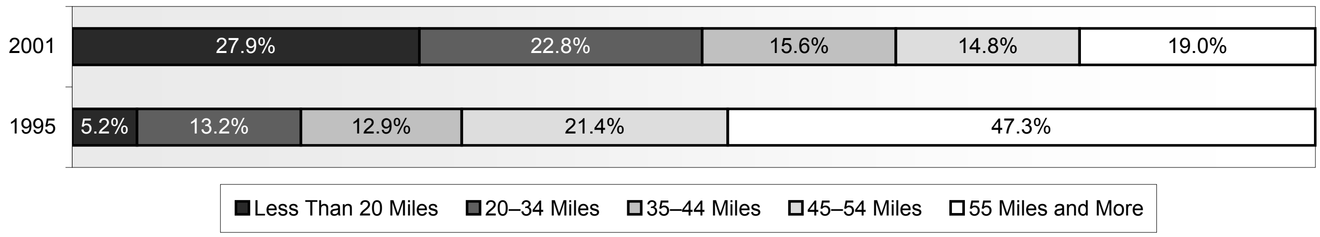
Change in Mean Travel Distance to Work for All Commuters in Large Cities Between 1995 and 2001



Source: 2001 NHTS.

Exhibit 15-21

Change in Miles to Work for Commutes of an Hour or Longer in Large Cities, 1995 and 2001



Source: 2001 NHTS.

Who Are the Workers With Hour-Long Commutes?

Workers with hour-long commutes are more likely to work in manufacturing (where mega-factories draw from a wide area for workers) or in professional and managerial occupations, as shown by *Exhibit 15-22*. Workers spending an hour or more to get to work have higher incomes on average—perhaps they travel farther for better pay or need more money to balance out the time and expense of these very long commutes.

These workers are more likely to have children, especially young children. Suburban and rural homeowners are more likely to have hour-long commutes than urban homeowners. Workers with hour-long commutes also work at home more often than commuters who spend less time traveling for work.

Exhibit 15-22

Characteristics of Workers by Commute Time, 2001

	Percent of Workers With Average Commutes (<60 min)	Percent of Workers With Commutes of 60 min or More
Occupation		
Sales and Service	25.6%	18.0%
Clerical/Admin	13.3%	10.8%
Manufacturing	20.0%	24.9%
Professional/Managerial	40.2%	43.9%
Telecommuting		
Works at Home Often	3.0%	4.1%
Works at Home Occasionally	3.6%	6.0%
Life Cycle		
No Children	46.3%	40.7%
Young Children	43.6%	50.6%
Teens	10.1%	8.7%
Income		
$50,000 or Less	46.9%	43.5%
$50,000–$100,000	28.0%	29.3%
$100,000 or More	15.4%	18.7%
No Report	9.7%	8.5%

** Works at home "often" means once a week or more and "occasionally" means at least once in the last 2 months.*

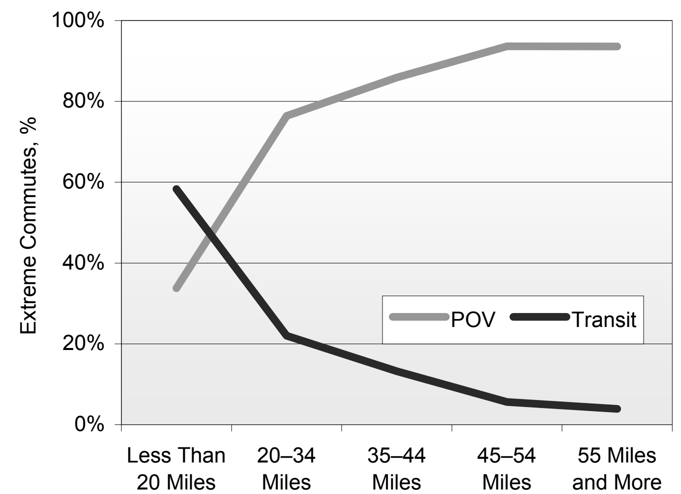
Source: 2001 NHTS.

The commuters who travel an hour or more one way leave earlier for work than other workers. In 2001, more than one-quarter of these workers (24 percent and 28 percent in large cities and small towns, respectively) left before 6 a.m. for their trip to work. In comparison, only 12 percent of workers with shorter commute times left this early. Although hour-long commuters were more likely to be men, the departure times for men and women are equally skewed toward the very early morning.

As shown by *Exhibit 15-23*, sixty percent of the commutes of less than 20 miles that take an hour or longer were on transit (total door-to-door time including walk, wait, and transfer times). For trips over 20 miles, however, the commutes were far more likely to be in a private vehicle.

Exhibit 15-23

Mode Split of Commutes of an Hour or Longer, 2001



Source: 2001 NHTS.

How much time are workers losing to family and community life, let alone productive work time, due to increased travel times? The 2001 survey shows that one out of 12 commuters spent an average of 2 hours and 48 minutes a day traveling to and from work, in addition to the 8 or more hours on the job. If congestion continues to worsen, more and more workers will be experiencing the strain of an hour-long commute.

Sound congestion reduction strategies, such as those currently being implemented by the DOT, can make a real difference in the quality of life for millions of Americans. For example, one of the initiatives seeks expanded telecommuting options. If each of these workers could telecommute 1 day a week, in a year they could save over 145 hours, or the equivalent of three and a half weeks of work—more free time than most workers take for an annual vacation.

Congestion: Non-Work Trips in Peak Travel Times

Travel to work has historically defined peak travel demand and, in turn, influenced the design of the transportation infrastructure. Commuting is a major factor in metropolitan congestion. According to the 2001 NHTS, 85 million workers (two-thirds of all commuters) usually left for work between 6 a.m. and 9 a.m., and over 88 percent of these workers traveled in private vehicles. However, as shown in *Exhibit 15-24*, a significant number of non-work vehicle trips were made during peak periods, which complicates the issue of congestion management.

The amount of travel for non-work purposes, including shopping, errands, and social and recreational activities, is growing faster than work travel, a shift that is important for understanding trends in congestion. Growth in these kinds of trips is expected to outpace growth in commuting in the coming decades.

Understanding the overlap of work and non-work travel during the peak travel periods is critical for finding cures for congestion. Primarily, these non-work trips are to drop or pick up a passenger, shop, or run errands.

More than half of peak period person trips in vehicles were not related to work [*Exhibit 15-24*]. The balance has changed substantially since the 1990s. On an average weekday, non-work travel constituted 56 percent of trips during the AM peak travel period and 69 percent of trips during the PM peak.

After traveling to work and giving someone a ride, the next largest single reason for travel during the peak period was to shop, including buying gas and meals. In fact, as shown in *Exhibit 15-25*, more than 20 percent of all trips made during peak travel periods were solely to shop, not shopping trips made during a commute.

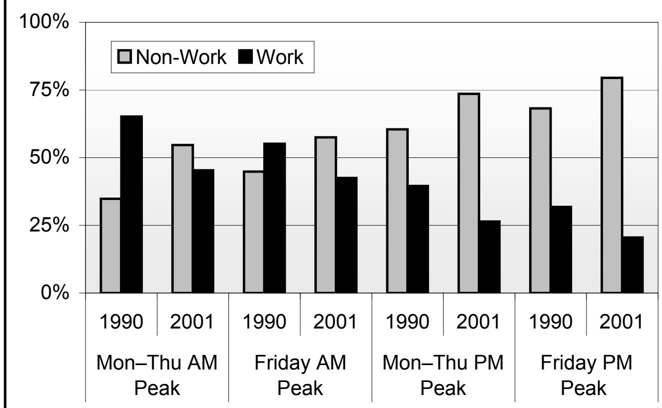
In addition to these separate peak period shopping trips, a number of workers stopped to shop, including getting coffee or a meal, during the commute—and this behavior (trip chaining) is increasing.

The 2001 survey showed that since 1995, 25 percent more commuters stopped for incidental trips during their commutes to or from work, and stopping along the way is especially prevalent among workers with the longest commutes.

Commuters stop for a variety of reasons, such as to drop children at school or to stop at the grocery store on the way home from work. This is described by *Exhibit 15-26*. Real-life examples show that trip chaining is often a response to the pressures of work and home. But, the data also show that some of the growth in trip chaining results from grabbing a coffee or meal (the Starbucks effect), activities that historically were done at home and did not generate a trip.

Exhibit 15-24

Distribution of Non-Work Trips and Work Trips During Peak Commute Periods, 1990 and 2001

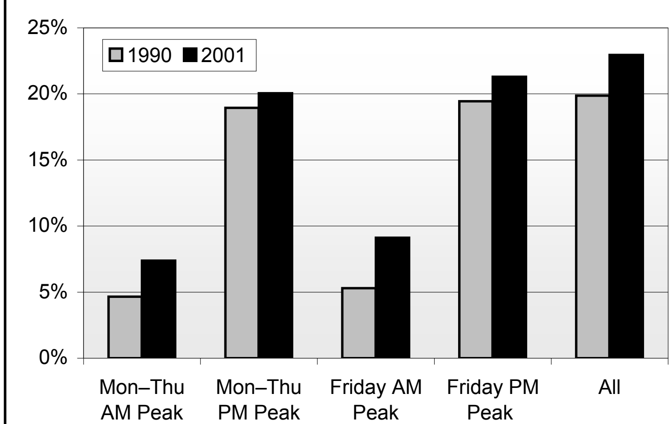


AM Peak = 6:30–9:00 a.m.; PM Peak = 4:00–7:00 p.m.

Source: NHTS Data Series.

Exhibit 15-25

Distribution of Shopping Trips During Peak Commute Periods, 1990 and 2001



AM Peak = 6:30–9:00 a.m.; PM Peak = 4:00–7:00 p.m.

Source: NHTS Data Series.

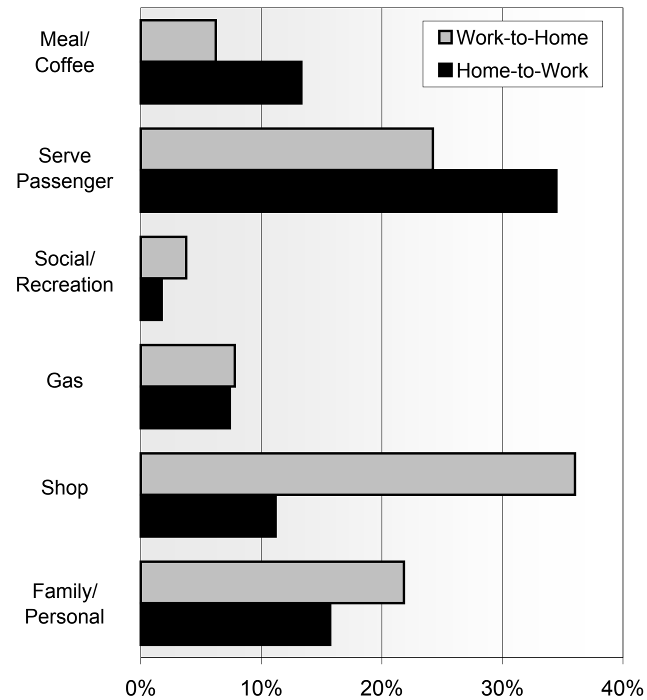
The overall growth in travel for shopping, family errands, and social and recreational purposes reflect the busy lives and rising affluence of the traveling public. The growth in non-work travel is not only adding to the peak periods but expanding congested conditions into the shoulders of the peak and the midday. *Exhibit 15-27* describes the distribution of person trips by start hour for several types of trip purpose.

On an average weekday, the number of trips for family and personal errands, including shopping, is far greater than commutes or trips for school. This is true from 8 a.m. throughout the rest of the day. The mountain of travel during the midday builds to the PM peak, where the commute home, errands, and social/recreational travel all intersect.

The issue of urban congestion is complex, and effective solutions cannot be realized by focusing on the work trip alone. A comprehensive policy response is required. Understanding the determinants of travel demand provides a basis for developing effective congestion relief strategies.

Exhibit 15-26

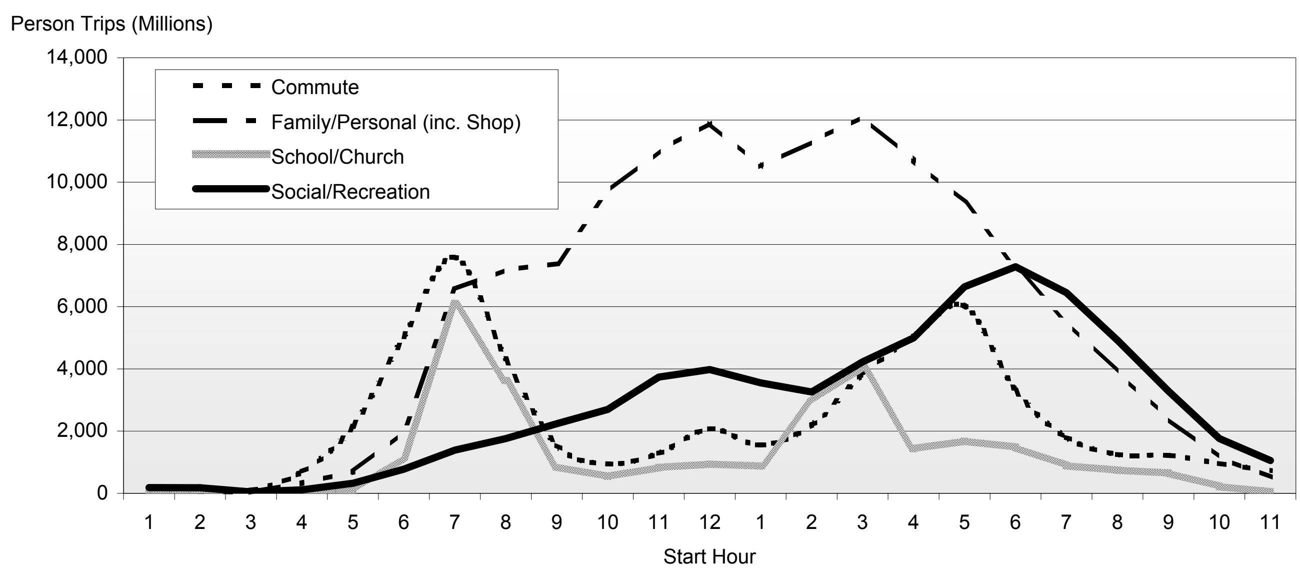
Distribution of Stops by Purpose During Weekday Commutes, 2001



Source: 2001 NHTS.

Exhibit 15-27

Distribution of Person Trips by Start Hour for Four Categories of Trip Purpose, 2001



Source: 2001 NHTS.

Congestion: Who is Traveling in the Peak?

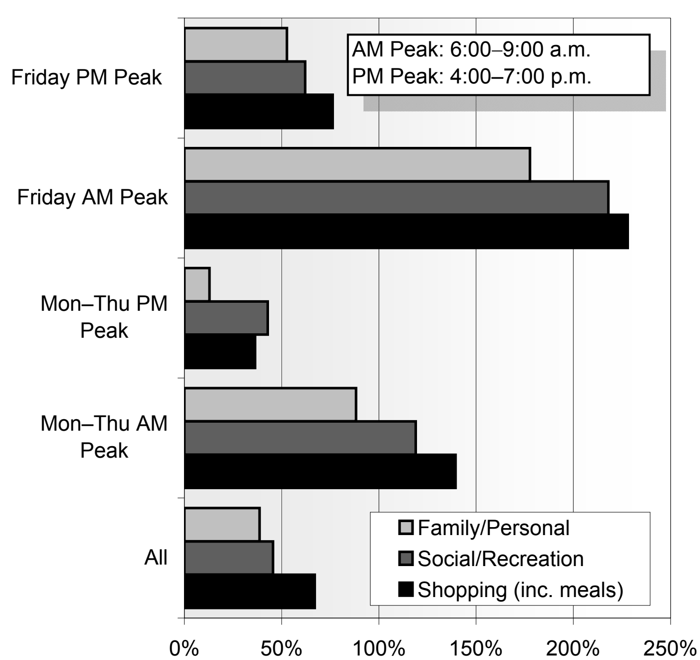
As noted above, the number of non-work trips that are occurring during peak weekday commute hours is growing. Understanding who is making these trips and for what purposes is important as the transportation community explores several congestion mitigation strategies in large urban areas and throughout the U.S. transportation system.

It is important to examine the trends, amount, and characteristics of non-work vehicle trips during the peak periods. The average American is taking approximately four more trips a week than a decade ago for non-work purposes; travel for eating out, recreational activities, and shopping have all increased.

Travelers know that Friday peaks are the worst. According to the NHTS, the level of non-work travel during the Friday AM peak grew by almost 200 percent between 1990 and 2001. Surprisingly, typical workday peak periods are also experiencing increased non-work travel. As shown in *Exhibit 15-28*, Monday through Thursday peak period non-work vehicle trips increased by 100 percent in the AM peak and 35 percent in the PM peak.

Exhibit 15-28

Percent Growth in Peak Period Vehicle Trips for Non-Work Purposes, 1990-2001



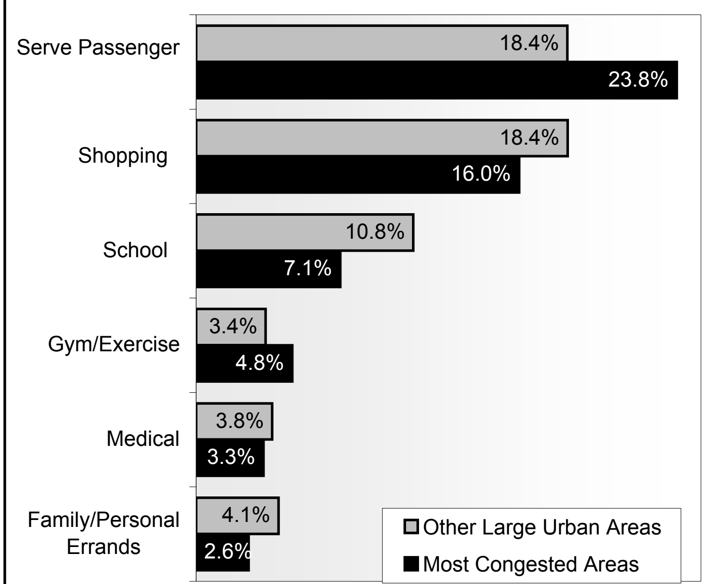
Source: NHTS Data Series.

Besides commuting to work, people travel during the peak to take their child to school, run out to buy milk before work, go to the gym, arrive at the doctor's office early to avoid a wait, or pick up their dry cleaning. *Exhibit 15-29* shows the relative proportion of these kinds of vehicle trips during the AM peak that were not incidental stops during a commute. Such incidental stops are defined as 30 minutes or less. Hence, most trips to the doctor's office or gym are included in *Exhibit 15-29*, while a short stop to drop a child at school while the driver continues on to work is not.

Also shown in *Exhibit 15-29* is a comparison of these AM peak trip purpose distributions for the 13 most highly congested areas (as defined by the Texas Transportation Institute) and other large urban areas. About 44 percent of all vehicle trips in both congested areas and other areas made during the AM peak were not to work or related to a work trip. However, the 13 areas with the worst congestion had slight shifts in the relative purposes of non-work trips. In the most congested areas, travelers were less likely to make school and shopping trips during peak periods and more likely to drive a passenger somewhere or go to the gym.

Exhibit 15-29

Distribution of AM Peak Period Vehicle Trips Unrelated to Commute in Congested Areas



Source: NHTS Data Series.

Note: About 44 percent of all vehicle trips in both congested and other areas made during the AM peak are not to work or related to a work trip. The graph shows the most common purposes adding up to about 60 percent of all non-work trips; miscellaneous other purposes account for the remaining 40 percent.

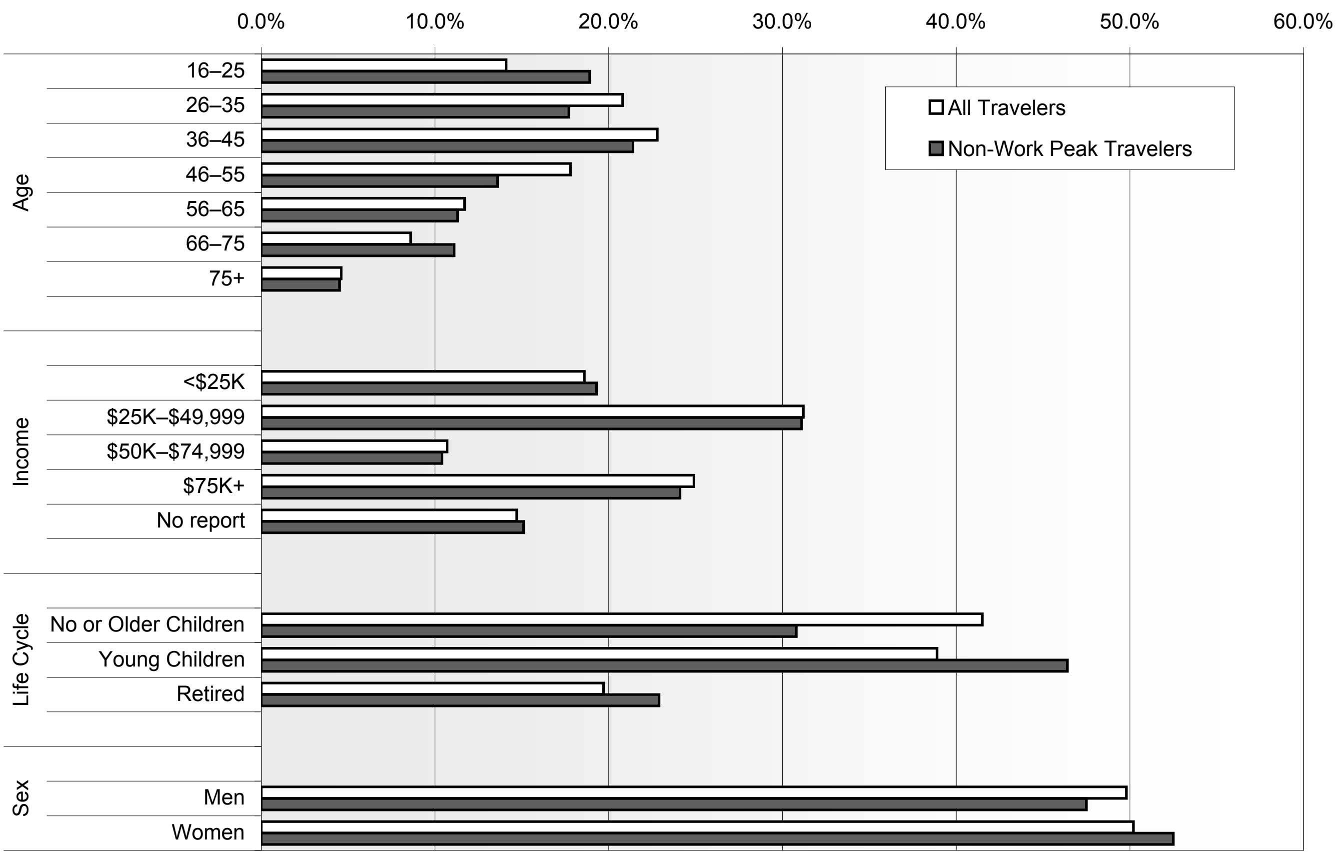
Exhibit 15-30 shows the traveler characteristics of people making non-work trips during the peak as compared with all travelers. While persons between the ages of 36 and 45 made up 23 percent of all non-work peak travelers, persons 16 to 25 and over the age of 65 were more likely to make non-work trips during peak periods as compared with their total travel.

Income has little effect on the propensity to make non-work trips during peak periods; however, life-cycle is an important factor. People with young children at home made up 39 percent of all travelers and more than 46 percent of travelers making non-work trips during peak periods. In comparison, 31 percent of non-work peak travelers had no children in the home and 23 percent were retired. Women were slightly more likely than men to make non-work travel during the peak.

The number of non-work trips during the AM peak for all areas, large and small, and the average trip distances, are shown in *Exhibit 15-31*. Dropping a passenger was the driver's purpose for 3.6 billion vehicle trips, adding 21.2 billion VMT to the AM peak. More than 78 percent of the trips to drop someone (serve passenger) involved driving children to school. The remaining 12 percent of serve passenger trips were to drop someone at work.

Exhibit 15-30

Distribution of Travelers Across Selected Survey Categories, 2001



Source: 2001 NHTS.

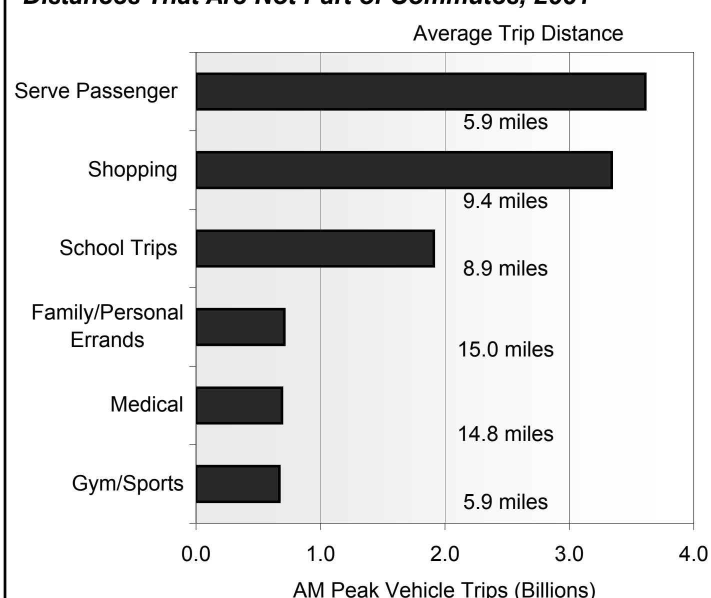
Shopping (including getting a meal) was the driver's purpose for 3.3 billion vehicle trips, adding 31 billion VMT to AM peak volumes.

The characteristics of people who made non-work trips in the AM peak varied by the type of trip, as illustrated by *Exhibit 15-32*. While most were workers, a larger portion of the people dropping passengers were women, and a larger portion of the people shopping (including getting a meal) were men. Nearly 80 percent of the people who dropped a passenger during the AM peak lived in households with young children. Retired people were more likely to shop or go to the doctor's office.

The demand side of congestion begins with people—who they are, what they need to accomplish in a day, and when they choose (or have time) to travel. In dealing with daily

Exhibit 15-31

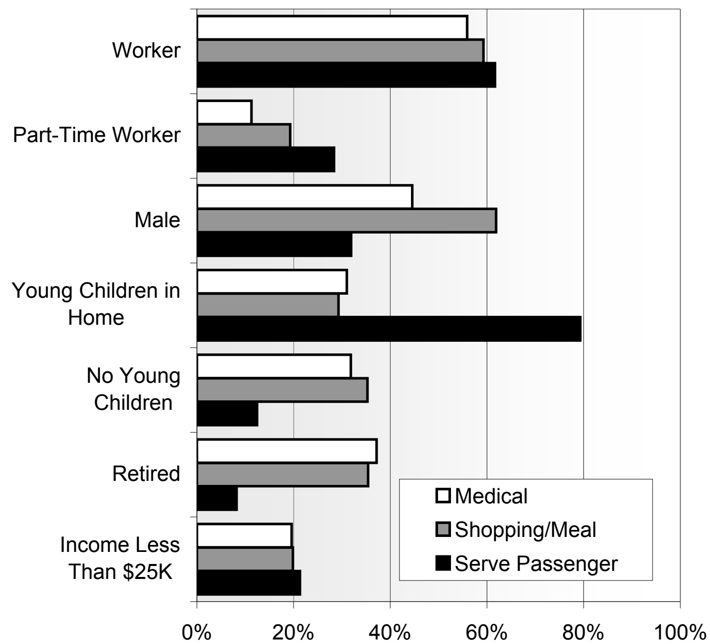
Morning Peak Vehicle Trips and Average Trip Distances That Are Not Part of Commutes, 2001



Source: 2001 NHTS.

Exhibit 15-32

Characteristics of People Making Morning Peak Vehicle Trips by Purpose, 2001



Source: 2001 NHTS.

congestion, people may change the routes or the times they travel. Some make changes in where they live or work. Every day people calculate how to accomplish all that they need to do, and understanding travel behavior means trying to understand the interrelation of people's complex choices and the transportation system.

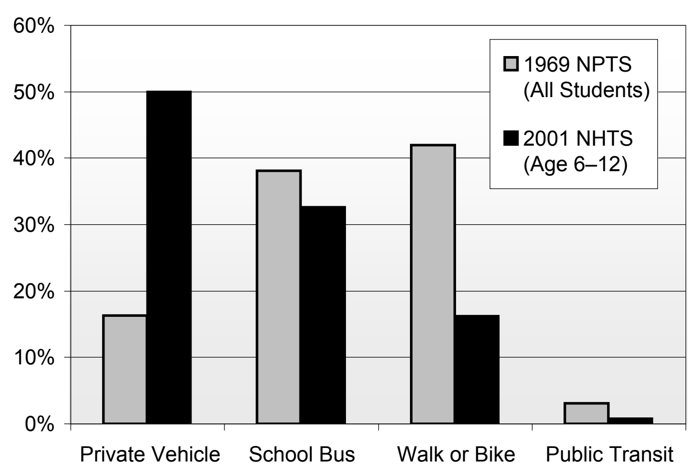
Travel to School: The Distance Factor

Like all trip-making, travel to school has changed dramatically over the past 40 years. The change that is most apparent is the increase in children being driven to school. In 1969, about 15 percent of school children ages 6 to 12 arrived at school in a private vehicle; in 2001, half of all school children were driven to school. *Exhibit 15-33* shows how children's travel to school has changed since 1969.

One factor underlying this change is the increased distance children travel to school. In 1969, just over half (54.8 percent) of students lived a mile or more from their schools. By 2001, three-quarters of children traveled a mile or more to school. *Exhibit 15-34* shows the dramatic change in trip distance to school for children ages 6 to 12.

Exhibit 15-33

School Arrival Modes for Children, 1969 and 2001

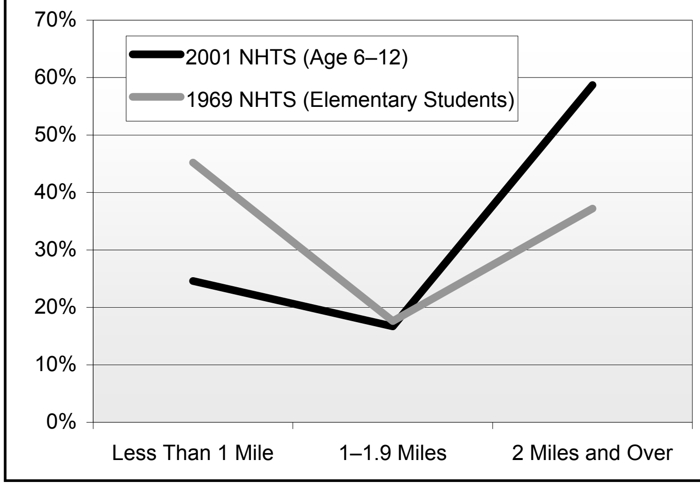


Source: NHTS Data Series.

Some of the change in distance may result from suburbanization and larger school districts. In 2001, 21.9 percent of students ages 6 to 12 lived within a mile from school in urban areas[4] compared with just 2.7 percent of students in rural areas (20 percent of the U.S. population lives in rural areas).

Exhibit 15-34

Distribution of Children Traveling to School Across Selected Distance Categories, 1969 and 2001



Source: NHTS Data Series.

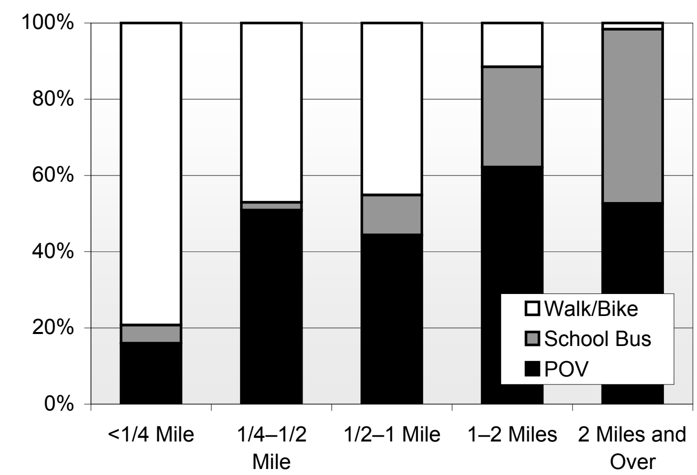
According to independent research using the NHTS data series, distance is one of the major factors in the shift in mode to private vehicle by schoolchildren.[5] This research also found that safety and security concerns are significant factors in parents' decisions to let their children walk to school, especially girls.

Other possible factors impacting the percentage of children biking or walking to school include the use of before- and after-school child care, availability of sidewalks, and inclement weather. The importance of these issues is being examined in the Safe Routes to Schools Program and in the 2008 NHTS.

As children live farther from school than in the past, it is not surprising that the mode of travel to school has changed. *Exhibit 15-35* shows the mode of travel by distance for school trips in 2001.

Exhibit 15-35

Mode of Travel to School for Children 6 to 12 Years of Age for Selected Distances, 2001



Source: 2001 NHTS.

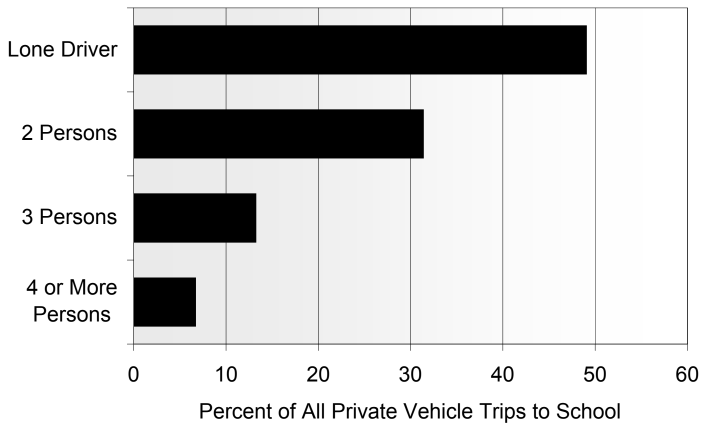
The distribution of these major modes (transit and "other" have been excluded) shows clearly that the majority of school trips of less than one-quarter mile were made by walking or biking. However, for trips between one-quarter and one-half mile, the private vehicle accounted for half, and POV was the dominant mode for school trips over 1 mile (in 2001, 75.4 percent of all school trips by children 6 to 12 were over 1 mile).

School trips by students ages 16 to 18 also were predominantly by private vehicle. Over three-quarters (76.9 percent) of all trips to school for children ages 16 to 18 were by private vehicle. This age group traveled farther to school than younger children, with an average distance of 6 miles compared with 3.6 miles for children ages 6 to 12. *Exhibit 15-36* shows that, of those private vehicle trips, half were driven alone, 31.3 percent were two-party trips, 13.4 percent had three persons, and 6.6 percent had four or more people.

Policies and programs that encourage walking and biking to school, especially for grade school children, need to account for the number of eligible walkers and bikers (living within a mile of school) along with the barriers to walking and biking such as security concerns of parents.

Exhibit 15-36

Distribution of Private Vehicle Trips to School by Students 16 to 18 Years of Age, by Traveler Count, 2001



Source: 2001 NHTS.

Endnotes

[1] Further information can be found on the NHTS Web site: http://nhts.ornl.gov/.

[2] U.S. Census Bureau, February 2003.

[3] U.S. Census Bureau, December 2003.

[4] Urban areas are defined by the Census Bureau as one or more place ("central place") and the adjacent densely settled surrounding territory ("urban fringe") that together have a minimum population of 50,000 personal. All other areas are "rural."

[5] McDonald, Noreen. 2008. "Children's Mode Choice for the School Trip: The Role of Distance and School Locations in Walking to School." *Transportation*, Springer Netherlands, January.

PART IV

Afterword: A View to the Future

Introduction

The data and analyses presented in this 2008 C&P Report are based on tools and techniques that have been developed over many years (in some cases even predating this report series). This process has produced models and data collection techniques that have evolved over time to reflect changing priorities and the most recent surface transportation research to the greatest extent possible. At the same time, there are areas of opportunity to improve our understanding of the physical conditions and operational performance of the Nation's surface transportation infrastructure, and in our analyses of future investment requirements.

This afterword is intended to discuss the gap between our current state of knowledge and the type of information that would be necessary and desirable to further improve this understanding. This section highlights issues and challenges that Federal, State, and local governments face in measuring infrastructure conditions and performance and, in doing so, helps point out some of the important limitations of the analyses that are presented in this report. Because many of these issues are fundamental or long term in nature, much of the discussion presented is carried over from previous editions of the C&P report.

A common theme running throughout this section is the importance of high-quality transportation data and the impact that data quality has on the analytical capabilities of the models that are used in the production of this report. In this context, data quality has many dimensions, including reliability, geographic depth and scope, and appropriateness for the types of analyses being undertaken. Many of the limitations of the current methodologies described here and elsewhere can ultimately be traced to limitations imposed by current data sources. In order to make significant improvements to the analyses based on these limitations, changes or improvements in data collection would be required to support revised analytical procedures. However, although more and better data are always desirable from the analyst's perspective, any improvements in this area must be balanced against the additional costs of collecting such data. Since most of the data used in this report are supplied to the Federal government by State and local government entities, issues relating to the cost of data collection, intergovernmental relationships, and the role played by each level of government in managing surface transportation assets must also be considered in determining what types of data collection are appropriate.

Q&A

What research efforts does FHWA currently have underway concerning the data used to support the analyses in this report?

The HPMS is the primary data source for many of the highway characteristics, conditions, and performance metrics shown in Chapters 2, 3, and 4. The HPMS sample data set is also the primary data input for HERS, which was used to generate the analyses of future investment for this report (see Appendix A). FHWA has just completed a comprehensive reassessment of the entire HPMS data collection process that began in January 2006. The HPMS Reassessment explored data collection methodologies, reporting requirements, data definitions, and the changing requirements of data users.

Because of the close connections between HPMS and the C&P report, the reassessment has carefully considered many of the conditions and performance measurement issues and potential analytical improvements discussed in this Afterword section, including pavement modeling, capacity analysis, safety analysis, and data coverage. Throughout the Reassessment, FHWA has worked closely with the State suppliers of the HPMS data to determine the feasibility of collecting new or modified data in these and other areas, using regional workshops, Web meetings, and other outreach tools. FHWA has also opened a docket to provide information and receive feedback from the public on any proposed changes to HPMS, which can be accessed at http://www.regulations.gov/search/index.jsp.

Most of the changes to HPMS would begin to be implemented beginning in 2009 for submittal to FHWA in 2010, and would thus be reflected in the 2010 data presented in the 2012 edition of the C&P report.

In addition to discussing data issues, this section examines a number of conceptual, analytical, and informational issues relating to the C&P report where significant opportunities for improvement exist. For many of these areas, similar issues arise for both transit and highways, though in somewhat different contexts. The issues discussed here are similar to those addressed earlier in this report, including the physical condition of the infrastructure; capacity, operations, and operational performance; safety and security; travel demand, revenue, and finance; and multimodal analysis. This afterword concludes with a discussion of the analytical approaches used in the report, including the scope and presentation of the report analyses, and discusses ways in which the tools and techniques developed for the report can be used for other policy analyses.

A number of question and answer boxes are also included in this section, describing ongoing research projects sponsored by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) that may address the issues raised here. Some of these research projects also help to keep existing procedures up to date with current research in the field. These projects are sponsored by the offices tasked with preparing the C&P report and are intended to directly affect the analyses and content of the report. It is important to note, however, that many other research activities sponsored by other organizational units within the U.S. Department of Transportation (DOT)—including the Office of the Secretary of Transportation—relate to some of these same areas. Selected research activities of the Office of the Secretary of Transportation's Office of Economic and Strategic Analysis under the Assistant Secretary for Transportation Policy, of the FHWA Office of Operations, and of the FHWA Office of Interstate and Border Planning are identified in callout boxes within this section.

In the discussion that follows, it is important to bear in mind that many conceivable and desirable improvements to the methodology may not always be practical because of either their complexity or their unrealistic data requirements. In some cases, improving one part of the analytical procedures can cause complications in other areas, introducing further uncertainty to the analysis. It should also be remembered that even a technically perfect analytical approach would always be inherently imprecise when forecasting long-term investment needs because future trends in transportation, technology, and the economy as a whole cannot be projected with certainty. At the same time, it is helpful to describe that ideal in order to ensure that future development work will bring us closer to that goal.

The analyses presented in the C&P report reflect the results of an aggressive program of research in recent years that is aimed at improving the analytical capabilities of the underlying models. A number of such research projects initiated using discretionary research funds made available under the Transportation Equity Act for the 21st Century (TEA-21) are still ongoing and will produce enhancements to the models that will refine the analyses presented in future editions of the report. Since the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), new research efforts in this area have been significantly scaled back. Therefore, the implementation of many of the new concepts discussed in this section should be viewed as a long-term effort that would likely need to be phased over an extended period of time.

While this afterword is intended to provide a fairly comprehensive discussion of these issues and reflect U.S. DOT's current thinking about them, it is not intended to be the last word on the subject. There are certainly other issues worthy of discussion and other potential solutions to some of the impediments to improved analysis that are identified here. Instead, the intent is to help frame the discussion and spur dialogue among U.S. DOT, stakeholders, and researchers in devising improvements to the analytical processes used in the production of this biennial report.

Conditions and Performance

Significant strides have been made over the last decade regarding our understanding of transportation system conditions and performance; however, there is considerable work yet to be done. The outstanding gaps in our knowledge include the measurement of conditions and performance, modeling conditions and performance in investment analysis, and understanding the relationships between conditions and performance measures and transportation user costs.

System Condition

Highways and Bridges

The FHWA currently collects and uses data based on the International Roughness Index (IRI) as its primary indicator for pavement condition. This measure has certain advantages, such as its objectivity and its direct impact on users of the road. However, concerns have been raised about its sufficiency as an all-encompassing indicator of pavement distress because it may not adequately reflect pavement structural problems that do not manifest themselves simply through roughness. There are also concerns that the pavement performance models currently being used may not fully reflect modern pavement design. This is particularly important in light of ongoing efforts to increase the useful life of pavement improvements. As part of the recent HPMS reassessment, the range of pavement data collected will be expanded to include information on other pavement distresses, as well as additional information regarding the structure of existing pavements. This new information will facilitate the development of improved models of pavement deterioration over time resulting from traffic loads and environmental factors.

The HERS currently considers only two types of pavement improvements: resurfacing and reconstruction. The addition of new pavement data items and performance modeling procedures could potentially allow for additional pavement improvements to be considered, including different degrees of reconstruction, different levels of resurfacing, and less aggressive pavement preservation techniques. As discussed in Chapter 7, the investment scenarios estimated in this report are for capital expenditures only and do not include ongoing routine maintenance. However, both FHWA and State departments of transportation are paying increasing attention to preventive maintenance strategies as a means of extending the useful life of pavement improvements. To the extent that such strategies are successful, they can reduce the need for capital improvements to address pavement condition deficiencies, an effect that the investment models should account for where possible. At a minimum, the models ought to be able to distinguish between the effects of standard preventive maintenance activities (presumably already captured) and more aggressive preventive maintenance strategies. Optimally, they would be able to directly evaluate the benefits, costs, and trade-offs between preventive maintenance and capital improvements.

Condition measurement and modeling issues also exist for bridges. As discussed in Chapter 3 and Appendix B, bridge condition indicators and bridge rehabilitation and replacement investment analyses are based on data from the National Bridge Inventory (NBI). These data are derived from bridge inspections and are reported for different major bridge components; however, in many cases, the data in the NBI are aggregated from more detailed element-level data. Since the structural deterioration models used in the National Bridge Investment Analysis System (NBIAS) are employed at the element level, such element conditions must be inferred from the aggregated component data. This presents the obvious question of whether it might make sense to directly collect the element data and use them in NBIAS.

Another bridge data issue concerns the types of distresses that are currently being evaluated. As with pavement condition, other structural distresses exist that are not currently being modeled or measured directly. Substructure deterioration attributable to scour and vulnerabilities to seismic events are both important factors in long-term bridge performance that are not considered in NBIAS, except to the extent

What research projects do FHWA and FTA currently have underway to improve the modeling of conditions and performance?

Q&A

Current FHWA research projects on conditions and performance include the following:

- Implementation of new pavement equations for HERS. The FHWA is refining a set of new pavement deterioration equations for the HERS model based on the Mechanistic-Empirical Pavement Design Guide issued by the American Association of State Highway and Transportation Officials. This project represents the final phase of a multiyear effort to evaluate the types of pavement data and pavement modeling procedures currently in use at State highway agencies. The new equations will take advantage of new pavement data items collected through HPMS to develop more analytically rigorous estimates of future pavement performance for use in the 2012 edition of the C&P report.
- Safety model improvements. As a step toward improving the estimation of the safety cost impacts of highway improvements, FHWA is examining recent research linking average speeds and other highway characteristics to crash rates and severity. One goal of this project is the development of new equations for urban two-lane roads for use in the 2010 edition of the C&P report.

Current FTA research on conditions and performance includes the following:

- Decay Model Improvements. Beginning in 1999, FTA initiated a program to collect consistent transit conditions data from across the country that are representative of the national experience. To date this research has yielded new asset decay relationships for bus and rail vehicles and related maintenance facilities and stations. Further, in 2008, FTA conducted a trackwork decay analysis workshop with representatives from seven transit agencies. Findings from these workshops will be incorporated into TERM for use in the 2010 edition of the C&P report.
- Facility Betterment Improvements. The FTA is refining how TERM looks at the replacement and rehabilitation of maintenance facilities. The primary source of TERM's under-prediction is that TERM replaces facilities "in-kind" while actual facility replacements by local agencies typically include some type of betterment (e.g., rehabbed/replacement facility is larger and/or better equipped). The FTA conducted eight site visits to gather and examine data relating to recent bus and rail facility rehabilitation and replacement projects. Findings from this analysis will be incorporated into TERM for use in the 2010 edition of the C&P report.
- Commuter Rail Requirements. Prior to 2008, many of the unit costs used to estimate commuter rail investment needs were derived from heavy and light rail costs. As a result of differences identified and addressed between modal asset components, modification of unit costs within TERM will be examined that would result in the ability for FTA to more accurately predict commuter rail investment needs. Findings from this analysis will be incorporated into TERM for use in the 2010 edition of the C&P report.

that scour affects the substructure condition ratings in the NBI. Questions of how such measurement should be done and the extent to which other measures might pick up such factors are part of the research agendas of the FHWA Offices of Policy, Infrastructure, and Research and Development.

Another bridge condition modeling issue relates to concerns about aging infrastructure. As discussed in Chapter 3, a significant portion of the Nation's bridges fall into the 40- to 60-year age range and may be nearing the end of their anticipated design lives. The age of a bridge, however, is not directly considered in the bridge condition modeling approach used by FHWA, which is based on bridge management systems used by a majority of States in the United States. Is this a glaring oversight, or is this a more accurate representation of bridge deterioration than conventional wisdom might suggest? The important, unknown factor is the impact that minor and major rehabilitation work can have on extending the useful life of bridges. Is it possible to postpone the ultimate replacement of bridges indefinitely through such timely investments and interventions, or do aging and loadings ultimately necessitate replacements regardless? If so, what historical data are available to determine which bridges of a given age have received such treatments and which have not, and could these be incorporated into the models instead?

A final area for improving our understanding of pavement and bridge conditions concerns the relationship between conditions and the costs borne by highway users and transportation agencies. How do agencies respond to different levels of pavement and bridge distress in terms of routine maintenance or capital maintenance expenditures in order to keep their facilities in operable condition? What is the actual relationship between pavement or bridge deck conditions and highway operating speeds? The impact of pavement roughness on vehicle operating costs has been documented in the past, but the studies are now more than two decades old; is new original research in this area warranted? Also, for bridges, one of the most significant impacts of deteriorated condition is that vehicle weight limitations may have to be imposed in order to maintain an acceptable margin of safety, potentially forcing some commercial vehicles to be diverted. Can such postings be quantitatively connected to bridge condition metrics? How should such potential user impacts be incorporated into estimates of the cost savings associated with pavement and bridge preservation improvements?

The ultimate rationale underlying much of the Federal highway bridge inspection and improvement program is to facilitate early actions in order to minimize the likelihood of a catastrophic failure. While the probability of such failures is low, the cost of such events is extremely high. Could this be a factor in explaining why State and local governments might appear to be overinvesting in bridge maintenance and rehabilitation in some areas? If so, should bridge modeling approaches directly incorporate such risk analysis?

Transit

The FTA uses a numerical scale ranging from 1 to 5 to describe the condition of transit assets. This scale corresponds to the Present Serviceability Rating formerly used by the FHWA to evaluate pavement conditions and is similar to condition rating systems used by some of the Nation's larger transit agencies.

The FTA has developed the Transit Economic Requirements Model (TERM) to estimate current transit asset conditions and the level of investment required to maintain and improve these conditions. The TERM is composed of a database of transit assets and deterioration schedules that express asset conditions as a function of an asset's age, utilization rate, and maintenance history. TERM has five major categories of assets—vehicles, stations, maintenance facilities, systems, and guideway. Deterioration schedules are estimated for more specific asset types within each major asset category.

Most of the condition data used to estimate the deterioration curves in TERM have been collected through on-site physical surveys. These on-site surveys were begun in the late 1990s, beginning with bus vehicles and continuing, through 2004, with rail vehicles, bus and rail maintenance facilities, and rail stations. Inspections of train control, communications, and electrification systems were conducted over the period from 2005 to 2007. In most cases, the assets modeled are composed of a more detailed set of components, each of which are examined and rated in the surveys. TERM has more than 50 estimated decay curves. The final asset condition rating for each asset is an average of the conditions of its subcomponents.

The decay curves in TERM were initially based on data collected by the Regional Transportation Authority of Northeastern Illinois and the Chicago Transit Authority in the 1980s and 1990s and, to a lesser extent, on data collected by the Metropolitan Commuter Rail Authority (Metra) and the suburban bus authority (Pace). The guideway deterioration schedules in TERM are still based on this information. Given that physical inspections of guideway (including track and related structures) are both disruptive to agency operations and dangerous to perform, FTA has examined alternative means of developing deterioration schedules for guideway assets that are more representative of all U.S. rail transit operators. In 2008, FTA conducted a trackwork decay analysis workshop with representatives from seven transit agencies. The results of the workshop include an array of updated decay curves that will be incorporated into TERM to forecast trackwork recapitalization in future C&P reports.

The FTA has recently added an over-age index to TERM's conditions rating output. This index measures the proportion of assets by replacement value exceeding their expected useful life. This over-age index provides a key measure of the level of deferred investment needs and a complementary measure of asset conditions to the numerical scale described above.

The FTA has also initiated studies to update TERM on the betterments of facilities in 2008 and the effect of betterments on asset replacement costs. Previous TERM analyses indicated that investment requirements have under-predicted the needs for facilities, systems, and stations for specific transit modes. This is contrary to the expectation that TERM will "over-predict" needs estimates as compared with actual expenditures by perhaps 10 percent to 25 percent, due to the nature of TERM's needs estimates being generated within a financially unconstrained context. Further, greater TERM values had been expected, considering transit authorities have a long history of deferring reinvestment funds intended for bus maintenance facilities. The primary source of TERM's under-prediction is that TERM replaces facilities "in-kind" while actual facility replacements by local agencies typically include some type of betterment (e.g., rehabbed/replacement facility is larger and/or better equipped). The FTA conducted site visits to eight agencies, each operating multiple modes of transportation to gather data relating to investment requirements for maintenance facility betterments. Key drivers of facility betterments were identified, including increased consumer demand, technological change and advancement, and increased regulations and policies. However, these needs are constrained by increased budget demands and deferred maintenance. Findings from this analysis will be incorporated into TERM for future C&P reports.

Operational Performance

Highways

One of the critical limitations in our current approach to evaluating highway operational performance is that many key performance indicators are modeled rather than directly measured. The most salient impact that highway congestion has on operational performance is a decrease in operating speeds, thereby increasing the travel time costs borne by users. As discussed in Chapter 4, there are several different aspects of highway congestion, including severity (the magnitude of congestion at its worst), extent (the size of the area or number of people affected), and duration (the length of the congested period). The different performance measures reported in Chapter 4 reflect some or all of these aspects to varying degrees. However, one characteristic they all share is that they are actually modeled on the basis of roadway characteristics and reported traffic volumes.

Ideally, travel delay would be measured directly on an ongoing basis over the complete highway network. While such direct measurement has been an abstract impossibility in the past, increasing deployment of intelligent transportation systems (ITS) infrastructure and collection of real-time traffic data on major freeways and arterials in large urban areas are making it possible to directly measure travel times at different times of day on these important routes. The FHWA is involved in efforts to archive these data for analysis, an effort that is being extended to an increasing number of metropolitan areas. This effort has also led to the development of two new performance indicators, the Buffer Index and the Planning Time Index, discussed in Chapter 4. FHWA also uses communications and geographic information systems technologies to measure system performance with truck speeds.

According to studies sponsored by FHWA and other groups, a significant portion of the delay experienced by travelers in the United States occurs at bottlenecks, where capacity and throughput are restricted relative to the adjacent roadways feeding into the bottleneck. This primarily occurs at major intersections and interchanges and at "lane drop" locations where the number of through lanes is reduced. Addressing these chokepoints is one of the most difficult challenges faced by transportation planners. However, current methods for modeling performance do not expressly take into account the operational characteristics associated with bottlenecks, and there is a great need for research into the data and methodologies that could be used to further our understanding in this area.

Among the most common locations for bottlenecks are major bridges, especially those over rivers in major metropolitan areas. Expanding the capacity of bridges is very expensive relative to adding lanes to roadways in the immediate vicinity. As a result, bridge structures often will have fewer lanes than immediately adjacent roadways, thus creating bottlenecks during peak travel periods. As long-lived components of the highway system, bridges may also have design features (such as lane widths or shoulders) that were appropriate for traffic conditions at the time they were first built, but that do not work well at modern traffic levels. Such bridges are termed to be functionally obsolete (see Chapter 3).

> The FHWA Office of Transportation Policy Studies is updating the impact of highway congestion on truck freight shipments. In 2004 the Initial Assessment of Freight Bottlenecks identified 14 types of freight bottlenecks that caused 240 million hours of delay and cost highway freight $8 billion in lost time. Urban Interstate interchange bottlenecks accounted for the largest portion of delay. The study is available at http://www.fhwa.dot.gov/policy/otps/bottlenecks/index.htm.
>
> The updated report will contain an overall measure of the delay freight experiences in highway bottlenecks and additional details on the 30 largest interchange bottlenecks involving highway freight.
>
> The FHWA Office of Operations has a "Localized Bottleneck Reduction" program that targets attention specifically to low-cost, spot-specific recurring congestion. This program encourages agencies to include spot-congestion improvements much in the same way they might include spot-safety improvements in an annualized program. Details of this program can be found at http://www.ops.fhwa.dot.gov/bn/index.htm.

Bridge functional issues, however, are not addressed very well in the current performance and investment modeling techniques. This results in large part from the distinct databases that are used for collecting highway and bridge information. Improving our understanding of bridge bottlenecks will require a means to link the highway and bridge functional information contained in the NBI and HPMS databases; FHWA has initiated efforts to do this.

Temporary losses of capacity that occur in work zones and under other conditions also cause bottlenecks. The HERS model now considers work zone delay in its benefit calculations. Improving our understanding of bottlenecks generally will also help improve estimates of work-zone-related delay, but additional research is warranted in other features of work zones (such as their typical length, duration, and timing).

In measuring highway performance, it is also important to consider that there are many different causes and types of delay, with different implications and solutions. For example, travelers care not only about average travel times on a given facility, but also about the reliability of those travel times. Most performance metrics are aimed at capturing the recurring congestion delay that travelers experience, but there is much less certainty about how to measure and account for improvements in reliability. The Buffer Index and the related Planning Time Index represent one attempt to measure reliability, but other possibilities have been suggested. FHWA's current investment analysis methodology attempts to address reliability by estimating incident-related delay (a common source of unreliability) distinct from recurring congestion delay, and valuing reductions in incident delay at a premium relative to reductions in regular travel time. Ideally, one would want to address reliability directly by forecasting reliability measures such as the Buffer and Planning Time Indices as a function of traffic and roadway conditions, but there is currently no method available for making such a link.

Traffic control devices are another source of delay on highways, as motorists are impeded by signals and stop signs. The HERS model estimates this type of delay (referring to it as "zero volume delay"), but does so on the basis of relatively limited information about the operation of traffic signals on a given highway segment. Improving estimates of this type of delay would require substantial additional data about signalization.

One phenomenon that is frequently observed as highway segments become increasingly congested during peak periods is that travelers will adjust their schedules to avoid the worst part of rush hour. While this effect, known as peak spreading, helps limit the maximum amount of delay experienced by motorists, it also means that many of them are being forced to travel at times other than those that they would prefer. A worker who would ideally like to work a 9-to-5 schedule, for instance, may rise several hours earlier (or spectators may leave an event early) in order to "beat the traffic." The result is referred to as schedule delay. While this type of delay is difficult to measure, increases in peak capacity that accommodate more traffic can significantly reduce schedule delay. These reductions can be quite valuable to highway users, even if some traffic shifts from adjacent time periods in such a way that peak hour delay is not reduced significantly. However, such impacts are not fully considered in the current investment and performance analysis methodology.

While the most obvious impacts of congestion are on traveler delay, it can also have an impact on vehicle operating costs. To some extent, these impacts are a result of the reduced average speeds caused by congestion. However, the constant speed changes associated with stop-and-go driving put additional stresses on vehicle components and fuel consumption. While the current methodology accounts for such impacts on signalized roadways, a more complete accounting for these impacts would also extend to stop-and-go conditions on unsignalized facilities and in work zones.

Transit

FTA's current modeling capabilities measure performance in terms of operating speed and vehicle occupancy rates. Investments to improve performance come from either investing in a faster transit mode or adding new vehicles to an existing mode and thus simultaneously reducing vehicle crowding and increasing service frequency. TERM employs user cost elasticities to estimate the additional ridership that is generated by service improvements, which reduce passengers' costs. At this point, TERM does not estimate how changes in asset conditions affect transit performance in terms of its reliability or safety performance.

FTA will be examining the possibility of using service interruptions as a measure of transit performance, provided that data on service interruptions more detailed than reported to the National Transit Database (NTD) can be collected from a sample of transit operators.

Safety

Safety is another key aspect of transportation system performance, and Chapter 5 presents data on various safety indicators. In the context of surface transportation infrastructure investment, there are many areas where there needs to be better understanding of the potential impacts of highway investment on highway safety.

The first challenge lies in linking crashes to transportation infrastructure characteristics. As described in Chapter 5, motor vehicle crashes and their severity result from many factors, including driver behavior, vehicle equipment, and weather conditions, in addition to infrastructure-related factors. As a result, it can be difficult to fully assign the proper responsibility for crashes to the infrastructure itself, and thus to properly model the impact of infrastructure improvements on safety outcomes.

FHWA is working with the Transportation Research Board to develop the Highway Safety Manual (HSM). The purpose of the HSM will be to provide factual information and tools in a useful format to facilitate roadway planning, design, operations, and maintenance decisions based on explicit consideration of their safety consequences. The emphasis of the HSM will be on the development of quantitative tools. Two software programs that will support the HSM analysis are the Interactive Highway Safety Design Model (IHSDM) and SafetyAnalyst. The HSM is intended to serve the same role for safety analysis that the Highway Capacity Manual serves for traffic operational analysis, and will provide a major opportunity for advancing the state of the practice in highway safety.

The process of linking infrastructure to safety outcomes would be improved by more precise crash location data. While extensive data are available on crashes involving fatalities, less information is available on injuries and property-damage-only crashes at a disaggregate level. As a result, the models have been unable to account for changes in the number of injuries or fatalities per crash on different types of roadways (such as different functional classes) over time.

A related issue is the impact of changes in average speeds on crash probability and crash severity. While the internal safety models used by HERS estimate crash rates on different types of roads, implicitly accounting for crash probability to some degree, no linkage is made to crash severity. As a result, the model may overstate the safety impacts of improving highway speeds on major urban freeways and arterials because any increases in fatality or injury probabilities per crash are not captured.

Finally, HERS and NBIAS are designed to model the effects of routine capital investments for highway and bridge preservation and capacity improvements and seek to incorporate the safety impacts of those routine improvements. The models do not address capital investments for system enhancements, including targeted safety enhancements (such as median barriers, improved merge areas, and additional turn lanes). Traffic control upgrades are also frequently driven by safety concerns, particularly on lower volume roads. Directly modeling national investment needs for these types of improvements would require an entirely new approach, including the collection of additional or supplemental data and the development of new safety capital investment tools.

As previously mentioned, FTA's modeling process does not estimate the impact of changes in transit asset conditions on safety. As with highways, this type of analysis would require linking specific transit incidents, injuries, and fatalities to the physical conditions of specific transit infrastructure (e.g., a rail line segment). To do so would require agencies to report both transit asset conditions data and safety incident data at this level of detail, a change that would entail a significant increase to current NTD reporting requirements. Moreover, at this point it is not clear whether the expense of undertaking this additional work would prove worthwhile. Transit has a very good safety record and is in general a very safe mode of transportation. However, any increases in asset costs that result from safety improvements will be included in the investment scenario estimates as information on actual asset costs is collected. Costs estimated by inflating cost data gathered in earlier years would not necessarily reflect cost increases stemming from asset improvements.

Environmental Impacts

As noted elsewhere in this report, one feature of transportation system usage is that it can have impacts on non-users of the system. These effects are referred to as externalities. To the extent that the level of such impacts is affected by transportation investment, they should be captured in the benefit-cost analyses of that investment.

The current highway investment methodology used by FHWA attempts to account for one of the most obvious externalities associated with highway investment and use, namely the effects of increases or reductions in vehicle emissions on the environment. The methodology used in the HERS model to estimate such emissions was last updated for the 2002 C&P Report based on the latest procedures used by the Environmental Protection Agency at that time (see Appendix A of the 2002 C&P Report for a more thorough discussion). Improvements that reduce emissions (such as by fostering more efficient engine operation) can produce environmental benefit; alternatively, those that might increase emissions (such as through additional highway usage) would produce environmental "disbenefits." Future changes in vehicle and fuel technologies and regulations can also have a significant impact on emissions rates, and these factors are reflected in the estimates produced by HERS.

Translating emissions levels into emissions costs for use in benefit-cost analysis, however, is a more challenging step, as it requires linking emissions, ambient air quality, the adverse effects of poor air quality, and the economic cost of those impacts. Some of these relationships can be complex and highly nonlinear. A comprehensive analysis of these linkages would require significant information about current air quality conditions and other emission sources by locality, adding a high degree of complexity to the modeling process. At a minimum, however, it is prudent to stay abreast of ongoing research in this area to ensure that the emissions cost estimates used by HERS for individual pollutants reflect the best information possible.

HERS does not directly model carbon dioxide emissions, the most prevalent and important component of greenhouse gas (GHG) emissions. This omission is significant because transportation is a major contributor to GHG emissions in the United States, and would likely be an important sector for policies designed to address the threat of global climate change.

While vehicle emissions are one type of environmental externality, other impacts could potentially be similarly modeled, such as the noise caused by highway and rail traffic. Such efforts would require two key types of inputs. The first is empirical estimates of the magnitude of such costs, related to the variables used or modeled in HERS (such as traffic levels by vehicle class). The second is more data on development densities (by type of activity) adjacent to roadways because noise impacts are very localized, and not much data are currently available. Similar issues would apply to other environmental externalities, such as water quality, climate change, and biodiversity.

In its benefit-cost analysis, TERM considers the social benefits of noise and emission reductions that result when travel is switched from automobile to transit.

Two final issues in this area concern Federal and State laws and regulations relating to transportation investment and the environment. The first issue concerns the cost of making improvements. Rather than taking as given the negative environmental impacts of transportation investment, laws and regulations require these effects to be mitigated to some degree. Such mitigation activities can add significantly to the costs of transportation system improvements, especially those extending beyond the current footprint of system facilities. The challenge is to understand what these costs are for typical projects of different types on different classes of facilities and to ensure that the improvement cost estimates fully reflect these mitigation costs.

The second issue concerns transportation investment in non-attainment and maintenance areas (i.e., regions that do not [or did not] meet the National Ambient Air Quality Standards). In regions that have been so designated, transportation investment projects must conform to plans for improving air quality. Some of the improvements modeled in HERS and NBIAS, while cost beneficial on economic grounds, may not be feasible on environmental policy grounds. In general, the investment scenarios in this report do not take into account Federal or State policies that could restrict certain types of improvements in specific locations, nor is it clear that they should do so, given the way in which the scenarios are defined.

Transportation Supply and Demand

At its core, transportation investment analysis involves balancing the demand for transportation services with the supply of those services; therefore, it is important that both sides of this equation be modeled with as much detail as possible within the constraints of the analysis. Some of the key subjects of concern in this area include understanding the costs of supplying transportation capacity, acknowledging the impact of operations improvements on increasing effective capacity, refining the modeling of transportation demand, and learning the link between investment needs and financing.

Capacity

Capacity improvements can take many forms, with widely varying costs and complexity. The most straightforward involve adding through travel lanes within the existing footprint of the facility (such as in the median of a multilane freeway) or using other right of way that has previously been reserved for that purpose. In other cases, however, the options for widening an existing roadway may be constrained by terrain, environmental considerations, existing roadway design factors, dense development immediately adjacent to the roadway, or other conditions. Under such circumstances, adding capacity may require more extreme and costly measures. These might include new parallel facilities or bypasses, tunneling, double-decking, fixed guideway transit facilities, the purchase of very expensive right of way, the reconstruction of existing overpasses, or some combination thereof.

The current approach used by FHWA to estimate needs for capacity expansion under constrained circumstances is to assume that the capacity equivalent of additional lanes could be added to the corridor in which the existing facility is located, but at much higher cost than under ordinary circumstances. The estimated per-lane-mile costs of such lane equivalents are based on estimates of the cost of the extreme measures described above. These higher costs help capture in part the cost of major highway capacity expansion projects and are therefore reflected in the national investment scenario estimates. However, the higher cost of such improvements (referred to in HERS as high cost lanes) makes them less attractive from a benefit-cost standpoint, making them somewhat less likely to be implemented in the model than other improvements.

While the procedure for estimating high-cost-lane equivalents helps address the question of investment needs for major capacity expansion, it does so based on very limited data. The determination of whether additional lane equivalents would be added at high or normal cost is based solely on the widening feasibility data item coded by States in HPMS. There are concerns that this single variable may not fully capture all the information used by a highway agency in determining whether to undertake a major high-cost expansion project. If additional data were available, they could potentially be used to improve modeling of such improvements. As part of the data changes resulting from the recent HPMS reassessment, States will be asked to supply the FHWA with more information concerning the types of obstacles to widening that may be present for individual sample highway sections.

Q&A

What research projects does FHWA currently have underway to improve the modeling of transportation supply and demand issues?

Current FHWA research projects on transportation supply and demand include the following:

- **Capital Improvement Cost Reviews.** The FHWA is assembling panels of outside technical experts to review the costs assigned for various types of capital improvements in HERS and NBIAS. These panels will assess whether these costs have been adjusted adequately for recent inflation, and whether they are still representative of typical costs experienced by States.
- **Time-of-Day Travel Demand Modeling**. The FHWA has an ongoing research program aimed at improving the analysis of travel demand within HERS. These projects are, to a large degree, sequential because earlier improvements set the stage for and enable later refinements and enhancements. The next phase in this effort involves disaggregating travel demand in HERS by time of day. This will require some accompanying modifications to the modeling of capacity and delay. Properly analyzing the demand-related aspects of peak period congestion requires segmenting daily travel demand into peak and off-peak periods and accounting for any cross-price effects between the two periods. This will also allow for a more refined approach to the analysis of congestion pricing in HERS.
- **Congestion Pricing Analysis Reviews**. The FHWA is assembling a panel of outside technical experts to review the current HERS pricing procedures as well as planned enhancements to procedures building on the time of day travel demand modeling effort.

Another class of highway capacity improvements includes functional improvements to freeway interchanges. In many locations, severe recurring congestion problems can be attributed to interchange deficiencies, rather than mainline capacity deficiencies. These bottlenecks may result from severe volume/capacity imbalances, in particular connecting ramps at interchanges (which, when extreme, can affect traffic in the through travel lanes). They may also be caused by other operational issues such as interchange spacing, inadequate merge areas, or weaving problems.

These bottlenecks generally occur at points where capacity becomes restricted (such as a lane drop on a major urban freeway) or where a functional issue (such as significant levels of intersecting, merging, or weaving traffic) serves to reduce the effective vehicle-carrying capacity of the road. Bottlenecks may also be associated with major intersections, bridges, or tunnels in large urbanized areas.

Untangling these bottlenecks often requires extremely complicated and costly investments. Solutions may also involve operations enhancements in addition to construction. Interchange designs are also becoming increasingly complex in some cases in order to accommodate high occupancy vehicle (HOV), truck-only lanes, or other special purpose lanes. States have indicated that interchange improvements represent a growing share of their overall highway capital expenditures.

The challenge for the C&P report is to ensure that the capacity issues that arise at interchanges and other bottlenecks are adequately captured in the investment modeling process. Improving capabilities in this area could involve upgrades to existing models and/or the creation of a new analytical tool to handle these types of investments. Some information will be added to HPMS by FHWA and the States regarding ramps and interchanges, which will facilitate additional analysis. However, it is likely that more robust interchange performance and capacity data will be needed in the future to support any extensive new modeling approaches.

Another limitation of the current approach to modeling highway capacity improvements is that the potential investments for new roads and upgrades of existing roads may not be fully captured. To some extent, as described above, the high-cost-lane equivalents feature is intended to capture new parallel routes in the same corridor (though modeled as an expansion of an existing facility). Given the relatively complete nature of the highway network in the United States, this makes a certain degree of logical sense. Because few new roads are being built into undeveloped frontier areas at this point in the Twenty-First Century, most new roads effectively substitute for existing roads to a certain degree. The new capacity in the model, however, is assumed to be of the same functional class as the existing route, which may not be the case. Instead, new roads (at least those justified on the basis of capacity needs) are often built to higher standards (such as limiting access). Furthermore, capacity expansion of existing roads often takes the form of functional upgrades in addition to adding lanes, but such upgrades are not directly modeled in HERS. Thus, while the current procedures are intended to reflect such investments indirectly, a more refined approach (likely requiring additional data) would be possible.

Another issue worth investigating is the concept of 2+1 lanes and how they might improve operations. A 2+1 lane system consists of two lanes in one direction and one lane in the other, alternating every few miles and usually separated with a steel cable barrier. Although this technique has been used in European countries such as Denmark and Sweden since the 1990s, it is relatively new to the United States; therefore, the HERS model does not capture the impact of such a configuration on operations.

Transit system expansion needs are currently driven by two variables—operating speeds and vehicle occupancy rates. A formula is uniformly applied to all systems to determine which are in need of performance-enhancing investments (in other words, they have speeds below and occupancy rates above certain threshold levels). Passenger access and waiting times are included in these performance measurements.

Another transit capacity issue is referred to as core capacity. In urban areas with rail systems, investment in new capacity often takes the form of extensions to or branches from existing lines. As the system expands and ridership grows over time, however, the central portions of the system (often the first parts built) may become saturated with trains and riders. When this occurs, improving the capacity of the overall system may require new capacity improvements in this central core. Such improvements can also affect the operation of the entire rail system beyond the locations of the actual investment, and thus offer significant benefits to riders. However, because the core sections of these systems are generally found in the densely developed central cores of major cities, expanding capacity in these areas can also be enormously expensive. The challenge faced by FTA is to ensure that the methodology used by TERM adequately reflects such improvements in its estimates of transit capacity investment needs and impacts.

An ongoing challenge faced by both FTA and FHWA is to ensure that the unit costs of various types of transportation investments used as inputs to the models fully reflect the current cost of building and constructing those improvements. The agencies currently do this by periodically revisiting the source data used to generate these unit costs and revising them accordingly. A trickier issue, however, is whether these unit costs will be stable (in inflation-adjusted terms) in the future. The key variable is the development and adoption of new technologies. Some technologies, such as longer-lived pavements or improved construction techniques, could make future infrastructure investments relatively less expensive; others, such as more accessible buses using cleaner fuels, could make them more expensive than at the present time. While such impacts are difficult to predict, they do add to the uncertainty surrounding the estimates of future investment needs.

Operations

As described in Appendix A and elsewhere in this report, the HERS model considers the impact of operations strategies and ITS deployment on highway system performance and potential future investment. The procedure is implemented in the form of exogenously specified scenarios for future deployments, which in turn impact the HERS calculations on the effects of different highway improvements.

Ideally, one would want to extend this feature by bringing operations inside the benefit-cost analysis, considering each strategy as an improvement alternative in addition to those already specified in HERS. However, such an effort would raise several issues. First, many operations strategies and deployments are implemented not as alternatives to traditional highway investment, but rather in conjunction with them. Almost all freeway reconstruction and expansion projects in large urbanized areas, for example, include new or upgraded ITS deployment as part of the overall project. Typically, some ITS deployments require modifications to the existing infrastructure, which can be made more cost effectively when major construction is already underway. Would it make more sense to assume that this trend will continue in the future and to "build in" the costs and impacts of such investment into the existing improvements analyses?

Another issue concerns the need to capture the full lifecycle costs of ITS infrastructure. Much of this infrastructure is based on electronic technology that has a shorter physical or useful life than traditional highway improvements. This consideration needs to be factored into the cost estimates of such deployments. Replacing or upgrading these systems may also present challenges or costs that do not occur during the initial deployment. The ITS technologies may require increased operating and maintenance costs to be effective, which would need to be considered in a benefit-cost analysis.

Another challenge to incorporating operations strategies more directly into the analysis is that some of these strategies are not capital investments at all, but rather programs that can be labor intensive, such as on-call service patrols. Analyzing such programs as direct alternatives to capital investment would require a shift away from the traditional focus of the report on capital investment needs only. This would raise issues similar to those associated with preventive maintenance expenditures.

Finally, the modeling of operations and ITS investment depends on collecting consistent and reasonably complete data on the current extent and location of ITS deployments. Although several such data items are currently collected through HPMS, the reporting of these data has not been sufficient for modeling purposes; these data items are scheduled to be dropped. This will require such operations analyses to rely more heavily on other data such as FHWA's ITS Deployment Tracking System. FHWA is currently examining what the best approach might be for collecting these data in the future.

TERM currently does not consider the impact of ITS on transit system performance. A measurable link between ITS deployment by transit systems and their performance has not been established, and data on ITS deployment by transit systems are not collected.

Travel Demand

Some of the most important inputs and procedures used in the transportation investment analyses found in the C&P report concern the modeling of current and future travel demand. As noted in Chapter 10, different assumptions about future travel growth can have significant impacts on the investment scenario estimates for both highways and transit. Improving this portion of the analysis would require more precise forecasts of future travel growth used in the models, as well as upgrades to the internal procedures used to adjust travel demand in response to changes in the performance of the system and the fees charged to users of the system. Opportunities to improve on forecasts that are done at the metropolitan planning organization (MPO) and State levels may be limited, however, especially when considering the uncertainty in any projections using a 20-year time horizon.

Travel Forecasts

The sources of the highway and transit travel growth forecasts used in the HERS and TERM models are described in Appendices A and C. These are very different, each with its own strengths and weaknesses. For highway forecasts, the HPMS sample data used in HERS include forecasts of future traffic levels for each highway segment in the database, as well as base year traffic volumes. Having these State-supplied forecasts for each section is an important advantage of the HPMS dataset. Obviously, improving the accuracy of these forecasts would improve the quality of the analysis produced by HERS. It is important to understand, however, what "accuracy" means in this context. A critical assumption made in the HERS logic regarding these forecasts is that they reflect a constant "generalized price" to users. Thus, an "accurate" forecast input to HERS would be one that correctly reflects the amount of travel that would occur at a constant price; it does not mean that the forecasts accurately predict actual traffic volumes in the forecast year, which depends on improvements that may be made (or not made) in the intervening years.

One issue with this approach concerns the definition of the "price" that is assumed to be constant in the forecasts. Is it based on maintaining level of service (as reflected in user costs), or is it based on all costs paid by users (including user fees)? The current assumption in HERS is that price is defined by the former. This question is particularly relevant in light of HERS procedures that allow the model to simulate changes in user fees through fixed or variable rate tolls or charges for vehicle miles traveled (VMT). The HPMS forecasts could be improved by having information on the assumed future performance level associated with each of the section forecasts. This information could be used in HERS to more accurately specify the baseline traffic volume forecasts, which would then be adjusted endogenously within the model.

Current methods also make some use of freight estimates and forecasts from the Freight Analysis Framework (FAF), and proposals to employ network and multimodal trade-off analysis will depend heavily on the FAF and a planned version of passenger travel. The FAF depends on continuation of the Commodity Flow Survey and the Transborder Freight Data program. The planned passenger travel analysis framework depends on continuation of the National Household Travel Survey. Both frameworks depend on restoration of the Vehicle Inventory and Use Survey, discontinued by the Census Bureau in 2002 because of budget reductions. While these data programs are expensive, they are miniscule compared with the investments guided by the information they provide.

> The FHWA Office of Freight Management and Operations is beginning to update the FAF with data from the most recent Economic Census. A number of improvements based on user experiences with the current FAF are also planned. The next FAF will be benchmarked on 2007 with forecasts through 2040 and provisional annual estimates for the most recent year.

Unlike HPMS, the NTD data reported to FTA by transit operators do not include projections of future transit travel growth. Instead (as described in Appendix C), the forecasts used in TERM are derived from forecasts made by MPOs as part of their overall transportation planning process. These planning documents provide the only widely available source of transit ridership forecasts available at the local level. TERM uses the most recent passenger miles traveled (PMT) projections available from a sample of the Nation's MPOs, including those from the Nation's 30 largest metropolitan areas. These are the most comprehensive projections of transit travel growth available. Projected passenger trips, or PMT, estimated as a function of projected VMT were used in lieu of projected PMT when the latter was unavailable. Transit travel growth rates for the urbanized areas for which transit travel projections were either unavailable or not collected were assumed to be equal to the average growth rate for an urban area of equivalent size for the FTA region in which that metropolitan area is located.

This methodology has limitations that should be noted. First, the regions covered by the PMT forecasts may not correspond precisely to the service areas of the transit operators to whom they are being applied, particularly in regions with multiple operators. Second, PMT forecasts may also be for passenger trips, rather than passenger miles as used by the model. Historically, movements in the number of passenger trips and passenger miles have been virtually identical, so this is not a major concern unless a particular area has a marked change in average trip length. Third, PMT is forecast as a function of VMT for areas where neither PMT nor passenger trips are available Finally, while the PMT forecasts come from a rigorous and documented process, the long-range plans produced by MPOs are required to be constrained by both projected fiscal resources and the need to maintain conformity with air quality standards. As a result, they may not include all of the improvements that would be made in an unconstrained environment (which is desirable as a baseline for investment scenario analysis).

Preliminary data on travel trends since 2006 suggest lower highway VMT growth and higher transit PMT growth than is reflected in the State and MPO long-range forecasts. It is unclear whether these recent changes are short-term in nature, and will eventually be overwhelmed by longer term trends, or if these changes reflect a permanent shift in travel patterns that has not yet been fully recognized in State and MPO forecasting procedures.

Demand Analysis

In the HERS model, the highway travel forecast inputs are adjusted endogenously in response to changes in estimated user costs on each section (see Appendix A). While these demand elasticity procedures add considerably to the quality of the analysis, they are applied to all traffic on the section on an equal basis. Disaggregating travel demand within the model could thus improve the precision of the analysis, as well as furthering the analysis of other policy options aimed at regulating travel demand.

One good candidate for disaggregation would be demand by time of day. Disaggregating by time of day would allow a better calculation of peak period travel delay and correspond more closely with the peak/off-peak capacity calculations that are already employed in HERS. The model would be able to capture the effects of trip time shifting between peak and off-peak periods in response to relative changes in travel times in the two periods and allow for different demand responses to changes in user costs within time periods (e.g., allowing for greater demand elasticity values in off-peak periods, where trips may be more discretionary).

Travel demand could also be disaggregated between different vehicle classes. In particular, truck freight movements are likely to have different demand characteristics than passenger auto traffic, making it sensible to disentangle them in the analysis. Doing so would also ensure that exogenous changes in the mix between trucks and cars (due to different baseline growth rates) do not inadvertently affect total estimated traffic volumes via changes in average user costs for all vehicles.

While demand disaggregation is thus desirable in its own right, there are potential drawbacks to such an approach. In particular, the additional segmentation of traffic volumes into different categories, each with its own demand characteristics, will dramatically increase the complexity of determining equilibrium traffic volumes. As a result, other compromises within the procedures could be required in order to keep the analysis tractable.

The analysis of travel demand in TERM is further limited. The model does not have procedures for balancing supply and demand directly because it does not calculate the price of travel to users. Instead, the travel growth forecasts are based on demand projections received from the MPOs, with limited procedures for adjusting ridership in response to certain performance improvements; no adjustments are made to the forecasts for any improvements that may be foregone. The effect of performance improvements on user costs is reflected with a one-time increase in demand (i.e., transit ridership) based on elasticities estimated by empirical studies of ridership responses to increases in headways or speed.

Pricing Effects

The highway pricing analyses reflected in this report are intentionally abstract; they assume that economically rational prices would be computed and imposed on highway users, but do not directly address the mechanics of how this could be accomplished or the impact that such financing mechanisms could have on different subsets of society. These topics are of interest, and are worthy of further exploration as supplemental analyses in future editions of the C&P report. However, the primary relevance of pricing to the C&P report analysis is its theoretical impact on future investment/performance relationships. It is reasonable to assume that many of the currently perceived technical and societal obstacles to the adoption of pricing could be overcome within the 20-year analysis period covered in this report.

There are many refinements that could be made to the pricing analyses that are presented in this edition of the C&P report, which are limited in their present form. These analyses assume the widespread simultaneous adoption of congestion pricing strategies. It would be beneficial to develop analytical procedures for analyzing the impacts of pricing a limited number of facilities within a system where such charges are generally not imposed, or to simulate the operation of dedicated high-occupancy toll (HOT) lanes. Time-of-day demand segmentation would allow for the analysis of optimal congestion pricing in different time periods, with time-varying tolls and peak shifting, but such an analysis would still be more illustrative than empirical. A more realistic analysis would require much more detailed modeling of the actual transportation network, including analysis of spillovers and feedback effects between parallel and connecting segments (see the discussion of network effects later in this chapter).

> The Office of Economic and Strategic Analysis under the Assistant Secretary for Transportation Policy at U.S. DOT is supporting research that attempts to provide quantitative estimates of some of the impact that widespread tolling/pricing could have on travel, congestion, investments, and the environment.
>
> More information on the activities of this office is available at http://ostpxweb.dot.gov/policy/index.htm.

Other potential refinements would expand the definition of optimal pricing in this context, beyond the current focus on travel delay. The analysis could address other externalities (such as environmental effects) that are currently unpriced. It could also be expanded to look at differential cost allocation schemes, which would require a greater degree of disaggregation between trucks and passenger vehicles than is presently found in the model.

Options for analyzing pricing in TERM (i.e., fare policies) are very limited at the present time because TERM does not explicitly model travel demand. While a more comprehensive analysis of transit investment and its impacts would include this as an option (as with road pricing), the appropriateness of doing this type of analysis at the national level is perhaps more questionable. While encouraging efficient pricing is currently a policy of the FHWA, transit fare policymaking has traditionally been considered a local matter, with little or no Federal input because transit operating costs are generally not Federally funded. Any efforts to include fare policy in the analysis would need to take this into account.

Finance

This report links estimates of future investment scenarios to the funding sources that would (or could) be used to pay for those improvements. The analysis is based on the imposition of fixed and/or variable tolls or other user charges on a per-VMT basis to cover any costs of increased investment under a given scenario. Further refinements of the procedures used in this analysis could allow for such features as assigning different user surcharges to different vehicle classes.

The HERS revenue analysis does not account for the distortionary impact that tax-based revenue sources for transportation have on the economy (sometimes referred to as the social cost of public funds). Since the extent of this distortion varies for different types of tax mechanisms (such as property, sales, or fuel taxes), different mixes of revenue sources would have different implications in this regard.

There is also room for improvement in the quality of the financial data collected by the Federal government. Data on local government highway revenues and expenditures, for instance, are more limited and less timely than the data collected from States, which necessitates interim estimates that occasionally may differ widely from final numbers. There are also limited data for lower-order highway functional systems, such as non-Federal-aid highways, and for transit operators in nonurbanized areas. Finally, there are limited data on private investment in surface transportation infrastructure. For example, local roads in residential or industrial areas are often funded by private developers, and local governments may require additional contributions toward improvements on nearby collectors and arterials as a condition of development. New freeway capacity is also being added in some areas under franchise agreements or Public-Private Partnerships, a trend that is expected to continue in the future; however, the extent to which such expenditures would be captured in the current data depends largely on whether the actual expenditure was made by the private or the government entity. Similar issues arise for public transportation services provided by private firms or organizations.

One of the results discussed in Chapter 7 regarding the analysis of congestion pricing is the significant amount of revenue that could be generated by the widespread adoption of congestion tolls. While these analyses assume that such revenues would be used to either support increased capital investment or to reduce existing fixed rate user charges, such revenues could be directed to other purposes, which could have significant implications in terms of tax policy and the availability of resources to support investment. The HERS analysis currently does not address situations in which only a limited number of facilities are priced, which would potentially have implications for their revenue-generating potential. HERS also does not currently evaluate HOT lanes; the toll rates that would need to be imposed to ensure a constant level of service on such lanes might deviate significantly from those that would be appropriate for a facility on which all lanes were priced.

Finally, it is implicit in all estimates of both highway and transit investment and highway and transit performance that a strong link exists between the two. However, there currently is not enough data available to directly link highway improvements and costs on a given section to changes in conditions and performance over time on that same section.

The Office of Economic and Strategic Analysis under the Assistant Secretary for Transportation Policy at U.S. DOT is supporting research that examines the revenue-generating characteristics of different road tolling/pricing options, the capital and operating costs of various tolling/pricing options, and the effect of different allocation policies for tolling/pricing revenues.

More information on the activities of this office is available at http://ostpxweb.dot.gov/policy/index.htm.

Analytical Issues

Another group of issues concerns the analytical procedures used in investment modeling themselves and the scope of the investments covered in the analysis. These issues include security and emergency preparedness in relation to infrastructure investment analysis; risk and uncertainty in the analyses; lifecycle costs analysis; new technologies and techniques; multimodal analysis; the impacts of infrastructure investment on productivity and economic development; investment on lower functional systems; the scope and scale of the information covered in the report; and other potential applications for the analytical tools.

Q&A

What research projects do FHWA and FTA currently have underway aimed at addressing some of these analytical issues?

FHWA and FTA have the following projects in progress in these areas:

- **HERS lifecycle cost analysis**. This project will explore different means of bringing more lifecycle cost considerations into the HERS analysis by assessing the timing of investments as part of the benefit-cost analysis procedure.
- **Multimodal Investment Analysis**. This project will explore strategies for creating a mulitimodal investment needs analysis capability, either through modifications to HERS, NBIAS, or TERM models, or through the development of a new generation of analytical tools and supporting databases.

Security and Emergency Management

Transportation infrastructure's relationship to national security and preparedness is an area of potential improvement in our understanding of investment needs. Transportation obviously plays a critical role in evacuating citizens and providing access for emergency responders in the event of a natural or man-made catastrophe. The effectiveness of such responses depends in large measure on the installed capacity of the transportation system to operate under extreme conditions; thus, some level of transportation investment could conceivably be justified on the basis of improved security. The difficulty, however, is in defining an investment "need" in such circumstances. Is the standard benefit-cost analysis framework for analyzing potential future investments sufficient when considering investments with such alternative purposes? In particular, how does one define investment needs to handle events with extremely low probability but potentially catastrophic consequences? More generally (and perhaps most importantly), is transportation infrastructure investment modeling the appropriate place to analyze security needs, or should they be derived from an independent review that is more closely tied to Federal, State, and local government policies and priorities?

A related issue is the value of redundancy in the transportation network. By their very nature, key transportation facilities such as highway bridges or transit tunnels are vulnerable to becoming disabled during a crisis, or could themselves be targets of an attack. The viability of alternative routes or models of transportation under such circumstances thus becomes critical. A transportation network with many alternate pathways and modes would be advantageous in such circumstances, but providing such alternatives could result in significant underutilized capacity during the majority (or perhaps entirety) of the time that a crisis does not exist. How should this excess capacity then be valued from a benefit-cost standpoint? Because redundancy is inherently a network phenomenon, modeling its impacts and benefits would require the type of network analysis tools discussed below. At the same time, redundancy in the system also plays a role in helping highway authorities deal with major incidents as well as disasters; thus, some of the benefits of redundancy would appear as reductions in incident-related delay.

Risk and Uncertainty

Another feature of an ideal investment analytical process would be a better understanding and exposition of the uncertainty in the estimates of future investment needs, and a system in which such uncertainty is minimized to the extent possible. Improving our understanding of uncertainty in the estimates would require a better understanding of the impact that key variables have on the estimates and the actual statistical distributions of those variables. The current approach to evaluate such uncertainty used in the report is the sensitivity analysis presented in Chapter 10, but other methods (such as Monte Carlo simulations of confidence intervals) would be possible. However, these methods could involve trade-offs between such capabilities and other refinements in the model inputs and procedures, which would need to be considered before implementation.

Minimizing the uncertainty of the analyses would largely require improvements in the reliability of the data inputs (in addition to model improvements described elsewhere in this chapter). FHWA and FTA have various quality control measures in place in their data collection systems and are continually looking for opportunities for improvement. This is also one of the goals of the current HPMS reassessment described earlier. The Travel Model Improvement Program, sponsored by the two agencies (and described in the 2002 C&P Report), is intended to improve the reliability of the future travel forecasts that are key inputs into the highway and transit models. As always, however, the benefits of improved data quality must be balanced against the ongoing or increased costs of collecting that data.

Lifecycle Cost Analysis

In addition to estimating the economically optimal level of future investment, an ideal investment analysis tool should be able to address the optimal timing of that investment by comparing the lifecycle costs of alternative temporal improvement strategies. It should also be able to quantify the trade-offs between early, less aggressive improvements and deferred, more extensive improvements. While the input costs and modeled or assumed improvement lives used in the current investment models are intended to reflect the full lifecycle costs of improvements, this area remains a significant limitation on the methodology in use.

Each of the tools currently used by FHWA and FTA models system investments on a year-by-year (or period-by-period) basis. Although the improvements made in one period affect the condition of the system and improvement options available in subsequent periods, and the benefits of these improvements are evaluated over multiple periods that an improvement is in use, potential improvements in different time periods are not compared with one another. For example, while a particular improvement on a section may be justified on economic grounds, it could be more advantageous to postpone the improvement until a later time. The models do not currently consider this option, nor do they consider the potential effects of advancing certain actions.

The HERS model is also limited by the way that it evaluates pavement improvements. The decision on whether a resurfacing improvement or full-depth pavement reconstruction is warranted is currently a mechanical one, based solely on whether the pavement condition is above or below a threshold reconstruction level. Ideally, such a decision would be made based on a trade-off analysis between the less aggressive resurfacing option and the more expensive (but longer-lasting) reconstruction.

New Technologies and Techniques

The investment estimates reported in the C&P report are intended to reflect existing technologies and techniques, and FHWA and FTA devote considerable resources to keep the models and methodologies used in the C&P analysis current with transportation industry research and practice. However, it is entirely possible that new technologies and methods might be developed over the course of the 20-year horizon analyzed in the report that could affect the performance of the transportation system and the cost of transportation infrastructure improvements. Such developments might come in several areas, including construction methods and materials, operations strategies and ITS technologies, and transit vehicle technologies.

FHWA continues to devote significant research resources to improving pavement and bridge technologies, preventive maintenance strategies, and construction methods and management techniques. To the extent that these technologies and techniques extend the useful lives of pavements and bridges, they could reduce the need for future investments in system preservation. Some strategies, however, might also be aimed at reducing the impacts of highway construction on users and adjacent landowners. In many cases, such strategies might involve a trade-off of higher construction costs for lower user impacts during the construction, thus increasing the future costs of capital improvement needs (while still benefiting users of the transportation system).

Highway operations strategies and ITS technology are other obvious candidates for continuing improvement over time. The aggressive deployment and full deployment scenarios analyzed in Chapter 10 assume accelerated adoption rates for operations and ITS, but the investments and strategies themselves are largely the same as those available at the present time. However, if the effectiveness of such strategies and technologies improves over time or if new technologies were to be developed, then the impact of such investments on highway performance (and thus the investment scenario estimates) would also increase. For transit, new or improved ITS technologies could similarly improve the operation of transit systems, potentially allowing them to provide more service with the same asset base and reducing the need for additional investments.

Highway and transit vehicle technologies are the final area where new development would be expected over time. Future automotive technologies could interact with ITS deployments to further improve operating efficiency and reduce the risk and impacts of crashes and other incidents. Such developments could also apply to transit vehicles. However, some of the new or improved transit vehicle technologies could be aimed at other public policy goals, such as reducing emissions or fuel consumption or improving access for the disabled. New technologies in these areas could have the effect of increasing the future cost of transit vehicles and thus raise the level of investment that would be required to achieve a given level of conditions and performance (though improved accessibility could have some impacts on performance by reducing transit vehicle dwell times).

Multimodal Issues: Benefit-Cost Analysis

As described in earlier chapters, the investment analyses conducted for this report employ three different methodologies using datasets and models developed specifically for the analysis of highway (HERS/HPMS), bridge (NBIAS/NBI), and transit (TERM/NTD) investment. This approach offers the advantage of having specialized models that have been designed and adapted to the unique characteristics of each mode and data source. The disadvantage, however, is that the resulting analyses may not be strictly compatible with one another. It also means that the combined total investment scenario estimates for highway, bridges, and transit may not reflect potential trade-offs between alternative investments aimed at addressing the same performance issues at the transportation system level. These issues are discussed in more detail below.

Benefit-Cost Analysis Procedures

Although each of the three investment tools uses benefit-cost analysis to some degree in estimating future investment under different scenarios, the models vary widely in how that application is made. The models use different inputs and apply benefit-cost analyses at different points in the improvement selection process, making it difficult to compare the recommended improvement sets on that basis. To a large extent, these differences reflect the distinct data sources and different development histories of each of the tools, but the result is that it is difficult to compare the performance and investment results produced by the models with one another on an economic basis. If the benefit-cost analysis approaches in the models could be harmonized, then any cross-modal comparisons would become meaningful, and joint criteria (such as a common benefit-cost ratio threshold) could be applied to each of the separate analytical models, producing some potentially enlightening results about the mix of investments.

Many of the potential methodological improvements described elsewhere in this discussion would ultimately be aimed at improving the quality of the benefit-cost analyses in the models. However, fundamental improvements in the application of these analyses also could be made. Investment analysis as practiced for the C&P report involves determining potential deficiencies in conditions or performance that might warrant correction, and then designing, evaluating, and selecting improvements for implementation that might address these deficiencies. The total level of investment in a given scenario is then determined by imposing some constraint on the final improvement selection process (to tell the models when to stop making additional improvements). Ideally, benefit-cost analyses would be employed at the evaluation and selection stage for particular investments. Among the three investment analytical tools, however, only the HERS model currently operates in this fashion (owing largely to the suitability of its data set and the longer time that the model has been under development). HERS is thus the only one of the three tools that is able to fully specify an investment scenario solely on the basis of economic efficiency. As a result, much of the discussion within the U.S. DOT on improving the comparability of benefit-cost analyses in the models involves modifications to TERM and NBIAS to make them more consistent with HERS, although there are aspects of all three models that warrant consideration for adoption into the others.

As of 2006, TERM only evaluated the benefits of each transit mode relative to three potential modal alternatives. These alternatives included auto (for nondependent riders), a slower transit alternative (e.g., bus instead of rail), and taxi (for dependent riders). Since that time, the number of alternatives has been expanded to include alternatives such as walking, bicycling, sharing the ride, or not making the trip at all, and thus the analysis now better reflects riders' actual modal options.

In TERM, improvements are selected under one of four different modules (see Appendix C). However, only investments selected under the performance improvement module are directly subjected to a benefit-cost test at the time the improvement is considered. In contrast, the costs and benefits of investments to replace worn assets or to maintain the performance of existing transit operations are assessed over the full 20-year period of analysis covered by each TERM run. More accurately, TERM's benefit-cost analysis for these types of investments compares the total investment needs for each individual agency-mode combination, (including operating costs) with the total benefits derived from the continued operation of that agency-mode over the 20-year analysis period. Agency-mode combinations that fail this benefit-cost test then have all their investments removed from TERM's tally of National investment needs.

Changes made to the NBIAS model prior to the 2004 C&P Report have enabled significant upgrades to the benefit-cost component of the analysis, allowing some degree of trade-off analysis between bridge replacement and rehabilitation investment options. However, the benefit-cost analysis conducted in the model remains somewhat fragmented, occurring at separate stages of the analysis and using different procedures that are not necessarily closely related to one another.

One of the prime challenges in benefit-cost analyses for bridge rehabilitation and replacement is to adequately capture the impacts of physical conditions on users. Unlike highways, where poor pavement quality can directly affect vehicle wear and tear and operating speeds, poor structural conditions on bridges are largely unseen and do not directly affect the quality of users' experiences as they traverse the facility. Users are thus generally affected only when structural conditions deteriorate to the point where a bridge must be closed or have vehicle weight limitations imposed as a safety precaution. When this occurs, of course, the user impacts can be quite severe, depending on the availability of other nearby options, and are especially significant for the freight trucking sector.

Improving bridge investment benefit-cost analysis will thus require better information on user costs. The key data that would be required for such analytical enhancements include better information on highway use by vehicles of different weight classes and an improved understanding of the relationship between bridge condition ratings and posted weight limitations. Some vehicle weight data may be available from past FHWA studies of highway cost allocation and truck size and weight, but this information would need to be updated more regularly for use in the C&P analyses. Incorporating weight restrictions into the NBIAS analysis will likely require additional, perhaps original, research.

It should be restated that the limitations of the TERM and NBIAS analyses described here are largely due to the nature of the data sources and the types of improvements that they are designed to simulate, rather than to flaws in their design or implementation. The HPMS was originally designed specifically to provide the types of information required for the type of investment/performance analysis reflected in the C&P report, whereas the NTD and NBI were developed primarily for other purposes. Increased availability of more specific data would offer significant opportunities for progress toward a more complete analysis of transportation investments.

Investment Scenarios

This edition of the C&P report represents the first time that highway and transit investment scenarios were directly linked. In Chapter 8, transit investments scenarios were developed that accounted for increased transit PMT that might result from the imposition of variable rate user charges assumed in some of the highway investment scenarios. However, most of the highway and transit scenarios were developed independently of one another.

The limitations to the benefit-cost analyses in the different models lead to the disparate scenario definitions employed for highway, bridge, and transit investments in this report (see the Introduction to Part II). These scenarios can be classified into those that "Maintain" a particular set of performance indicators or funding levels, and those than "Improve" the performance of the system.

While "Maintain" and "Improve" scenarios are estimated for each of the three modes, the scenarios themselves represent different concepts. Among the "Improve" scenarios, only the HERS-derived scenario components are defined on the basis of maximizing net benefits. While TERM and NBIAS use benefit-cost analyses as a screen or filter, improvements are not selected solely on that basis. Thus, the "Improve" scenarios for these two models cannot be described in economic terms at the present time; instead, they represent conditions and performance benchmarks only, without direct consideration of the economic desirability of reaching that level of performance (in HERS, the level of conditions and performance reached under the "Improve" scenarios are a result rather than a specification).

The "Maintain" investment scenario concept, on the other hand, inherently involves reaching some future benchmark conditions and performance target that corresponds to the current state of the system. Because defining this benchmark can be difficult, various definitions have been used over the life of this report series. For the TERM analysis, the implementation is relatively straightforward because condition-related and performance-related improvements are estimated independently of one another. In HERS, rehabilitation and expansion improvements are modeled simultaneously, and trade-offs are made among improvements with varying impacts on conditions and performance. As a result, different levels of investment will correspond to different benchmarks (see Chapter 7). The Maintain Adjusted User Costs concept represents a reasonable blending of the two, but no comparable measures are available from either NBIAS or TERM in their present form.

The NBIAS "Improve" and "Maintain" scenario definitions are even more limited than those of HERS and TERM. The conditions and performance measure used for the analysis is based on the dollar cost of the backlog, rather than on an actual system-level physical condition measure. Further work is needed to calibrate the models to allow the calculation and prediction of such conditions measures with a sufficient degree of confidence; only then could the NBIAS scenarios to be redefined based on broader performance outcomes.

Finally, it should also be noted that there are important differences between HERS and TERM in their calculations of system condition measures for the "Maintain" scenarios. In HERS, the average IRI measure is calculated for the entire system at any one time. In calculating this measure, no distinction is made between the condition of new lanes and pre-existing lanes. Thus, the average IRI reported at any given investment level will represent the overall state of the system at that time, with the new pavements from newly added lanes fully weighted in. In the TERM analysis, however, the average condition rating measure is applied only to existing and replacement assets when defining the "Maintain Conditions and Performance" scenarios. The impact of new assets intended for system expansion is not included in the calculation of the condition and performance target. As a result, if transit capital funding were to be sustained at the Maintain Conditions and Performance level, the average asset condition measures representing the state of the entire system would be expected to increase over time, rather than remaining constant.

Network and Multimodal Trade-Off Analysis

In addition to analytical comparability, significant multimodal issues exist that concern the independence of the investment results produced by the C&P models. In particular, the models do not account for potential trade-offs between alternative highway and transit investments aimed at addressing the same performance issues at the transportation system level. These issues are closely related to the concept of performing analysis at the network level for highways; both are discussed here.

Network Analysis

One of the key limitations of the highway and bridge investment analyses presented in this report is that the analysis is conducted at the individual segment or bridge level. As a result, investments on any one facility are not shown to have a direct impact on the performance of any other facility in the models, although one of the key characteristics of the highway system in the United States is its extraordinary degree of interconnectivity, with numerous intersecting and parallel routes forming a complete network. Changes on one road can affect another and the functional performance of a bridge can significantly impact adjacent roads on either side.

It is clear, then, that a comprehensive highway investment tool would need to be network-based in order to fully capture all of these interrelated effects. However, the challenges involved in constructing such a framework are daunting. First, the highway data used as inputs into HERS are based on a sample of segments on higher-order systems. These sample segment data are sufficient for the national-level analyses performed in HERS, but a network analysis would require data on the universe of highway segments, requiring either expensive burdensome data collection or new statistical methods for expanding sample data to the universe. Some representation of rural minor collectors and rural and urban local roads would also need to be made in such a model (though perhaps not each facility individually), further increasing the amount of data needed.

Even if the data needed to feed a national-level network analysis tool were readily available, such a model could be extremely complex and computationally intensive. The network models used by MPOs and State highway agencies are quite costly and complicated, even for analyzing a single region; modeling at the national level could increase this complexity by orders of magnitude. Keeping the scope of the analysis within tractable limits would force simplifications and compromises in other areas of the analysis; there would thus be trade-offs involved in moving to such an approach. The network models currently in use also can be very sensitive to small changes in the network infrastructure. While these reflect the interrelated nature of the network, the magnitude and inconsistency of some of these results far from the location of the improvement may raise questions about how suitable such models are for some policy analysis applications.

While comprehensive network analysis may thus prove to be elusive, it would nevertheless be possible to improve the current models and methodologies that attempt to mimic some of these network effects. Although no direct linkages exist among the sample highway segments in HPMS, procedures have been added to HERS to take some network effects into account indirectly. For example, the delay estimation procedures have been calibrated to account for the impact that capacity restrictions on one segment can have on other segments through queuing. The travel demand elasticity procedures used in HERS reflect the fact that traffic may be diverted from or attracted to other highway segments in response to performance changes on the particular segment being analyzed. This is adequate for purposes of analyzing the benefits and costs of making an investment on an individual section, but it would be desirable to track and account for traffic shifts in a more comprehensive manner for purposes of assessing the systemwide impacts of an investment scenario. The FAF and the planned passenger travel analysis framework may provide a basis for resolving some of the analytical challenges associated with accounting for network effects without excessive computational complexity.

It might also be possible to make more limited changes to the data collection process that could facilitate some limited network analysis. For example, highway data might be sampled on the basis of corridors rather than segments, with data collected for multiple segments within a corridor. This would allow some intersegment relationships to be captured while maintaining the advantages of a sample approach.

Another desirable highway network analysis feature would be to link the highway and bridge analyses more directly. In the real world, bridge rehabilitation and other highway improvements in the same corridor are closely related to one another, and significant economies can be achieved if they are scheduled accordingly. This is particularly true for pavement resurfacing/reconstruction and bridge redecking improvements, and for bridge capacity expansion and other rehabilitation or replacement improvements; in both cases, these improvements are modeled separately in HERS and NBIAS, respectively. Linking the two analytical approaches would require linking the HPMS and NBI databases to one another so that bridges could be properly located on their associated highway segments (a more difficult task than might be intuitively supposed, given the different geocoding approaches used in the two databases). At a minimum, knowledge of the number and type of bridges on a given highway segment could be used to significantly improve the estimates of highway expansion costs assumed in HERS.

Potential does exist for improving the consideration of network effects in the highway and bridge investment analyses found in this report. At a minimum, future modifications to the model should be structured to make the models more consistent with network principles, rather than less so.

Multimodal Trade-Off Analysis

In principle, the network analysis concept could be extended to cover both highway and transit networks. Doing so would allow for an integrated analysis of surface transportation investment, a worthy goal for the C&P reporting process. If such a goal could be accomplished, then the combined total investment scenario estimates for highways, bridges, and transit would reflect the needs of the transportation system generally, rather than simply being a summation of mode-specific improvements.

> The FHWA Office of Transportation Policy Studies is developing a strategic multimodal framework for studying investments aimed at improving freight flow. While this analysis does not examine highway investment in detail, it uses HERS and other tools to examine investments across different freight modes in key trade corridors.
>
> This office also develops and maintains highway cost allocation models and truck size and weight models that can aid in the analysis of multimodal transportation issues.

As with highway network analysis, significant hurdles would need to be overcome in order to achieve a true multimodal network analysis capability. For highway network analysis, the current data collection process would need to be extended to a much larger portion of the highway system. Multimodal network analysis, however, would require the systematic collection of transit asset and use data on a fundamentally new basis. Presently, as noted elsewhere in the report, NTD data are collected only at the operator-mode level; to link up with highway network data, transit data would be needed on a detailed geographic level.

Because driving cars and riding transit represent alternative choices to users of the transportation system, investments in highway or transit infrastructure are often viewed as substitutes, and a complete analysis would reflect this view. The most frequently cited use of multimodal network analysis would be for trade-off analysis between highway capacity expansion and new or upgraded transit investment in a congested corridor. In such cases, a unimodal (or dual-modal) approach might overstate the level of investment required to address deficiencies by recommending that both transit and highway facilities be upgraded to the fullest extent.

Investments for operational performance needs are only one type of capital investment. As described in Chapter 8, a significant portion of future investment under the scenarios is for preserving the current asset base. Also, as noted in Chapter 1, there are many aspects of highway and transit investment that are complimentary, so that investments in one can improve the efficiency of the other. Thus, it is not clear that fully considering these cross-modal effects would lead to reduced estimates of highway and transit investment scenarios.

An example of a complementary transportation investment type that is not currently modeled, but that would affect both highways and transit operations, is high occupancy vehicle lanes. Investments in these facilities can both allow for improved transit service in a corridor and affect the demand for highway use by affecting vehicle occupancy rates. Thus, analyzing high occupancy vehicle lane investments would be an important part of any multimodal investment analysis.

Finally, while multimodal trade-off analysis is often cast in terms of options for intraregional passenger transportation, the concept could conceivably be extended to intercity passenger travel and to freight transportation, and include tradeoff analyses involving air, rail, and water transportation. While such capabilities would be useful for policy analyses of particular issues (such as truck-only lanes), they would also represent an expansion of the current scope of the C&P report, which focuses on highway and transit investment.

Productivity and Economic Development

Although the C&P report includes extensive analyses of highway and transit investment, focusing on the implications of that investment in terms of system conditions and performance, it does not directly address the impact of transportation infrastructure investment on productivity and economic activity. The 2002 edition of the report included a special topics chapter outlining some of the relationships between infrastructure and the economy. In the context of this view to the future of the C&P report, there are three subjects to be explored: the relationship between productivity impacts and benefit-cost analyses, the economic impacts of transportation system performance improvements, and highway investments specifically targeted to spur economic development.

One of the most prominent effects of transportation infrastructure is the impact that it can have on the location and level of business development. Indeed, this is one of the primary rationales for public involvement in transportation. Such impacts are likely to be most prominent in underdeveloped regions where inadequate infrastructure poses a significant impediment to growth by limiting access to national and regional markets. To a large extent, these impacts simply represent the translation of transportation system performance improvements into economic activity. Questions have been raised and theories proposed in recent years about whether some of these impacts might represent additional benefits of investment that are not currently captured in benefit-cost analyses. To the extent that such benefits might exist, the current methodology would understate transportation investment benefits by failing to account for this positive externality. At the present time, however, there is significant debate within the transportation research community on this subject, and it remains a controversial topic.

Even if such positive externalities could be identified and isolated, incorporating them into the current methodology could be challenging. Estimating such impacts would require additional information that is not currently collected on land use and economic activity in the area surrounding a potential improvement. Such impacts could well occur in regions not directly adjacent to an improvement, further expanding the scope of the data that would need to be captured.

If it were determined that economic impacts shouldn't be additively considered in the benefit calculations, there might still be some merit in measuring such impacts. Since any performance impacts are likely to result in new or relocated economic activity, such measures would represent an alternative illustration of the effects of investment, which could be quite useful to policymakers. This information could also help steer the discussion of the relationship between

> The FHWA Office of Interstate and Border Planning has conducted and/or sponsored research on the economic development impacts of highways. This research looks at the impact of highway investment on economic development from various perspectives. Some studies have examined State highway programs targeted at economic development to gauge their extent and impacts. Other research, including that in which FHWA played a coordinating and/or advisory role rather than acting as sponsor, has sought to understand the actual causes and mechanisms through which highway improvements can spur local economic development.
>
> Included within these research efforts are a number of before-and-after case studies of the economic impacts of specific rural freeway and expressway investments. Some of this research includes a discussion of cases where such investment has had success in supporting economic development and cases where it had not (or had not yet at the time of the study), and derives some conclusions (some broad, some specific, some tentative) about highways and economic development that can be drawn from the studies.
>
> More information on this research is available at http://www.fhwa.dot.gov/planning/econdev/index.html.
>
> The FHWA Office of Freight Management and Operations has also sponsored research into economic benefits of highway investments, focusing on long-term economic adjustments that are not captured in traditional benefit-cost methods. More information on this research is available at www.ops.fhwa.dot.gov/freight/freight_analysis/econ_methods.htm.

infrastructure development and the economy away from the transitory, short-term impacts on employment and onto the more permanent impacts that this investment can have on promoting commerce and industry. If such indicators could be reliably and consistently estimated based on the performance results of the investment models, they might make a valuable addition to the traditional analyses presented in the report.

As discussed in Chapter 7, an FHWA study estimated that between $500 million and $2 billion of highway spending per year is specifically targeted at regional economic development. These funds included programs tied to specific economic development outcomes (such as collateral private investment) as well as broader economic development programs, some of which may be implemented in conjunction with State economic development agencies.

From the perspective of the C&P report, the key question is the extent to which these types of expenditures are reflected in the investment scenarios. While the investment modeled in this report is aimed at correcting existing deficiencies in conditions or performance, economic development highway initiatives are intended to meet other goals. In many cases, such initiatives target existing deficiencies that are seen as barriers to improved commercial opportunities in a region; this type of investment would likely be included in the C&P report's estimates as well. In other cases, this goal might be met through significant upgrades to the transportation infrastructure that do more than simply address current deficiencies. As discussed in Chapter 7 and the Introduction to Part II, State and local governments may use criteria beyond those employed in the C&P report's investment analyses, and this portion of economic development highway funding would fall into that category.

Lower Functional Systems

The three investment models used in this report (HERS, NBIAS, and TERM) are all designed to use input data on system characteristics and conditions that are supplied to FHWA and FTA by State and local transportation agencies and operators. The data are assembled into three databases: HPMS, NBI, and NTD (see Appendices A, B, and C for more information). While mandatory reporting requirements are in place for each of these data series, ensuring that the datasets are reasonably rich and complete, the requirements do not cover all roads or transit systems. As a result, several limitations apply to these data.

On the FHWA side, only roads in functional classes that are eligible for Federal aid are included in the HPMS sample dataset (though limited data are collected universally), meaning that rural minor collectors and rural and urban local roads are not directly included in the HERS analysis. As a result, potential future investments on these functional classes must be accounted for indirectly, rather than being actually modeled (see Chapter 7).

Because all bridges on public roads are eligible for Federal aid, the same limitation does not apply to the NBIAS results. However, the bridge-level data items included in the NBI are more aggregate than the element-level inspection data that many States collect, but reporting of these more detailed data to FHWA is not required.

Prior to 2005, only transit systems in urbanized areas (over 50,000 in population) that receive Federal funding were required to report to NTD. In 2005, the NTD reporting requirement was expanded to include transit operators in non-urbanized (rural) areas, and, as a result of this change, these capital needs are now modeled within TERM. Following this change, transit operators receiving FTA Section 5310 Elderly and Disabled Specialized Transit Program funds are now the only remaining operator type not required to report to NTD. Consequently, these capital needs for these operators are modeled outside of TERM.

From a conceptual standpoint, having more complete data from these lower-order systems would obviously improve the precision of the national investment estimates. However, such improvements must be weighed against the reporting burden that would be placed on the providers of the data. Enforcing any mandatory reporting requirements could also be an issue with providers that do not receive Federal funding. As a result, FHWA and FTA are and will be pursuing other projects aimed at improving estimates for these classes of roads and operators.

Scope of the Report

While the chapters in Part I of this report include data on both capital and noncapital spending and activities, the investment analyses of Part II focus exclusively on capital improvements. To some degree, this reflects the traditional focus of Federal assistance for surface transportation on infrastructure development, with operating, maintenance, and administrative responsibilities left to State and local governments (see Chapter 1). It also reflects a view that ongoing, noncapital expenditures are simply a cost associated with a given level of infrastructure provision, rather than representing long-term investment needs.

Two issues have been raised concerning the capital focus of the report. First, as noted above, operations strategies and preventive maintenance are increasingly being seen as a partial alternative to infrastructure investment in today's world as part of an asset management strategy, rather than simply as a cost of doing business. How should this best be reflected in the investment analyses presented in this report? The discussion of highway operations strategies in Part II reflects an initial effort along these lines, but this presentation is likely to change over time as thinking on this subject evolves.

Another issue regarding the focus on capital outlay is that it does not fully inform policymakers about the true cost of program delivery. While agencies strive to streamline their programs and systems in order to stretch limited funds as far as possible, new mandates and legislative requirements may make this more difficult. If such trends are present and growing into the future, then more overall resources would be required to sustain a given level of capital investment. Should the investment scenario estimates reflect such possibilities?

Current modeling programs do not consider investment requirements for highway tunnels in the Nation's tunnel network. There is no nationwide database for tunnels equivalent to the NBI, and neither HERS nor NBIAS is currently equipped to directly analyze them. Meanwhile, there is growing interest in the quality of the Nation's tunnel network. On July 28, 2008, the U.S. House of Representatives approved H.R. 3999; this bill, if enacted into law, would establish a national tunnel inspection program.

A final scope issue concerns the particular modes that are included in the report analyses. The highway and transit conditions and performance reports were originally prepared separately, reflecting the fact that the legislative requirements for the reports were found in separate parts of the *United States Code.* Since 1993, these analyses have been combined into a single report; SAFETEA-LU altered the legislative mandate by including transit in the scope of the report defined in Section 502(h) of Title 23. However, while these two modes are both economically significant and closely related, they do not represent the entirety of the Nation's surface transportation system. In particular, conditions, performance, and investment analyses for intercity rail and bus, maritime transportation, inland waterways, railroads, and port and international gateway facilities are not included in the report. Some of these modes are typically characterized by private sector control over management, finance, and investment, but others do have substantial public involvement in their infrastructure financing. Past analyses (such as the 1995 C&P Report) have included discussions of some of these modes, and recent reports have included additional analyses of specific components of the system (such as transit on Federal lands, highway-rail grade crossings, and intermodal connectors).

Changing the scope of the C&P report on any of these accounts would represent a significant change in the character of the report. They would thus require extensive consultation with policymakers and stakeholders before implementation. More generally, the issues listed above and many of the topics discussed elsewhere in this Afterword section ultimately relate to the basic purposes of the C&P report. Should it become a comprehensive source for a variety of transportation policy analyses, or should it retain its focus on national-level conditions, performance, and investment scenario reporting? Do the special topics and analyses that have been included in the report in recent years add useful breadth to the report, or do they ultimately distract from its central purpose? If these other analyses and information would truly be useful to Congress and other policymakers, one option would be to provide them in separate reports, allowing the C&P to retain its basic character and function. Separate reports could also be more focused on key policy issues than would be possible in a more inclusive document.

Extensions of the Analysis

A final topic concerning the future of the C&P report relates to extensions of the analysis to other purposes. The U.S. DOT and its agencies have devoted considerable research and staff resources over many years to the analytical tools developed for this report series. Are there ways that this investment could be leveraged beyond the C&P report itself? Two potential areas come to mind: using the tools in other contexts and bringing the tools to other agencies.

The C&P analytical tools represent a blend of analytical sophistication and limitation commensurate with the purposes that they serve. Are they appropriate for use in other policy analyses as well? If the models are to be used in other contexts, they may require some customization and fine-tuning for those purposes. Such efforts could require diverting resources from other model development work, and care would need to be taken to ensure that any resulting changes would not interfere with the operation of the models for C&P purposes. More importantly, could the models produce misleading results if used out of context? The FHWA is currently exploring such extensions of the HERS analysis for studying freight bottlenecks. The longer-term pavement modeling research described above is also being conducted to ensure that the basic pavement deterioration modeling approach is consistent in both HERS and in tools used for highway cost allocation studies.

Another extension of C&P research is to offer the use of the analytical tools to other stakeholders outside of U.S. DOT. The FHWA has developed a version of HERS for use by State highway agencies, known as HERS-ST. The agency has actively promoted HERS-ST as an asset management tool since its initial release in 2002 and has provided training and support for the software to a number of different States. Local transportation agencies and regional planning organizations have also expressed interest in the tool. These efforts allow others to benefit from the research and development that FHWA has conducted. By helping to improve decision-making about capital investments at the State and local levels, they also make it more likely that the estimated performance level associated with a given level of investment can be achieved. Finally, by extending the use of the HERS model, FHWA is receiving valuable insights into the operation of the model and suggestions for future enhancements. The FHWA and FTA are considering whether similar outreach efforts might be warranted for the other analytical tools.

PART V

Appendices

Introduction

Appendices A, B, and C describe the modeling techniques used to generate the investment/performance analyses and selected capital investment scenario estimates highlighted in Chapters 7 through 10, focusing on changes in methodology since the previous edition of the C&P report. All three models incorporate benefit-cost analysis in their selection of transportation capital improvements.

Appendix A describes changes in the **Highway Economic Requirements System** (HERS), which is used to analyze potential future investments for highway resurfacing and reconstruction and highway and bridge capacity expansion. Significant changes to HERS include revised procedures for linking investment levels and highway user charges including congestion pricing, improved estimates for the potential impacts of operations strategies and Intelligent Transportation Systems, and updated capital improvement cost estimates.

The **National Bridge Investment Analysis System** (NBIAS) is the primary tool for analyzing potential future bridge rehabilitation and replacement investments. For this report, the unit costs for varying types of bridge improvements were updated, the number of alternative climate zones analyzed by the NBIAS model was increased, and the assessment of the relative benefits of different types of investments was updated to take into account current assumptions being made by States for analyses using similar procedures. These changes are described in **Appendix B**.

Appendix C presents technical information on the **Transit Economic Requirements Model** (TERM), which is used to analyze potential future transit investments in urbanized areas. TERM includes modules which estimate the funding that will be required to replace and rehabilitate transit vehicles and other assets, to invest in new assets to accommodate future transit ridership growth, and to improve operating performance to targeted levels.

Appendix A

Highway Investment Analysis Methodology

Highway Investment Analysis Methodology

Investments in highway resurfacing and reconstruction and in highway and bridge capacity expansion are modeled by the Highway Economic Requirements System (HERS), which has been used since the 1995 C&P Report. This appendix describes the basic HERS methodology and approach in slightly more detail than is presented in Part II, including the treatment of intelligent transportation system (ITS) deployment and operations strategies, the allocation of investment across improvement types, and the calculation of the highway backlog. It also explores some of the improvements that have been made to the model since the 2006 C&P Report. These include the refinement of procedures that link investment levels to revenues and simulate the effect of universal congestion pricing, the extension of the analytical procedures to consider a broader range of operations strategies, and updates to the improvement costs matrix.

Highway Economic Requirements System

The HERS model initiates the investment analysis by evaluating the current state of the highway system using information on pavements, geometry, traffic volumes, vehicle mix, and other characteristics from the Highway Performance Monitoring System (HPMS) sample dataset. Using section-specific traffic growth projections, HERS forecasts future conditions and performance across several funding periods. As used in this report, the future analysis covers four consecutive 5-year periods. At the end of each period, the model checks for deficiencies in eight highway section characteristics: pavement condition, surface type, volume/service flow (V/SF) ratio, lane width, right shoulder width, shoulder type, horizontal alignment (curves), and vertical alignment (grades).

> **Q&A**
>
> **Where can I find more detailed technical information concerning the HERS model?**
>
> The Federal Highway Administration has previously developed a Technical Report for the Highway Economic Requirements System. The most recent printed edition, dated December 2000, is based on HERS version 3.26, which was utilized in the development of the 1999 edition of the C&P report.
>
> The FHWA also has developed a modified version of HERS for use by States. This model, HERS-ST, builds on the primary HERS analytical engine, but adds a number of customized features to facilitate analysis on a section-by-section basis. HERS-ST version 4.0 is largely based on HERS version 4.097, which was utilized in developing the 2004 edition of the C&P report. "The Highway Economic Requirements System – State Version: Technical Report" is available online at http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersdoc.htm.

Once HERS determines that a section's pavement or capacity is deficient, it identifies potential improvements to correct some or all of the section's deficient characteristics. The HERS model evaluates seven kinds of improvements: resurfacing, resurfacing with shoulder improvements, resurfacing with widened lanes (i.e., minor widening), resurfacing with added lanes (i.e., major widening), reconstruction, reconstruction with widened lanes, and reconstruction with added lanes. For improvements that add travel lanes, HERS further distinguishes between those that can be made at "normal cost" and those on sections with limited widening feasibility that could only be made at "high cost". HERS may also evaluate alignment improvements to improve curves, grades, or both.

When evaluating which potential improvement, if any, should be implemented on a particular highway section, HERS employs incremental benefit-cost analysis. The HERS model defines benefits as reductions in direct highway user costs, agency costs, and societal costs. Highway user benefits include reductions in travel time costs, crash costs, and vehicle operating costs; agency benefits include reduced maintenance costs (plus the residual value of projects with longer expected service lives than the alternative); and societal benefits include reduced vehicle emissions. Increases in any of these costs resulting from a highway improvement (such as higher emissions rates at high speeds or the increased delay associated with a work zone) would be factored into the analysis as a negative benefit or "disbenefit."

Dividing these improvement benefits by the capital costs associated with implementing the improvement results in a benefit-cost ratio that is used to rank potential projects on different highway sections. The HERS model implements improvements with the highest BCR first. Thus, as each additional project is implemented, the marginal BCR declines, resulting in a decline in the average BCR for all implemented projects. However, until the point where the marginal BCR falls below 1.0 (i.e., costs exceed benefits), total net benefits will continue to increase as additional projects are implemented. Investment beyond this point would not be economically justified because it would result in a decline in total net benefits.

Because the HERS model analyzes each highway segment independently, rather than the entire transportation system, it cannot fully evaluate the network effects of individual highway improvements. While efforts have been made to indirectly account for some network effects, HERS is fundamentally rooted to its primary data source, the national sample of independent highway sections contained in the HPMS. To fully recognize all network effects, it would be necessary to develop significant new data sources and analytical techniques. Part IV, Afterword, includes more discussion of this issue.

Allocating HERS Results Among Improvement Types

Highway capital expenditures can be divided among three types of improvements: system rehabilitation, system expansion, and system enhancements (see Chapters 6 and 7 for definitions and discussion). All improvements selected by HERS that did not add lanes to a facility were classified as part of system rehabilitation. For improvements that added lanes, the total cost of the improvement was split between rehabilitation and expansion because widening projects typically improve the existing lanes of a facility to some degree and because adding new lanes to a facility tends to reduce the amount of traffic carried by each of the old lanes, which may extend their pavement life. The allocation of widening costs between preservation and capacity expansion was based on the improvement cost inputs and implementation procedures within the HERS model.

Highway Investment Backlog

To determine the action items for inclusion in the highway investment backlog, HERS evaluates the current state of each highway section before projecting the effects of future travel growth on congestion and pavement deterioration. Any potential improvement that would correct an existing pavement or capacity deficiency, and that has a BCR greater than or equal to 1.0, is considered part of the current highway investment backlog.

As noted in Chapter 7, the backlog estimate produced by HERS does not include either rural minor collectors or rural and urban local roads and streets (since HPMS does not contain sample section data for these functional systems), nor does it contain any estimate for system enhancements. The backlog for the bridge portion of system rehabilitation is modeled separately through the National Bridge Investment Analysis System (NBIAS), which is discussed in Appendix B.

Travel Demand Elasticity

The States furnish projected travel for each sample highway section in the HPMS dataset. As described in Chapters 7 and 9, HERS assumes that the HPMS forecasts are constant-price forecasts, meaning that the generalized price facing highway users in the forecast year is the same as in the base year. The HERS model uses these projections as an initial baseline, but alters them in response to changes in highway user costs on each section over time. The travel demand elasticity procedures in HERS recognize that some potential travel on a highway may be deterred as the facility becomes more congested, and that the volume of traffic may increase when lanes are added to a facility.

> **Q&A**
>
> **What are some examples of the types of behavior that the travel demand elasticity features in the HERS represent?**
>
> If highway congestion worsens in an area, this increases travel time costs on the road network. In response, some highway users might shift their trips to mass transit or perhaps forgo some personal trips they might ordinarily make. For example, they might be more likely to combine multiple errands into a single trip because the time spent in traffic on every trip discourages them from making a trip unless it is absolutely necessary. Increases in fuel prices also increase the cost of driving, and would tend to have a similar impact.
>
> In the longer term, people might make additional adjustments to their lifestyles in response to changes in user costs that would impact their travel demand. For example, if travel time in an area is reduced substantially for an extended period of time, some people may make different choices about where to purchase a home. If congestion is reduced, purchasing a home far out in the suburbs might become more attractive, since commuters would be able to travel farther in a shorter period of time.

The basic principle behind demand elasticity is that, as the price of a product increases relative to the price of other products or services, consumers will be inclined to consume less of it. Conversely, if the price of a product decreases, consumers will be inclined to consume more of it, either in place of some other product or in addition to their current overall consumption. The travel demand elasticity procedures in HERS treat the cost of traveling a facility as its price. This means that the volume of traffic growth tends to be constrained when a highway becomes more congested and the cost of traveling it (i.e., travel time cost) increases, and that volume of travel tends to increase when lanes are added and highway user costs decrease.

As a result of travel demand elasticity, the overall level of highway investment has an impact on projected travel growth. For any highway investment scenario that results in a decrease in average highway user costs, the effective vehicle miles traveled (VMT) growth rate tends to be higher than the baseline rate. For scenarios in which highway user costs increase, the effective VMT growth rate tends to be lower than the baseline rate. However, this effect is dampened for scenarios that assume that increases in the overall level of highway investment will be funded by increases in fixed or variable highway-user charges.

Demand elasticity is measured as the percentage change in travel relative to the percentage change in costs faced by users of the facility. Thus, an elasticity value of –0.65 would mean that a 10-percent increase in user costs would result in a 6.5 percent decrease in travel.

HERS Revenue and Pricing Analysis

The 2006 C&P Report introduced new HERS analytical procedures involving highway revenue and pricing analysis. Although these two procedures addressed related issues, they were initially implemented distinctly from one another within the model. For this report, these procedures have been revised to directly interact so that they can be used in conjunction with one another.

Congestion Pricing

The HERS congestion pricing procedures simulate the impact of imposing a charge on peak-period users of congested highway facilities. The congestion pricing feature was constructed using the existing HERS procedures for calculating delay and travel demand. HERS first calculates average user costs for an individual highway section in its usual fashion, and then derives the marginal congestion cost from the delay equations (coupled with value-of-time inputs). The difference between average costs and marginal costs represents the estimated congestion externality that each additional vehicle imposes on other users for that particular highway section. The model then applies a toll equal to this cost differential, requiring users to pay for this externality (thus improving efficiency), and determines a new equilibrium volume and price, reflecting the travel demand elasticity procedures described above.

The congestion pricing procedure is applied to peak period traffic on all roads with a volume/service flow (V/SF) ratio of 0.80 or greater. This is the threshold used in Chapters 4 and 7 to identify congested roads. While the primary congestion pricing strategy reflected in this report is described as "universal congestion pricing," this refers only to the implementation of these procedures on all congested roads. The size of the charge imposed varies considerably from section to section, as the impact of adding vehicles to heavily traveled and severely congested roadways is much greater than the impact of adding vehicles to moderately congested roadways.

HERS Revenue Analysis

The HERS revenue analysis procedures provide the option of imposing a "balanced budget" constraint on the results This was done by creating a mechanism to link the HERS levels of investment to the additional revenue that would be required to fund those investments.

The first step in the procedure is to determine the amount of revenue that must be raised to reach a target funding level. This calculation is based on the difference between the funding constraint specified for the run and base-year HERS-related expenditures, which were calculated from 2006 highway capital expenditure data. A multiplier is then applied to this difference to ensure that revenues would be sufficient to cover other capital expenditure types (including bridge rehabilitation and replacement and system enhancement) and functional systems (rural minor collector, rural local, and urban local) that are not modeled in HERS. The resulting total is then multiplied by a user-specified percentage indicating the portion of total revenue that should be assumed to come from system users in the form of a surcharge imposed on either a per-mile or a per-gallon basis.

For this report, the percentage of total revenue assumed to come from system users was set at 0 percent for both per-mile and per-gallon surcharges; for those analyses assuming funding from user-based sources, the per-mile surcharge percentage was set at 100 percent. This represents a departure from the 2006 C&P Report, which instead assumed a per-gallon surcharge.

The next step in the procedure is to compute a surcharge tax rate by dividing the amount of required revenue by the estimated total VMT and/or fuel consumption. Since the imposition of the surcharge would impact the price of driving and thus influence total VMT, the surcharge tax rate is computed iteratively until a new equilibrium of volume and price is established that generates approximately the amount of required revenue. The revenue and surcharge calculations are repeated sequentially for each funding period. However, during the benefit-cost analysis in each period (which typically extends over multiple periods), HERS assumes that the surcharge tax rates in that period are carried forward into future periods.

For this report, the revenue analysis procedure was modified so that the surcharge tax rate could be negative in cases where the level of investment being analyzed was below the current investment level, or if other revenues were available from congestion pricing as described in the next section. A negative surcharge represents the equivalent of reductions in existing user charges such as tolls or fuel taxes.

Linking of Congestion Pricing With Revenue Analysis Procedures

The analyses in this report that assume funding from variable rate user-based sources make use of both the congestion pricing and revenue analysis procedures described above. In determining the fixed rate VMT surcharge, HERS takes into account the total revenue that is required to be raised to achieve the target funding level as well as the revenue that would be generated from the variable congestion pricing charges. In cases where the congestion pricing revenue exceeds the amount of total revenue required, a negative fixed rate VMT charge is imposed, which has the effect of shifting some costs from off-peak highway users to peak-period highway users.

Because the fixed rate and variable rate charges both impact travel volumes through the travel demand elasticity procedures described above, the process of developing a new equilibrium volume and price is significantly more complex for analyses that incorporate both the congestion pricing and the revenue analysis procedures.

Operation Strategies and ITS Deployment

One of the key modifications to HERS featured in the previous report was the ability to consider the impact of highway operations strategies and ITS deployments on highway system performance. This feature is continued in this report with only minor modifications. Current and future investments in operations are modeled outside of HERS, but the impacts of these deployments were allowed to affect the internal calculations made by the model, and thus also affect the capital improvements considered and implemented in HERS. As discussed in Part IV, a longer-term goal would be to analyze operations as alternative investment strategies directly in HERS.

While numerous operations strategies are available to highway agencies, a limited number are now considered in HERS (based on the availability of suitable data and empirical impact relationships). The types of strategies analyzed can be grouped into four categories: arterial management, freeway management, incident management, and travel information as follows:

- Arterial Management
  - Signal Control
  - Electronic Roadway Monitoring (considered to be a supporting deployment necessary to other operations strategies)
  - Variable Message Signs (VMS)
- Freeway Management
  - Ramp Metering (preset and traffic actuated)
  - Electronic Roadway Monitoring (considered to be a supporting deployment necessary to other operations strategies)
  - VMS
  - Integrated Corridor Management (ICM)
  - Variable Speed Limits (VSL) (also known as “speed harmonization”)
- Incident Management (freeways only)
  - Incident Detection (free cell phone call number and detection algorithms)
  - Incident Verification (surveillance cameras)
  - Incident Response (on-call service patrols)

- Traveler Information
  - 511 systems
  - Advanced in-vehicle navigation systems with real-time traveler information (enabled by Vehicle-Infrastructure Integration deployment)
  - Incident response (on-call service patrols).

Creating the operations improvements input files for use in HERS involved four steps: determining current operations deployment, determining future operations deployments, determining the cost of future operations investments, and determining the impacts of operations deployments. Different levels and types of deployments can be selected for an individual scenario.

Current Operations Deployments

To determine current operations deployments on the HPMS sample segments, data were used from three sources: HPMS universe data, HPMS sample data, and data from the ITS Deployment Tracking System. The data assignments that were made reflected the fact that operations deployments occur over corridors (or even over entire urban areas, as with traffic management centers).

Future Operations Deployments

For future ITS and operations deployments, three scenarios were developed. For the "Continuation of Existing Deployment Trends" scenario, an examination of current congestion levels compared with existing deployments was made to set the congestion level by urban area size for each type of deployment. For the "Aggressive Deployment" scenario, an accelerated pace of deployment above existing trends was assumed, along with more advanced forms of operations strategies. The "Full Deployment" scenario is identical to the "Aggressive Deployment" scenario, except that it assumes that all deployments will occur immediately rather than being phased in over 20 years. The "Full Deployment" scenario is intended to illustrate the maximum potential impact of the strategies and technologies modeled in HERS on highway operational performance. *Exhibit A-1* identifies the strategies employed in the each scenario.

Exhibit A-1

Types of Operations Strategies Included in Each Scenario

	Scenario	
Operations Strategy	**Continue Existing Trends**	**Aggressive and Full Deployment**
Arterial Management		
Signal Control	●	●
Emergency Management Vehicle Signal Preemption	●	●
VMS		●
Advanced Traveler Information		●
Freeway Management		
Ramp Metering	●	●
VMS	●	●
511 Traveler Information	●	
Advanced Traveler Information		●
ICM		●
VSL		●
Incident Management (Freeways Only)		
Detection	●	●
Verification	●	●
Response	●	●

Source: Highway Economic Requirements System.

Operations Investment Costs

The unit costs for each deployment item were taken from the U.S. Department of Transportation's (DOT's) *ITS Benefits Database* and *Unit Costs Database* and supplemented with costs based on the ITS Deployment Analysis System (IDAS) model. Costs were broken down into initial capital costs and annual operating and maintenance costs. Also, costs were determined for building the basic infrastructure to support the equipment, as well as for the incremental costs per piece of equipment that is deployed. A major addition to operations deployment costs in this report is the inclusion of traffic signal replacement costs, which were not previously considered in the estimated capital costs.

Impacts of Operations Deployments

Exhibit A-2 shows the estimated impacts of the different operations strategies considered in HERS. These effects include the following:

- Incident Management: Incident duration and the number of crash fatalities are reduced. Incident duration is used as a predictor variable in estimating incident delay in the HERS model.
- Signal Control: The effects of the different levels of signal control are directly considered in the HERS delay equations.
- Ramp Meters, VMS, VSL, ICM, and Traveler Information: Delay adjustments are applied to the basic delay equations in HERS. VSL is assumed to have a small impact on fatalities as well.

Based on the current and future deployments and the impact relationships, an operations improvements input file was created for each of the two deployment scenarios. The file contains section identifiers, plus current and future values (for each of the four funding periods in the HERS analysis) for the following five fields:

- Incident Duration Factor
- Delay Reduction Factor
- Fatality Reduction Factor
- Signal Type Override
- Ramp Metering.

HERS Improvement Costs

For the 2004 C&P Report, significant changes were made to the structure of the HERS improvement cost matrix, the assumed unit costs in that matrix, and the manner in which those values were applied. The improvement cost updates reflected in the 2004 report were based on highway project data from six States (see Appendix A of that report for more information). Though adequate in most respects, that dataset was relatively thin in certain key areas. The 2004 update disaggregated the improvement cost values in urban areas by functional class and by urbanized area size. Three population groupings were used: small urban (5,000 to 49,999), small urbanized (50,000 to 200,000), and large urbanized (more than 200,000). However, the data used to create values for the latter group did not include a significant number of projects in very large urbanized areas, and concerns were raised about the degree of construction cost comparability between medium-sized cities and much larger ones.

For the 2006 C&P Report, additional project cost data were collected for large urbanized areas, rural mountainous regions, and high-cost capacity improvements. These data were used to update the HERS improvement cost matrix, which was also modified to include a new category for major urbanized areas over 1 million in population. The HERS improvement cost matrix was adjusted further for this report, based on some additional analysis of the data previously collected.

Exhibit A-3 identifies the costs per lane mile assumed by HERS for different types of capital improvements. For rural areas, separate cost values are applied by terrain type and functional class, while costs are broken down for urban areas by population area size and type of highway. These costs are intended to reflect the typical values for these types of projects in 2006. However, the project level data on which these estimates are based reveal a considerable amount of variability in costs, which can be attributed to a number of location-specific factors. For example, while the unit costs per lane mile for adding an additional lane are based on project data that reflect the costs of improving bridges, modifying interchanges, and addressing environmental issues, these values represent the average costs for a typical project. However, a project with

Exhibit A-2

Impacts of Operations Strategies in HERS

Operations Strategy	Impact Category	Impact
Arterial Management		
Signal Control	Congestion/Delay	Signal Density Factor = n(nx+2)/(n+2) where n = # of signals per mile x = 1 for fixed time control 2/3 for traffic actuated control 1/3 for closed loop control 0 for real-time adaptive control/SCOOT/SCATS Signal Density Factor is used to compute zero-volume delay due to traffic signals
Electronic Roadway Monitoring	Congestion/Delay	Supporting deployment for corridor signal control (2 highest levels) and traveler information
EM Vehicle Signal Preemption		
VMS	Congestion/Delay	-0.5% incident delay
Freeway Management		
Ramp Metering		
Preset	Congestion/Delay	New delay = ((1 - 0.13)(original delay)) + 0.16 hrs per 1000 VMT
Traffic Actuated	Congestion/Delay	New delay = ((1 - 0.13)(original delay)) + 0.16 hrs per 1000 VMT
	Safety	-3% number of injuries and PDO accidents
Electronic Roadway Monitoring	Congestion/Delay	Supporting deployment for ramp metering and traveler information
VMS	Congestion/Delay	-0.5% incident delay
Integrated Corridor Management	Congestion/Delay	-10% total delay
Variable Speed Limits	Congestion/Delay Safety	-5% total delay -5% fatalities
Incident Management (Freeways Only)		
Detection Algorithm/ Free Cell	Incident Characteristics Safety	-4.5% incident duration -5% fatalities
Surveillance Cameras	Incident Characteristics Safety	-4.5% incident duration -5% fatalities
On-Call Service Patrols		
Typical	Incident Characteristics Safety	-25% incident duration -10% fatalities
Aggressive	Incident Characteristics Safety	-35% incident duration -10% fatalities
All Combined	Incident Characteristics Safety	Multiplicative reduction -10% fatalities
Traveler Information		
511 Only	Congestion/Delay	-3.0% total delay, rural only
Advanced Traveler Information	Congestion/Delay	-12% total delay, all highways

Source: Highway Economic Requirements System.

a large number of bridges, complicated interchanges, major environmental issues, and/or other extreme engineering issues would be expected to cost considerably more that a less complex project.

The values shown for adding a lane at "Normal Cost" reflect costs for projects where sufficient right-of-way is available or could be readily obtained to accommodate additional lanes. The values for adding lane equivalents at "High Cost" are intended to reflect situations in which conventional widening is not feasible and alternative approaches would be required in order to add capacity to a given corridor. Such alternatives would include the construction of parallel facilities, double-decking, tunneling, or the purchase of extremely expensive right-of-way. While HERS models these lane equivalents as though they are part of existing highways, some of this capacity could come in the form of new highways or investment in other modes of transportation facilities.

Exhibit A-3

Typical Costs Per Lane Mile Assumed in HERS, by Type of Improvements

(Thousands of 2006 Dollars Per Lane Mile)

Category	Reconstruct and Widen Lane	Reconstruct Existing Lane	Resurface and Widen Lane	Resurface Existing Lane	Improve Shoulder	Add Lane Normal Cost	Add Lane Equivalent High Cost	New Alignment Normal	New Alignment High
Rural									
Interstate									
Flat	$1,791	$1,170	$1,014	$415	$77	$2,301	$3,191	$3,191	$3,191
Rolling	$2,007	$1,200	$1,167	$442	$127	$2,495	$4,037	$4,037	$4,037
Mountainous	$3,806	$2,627	$1,933	$654	$267	$7,769	$9,095	$9,095	$9,095
Other Principal Arterial									
Flat	$1,398	$936	$845	$333	$52	$1,844	$2,639	$2,639	$2,639
Rolling	$1,579	$962	$961	$371	$86	$1,974	$3,186	$3,186	$3,186
Mountainous	$3,066	$2,166	$1,862	$524	$114	$6,969	$8,025	$8,025	$8,025
Minor Arterial									
Flat	$1,279	$823	$788	$295	$48	$1,676	$2,353	$2,353	$2,353
Rolling	$1,544	$911	$980	$318	$89	$1,921	$3,030	$3,030	$3,030
Mountainous	$2,565	$1,682	$1,862	$436	$201	$5,883	$7,060	$7,060	$7,060
Major Collector									
Flat	$1,347	$871	$814	$301	$62	$1,741	$2,351	$2,351	$2,351
Rolling	$1,474	$885	$915	$320	$83	$1,779	$2,894	$2,894	$2,894
Mountainous	$2,235	$1,385	$1,332	$436	$129	$3,766	$4,919	$4,919	$4,919
Urban									
Freeway/Expressway/Interstate									
Small Urban	$2,921	$2,023	$2,302	$491	$90	$3,665	$11,997	$4,939	$16,861
Small Urbanized	$3,140	$2,040	$2,381	$581	$119	$4,031	$13,157	$6,658	$22,728
Large Urbanized	$5,008	$3,340	$3,688	$779	$450	$6,702	$22,478	$9,765	$33,337
Major Urbanized	$10,017	$6,680	$7,157	$1,291	$900	$13,403	$55,892	$19,530	$74,714
Other Principal Arterial									
Small Urban	$2,546	$1,718	$2,107	$412	$91	$3,115	$10,175	$3,894	$13,290
Small Urbanized	$2,724	$1,739	$2,202	$487	$122	$3,375	$11,066	$4,804	$16,398
Large Urbanized	$3,891	$2,549	$3,222	$612	$392	$4,939	$16,502	$6,594	$22,510
Major Urbanized	$7,782	$5,098	$6,444	$988	$785	$9,878	$38,292	$13,189	$57,092
Minor Arterial/Collector									
Small Urban	$1,876	$1,298	$1,593	$301	$66	$2,301	$7,451	$2,809	$9,590
Small Urbanized	$1,965	$1,313	$1,608	$343	$81	$2,424	$7,876	$3,447	$11,767
Large Urbanized	$2,646	$1,755	$2,199	$420	$221	$3,360	$11,157	$4,486	$15,313
Major Urbanized	$5,292	$3,510	$3,327	$700	$441	$6,721	$38,292	$8,973	$47,385

Source: Highway Economic Requirements System.

Appendix B

Bridge Investment Analysis Methodology

Bridge Investment Analysis Methodology

The National Bridge Investment Analysis System (NBIAS) was developed over the past 12 years as a tool for assessing national bridge investment needs and the tradeoff between funding and performance. NBIAS, first introduced in the 1999 edition of the C&P report, models investments in bridge repair and rehabilitation and functional improvements. Over time the system has seen increasing usage as an essential decision support tool for policy analysis and for satisfying the information needs of the U.S. Congress.

NBIAS is based on the same analytical framework as the Pontis bridge program first developed by the Federal Highway Administration (FHWA) in 1989 and subsequently taken over by the American Association of State Highway and Transportation Officials (AASHTO). AASHTO now owns and licenses Pontis to over 50 State transportation departments and other agencies.

Pontis provides the bridge engineer with the tools to conduct detailed analysis of the performance of bridges. In order to perform analysis at such a detailed level, Pontis requires data on over 100 elements pertaining to each individual bridge.

NBIAS incorporates economic forecasting analysis tools to provide budget and planning staff with the ability to forecast the multiyear funding needs required to meet user-selected performance metrics over the length of a user specified performance period. NBIAS is modified to work with bridge condition as reported by the States for the National Bridge Inspection System as well as the element/condition state inspection regime used in Pontis. NBIAS contains heuristics to synthesize representative projects so that they can be defined and manipulated using the same structure of condition states, actions, deterioration, costs, and effectiveness probabilities used in Pontis, making them compatible with Pontis' predictive models and analytical routines.

This appendix contains a technical description of the methods used in NBIAS to predict future nationwide bridge conditions and analyze bridge investment, including information on the system overview, determination of functional needs, determination of repair and rehabilitation needs, and planned improvements to future versions of the system.

NBIAS Overview

The NBIAS is an investment analysis tool used to analyze bridge repair, rehabilitation, and functional improvement investment needs. The system can be used to examine the backlog of needs, in dollars and number of bridges; distribution of work done, in dollars and number of bridges; aggregate and user benefits; benefit-cost ratios for work performed; and physical measures of bridge conditions. Outcomes can be presented by type of work, functional classification, whether the bridges are part of the National Highway System, and/or whether the bridges are part of the Strategic Highway Network.

Using the linear programming network optimization of Pontis, NBIAS generates a set of prototype maintenance policies for defined subdivisions of the Nation's bridge inventory. Models of element deterioration, feasible actions, and the cost and effectiveness of those actions are incorporated as major inputs for each subdivision of the inventory.

For functional deficiencies and improvements, NBIAS uses a model essentially similar in structure to the bridge level of service standards and user cost models of Pontis. This analysis is performed at the bridge level but is reported only at aggregate levels for Federal policy-making.

Methodology

With a set of synthesized projects developed from the maintenance and functional improvement models, NBIAS calculates a tradeoff structure showing how hypothetical funding levels may affect each of more than 50 performance measures. For this analysis it utilizes an adaptation of the same incremental benefit-cost model used in Pontis, with a graphical output showing the tradeoff between funding and performance. This graphical output and other network-level reports then become the basis of information presented to policy makers and the U.S. Congress.

To estimate functional improvement needs, NBIAS applies a set of improvement standards and costs that can be modified by the system user to each bridge in the National Bridge Inventory (NBI). The system uses the available NBI data to predict detailed structural element data for each bridge. The system then measures repair and rehabilitation needs at the bridge element level using a Markov modeling, optimization, and simulation approach and default models derived from Pontis.

Determining Improvement Costs

The replacement costs for structures are determined based on State-reported values provided by FHWA. Improvement costs are based on default costs from Pontis adjusted to account for inflation.

Determining Functional Improvement Needs

The standards for functional improvement include standards for lane widths, shoulder width, load ratings, and clearances (vertical and horizontal). NBIAS includes a set of standards by functional class, and additional standards derived from Sufficiency Rating calculations.

The standards used in NBIAS were initially set to be the same as those specified by default in Pontis, which were established as an initial effort to define level of service standards for AASHTO. The standards used in the previous editions of the C&P Report were reviewed and compared to design standards in the AASHTO Green Book and adjustments were made where warranted. A revised set of standards added in the most recent version of the NBIAS trigger consideration of a functional improvement whenever there is a deduction in Sufficiency Rating as a result of a lane width, load rating, or clearances.

The NBIAS determines needs for the following types of bridge functional improvements: widening existing bridge lanes, raising bridges to increase vertical clearances, and strengthening bridges to increase load-carrying capacity. Functional improvement needs are determined by applying user-specified standards to the existing bridge inventory, subject to benefit-cost considerations. For instance, a need to raise a bridge will be identified if the vertical clearance under the bridge fails to meet the specified standard and if the increased cost of diverting commercial vehicles around the bridge exceeds the cost of improving the bridge.

Because the benefit predicted for a functional improvement increases proportionately with the amount of traffic, the determination of whether a functional improvement is justified and the amount of benefit from the improvement is heavily dependent upon predicted traffic. In the current version of NBIAS, traffic predictions are made for each year in an analysis period based on NBI data. The NBIAS allows the user to apply either linear or exponential traffic growth projections. Linear growth was selected for this edition of the C&P report to be consistent with the assumption used in the Highway Economic Requirements System (HERS), as discussed in Chapter 9. This approach assumes that the rate of traffic growth will decline over the course of the period being analyzed and is intended to provide more accurate estimates of benefits from functional improvements.

In evaluating functional improvement needs (as well as repair and rehabilitation needs discussed in the next section), the system uses a set of unit costs of different improvement and preservation actions.

Determining Repair and Rehabilitation Needs

To determine repair and rehabilitation needs, NBIAS predicts what elements exist on each bridge in the U.S. bridge inventory and applies a set of deterioration and cost models to the existing bridge inventory. This allows NBIAS to determine the optimal preservation actions for maintaining the bridge inventory in a state of good repair while minimizing user and agency costs. The following paragraphs discuss major aspects of the repair and rehabilitation modeling approach.

Predicting Bridge Element Composition

The NBIAS analytical approach relies on use of structural element data not available in the NBI. In order to develop this data, NBIAS uses a set of Synthesis, Quantity, and Condition (SQC) models to predict what elements exist on each bridge in the NBI and the condition of those elements.

The current version of NBIAS has the capability to accept the direct import of structural element data where these data are available, but this capability was not used for the development of this report. While most of the States now routinely collect such data on State-owned bridges as part of the bridge inspection process, these data are not currently part of the NBI data set. It is expected that in the future structural element data may be provided by some or all States. It should be noted, however, local-owned bridges may not have structural element data available. Once a mechanism is established for sharing these data, they could be incorporated in future NBIAS analyses to improve the prediction of bridge element composition.

Calculating Deterioration Rates

The NBIAS uses a probabilistic approach to modeling bridge deterioration based on techniques first developed for Pontis. In the system, deterioration rates are specified for each bridge element through a set of transition probabilities that specify the likelihood of progression from one condition state to another over time.

Applying the Preservation Policy

Using transition probability data, together with information on preservation action costs and user costs for operating on deteriorated bridge decks, NBIAS applies the Markov modeling approach from Pontis to determine the optimal set of repair and rehabilitation actions to take for each bridge element based on the condition of the element. During the simulation process, the preservation policy is applied to each bridge in the NBI to determine bridge preservation work needed to minimize user and agency costs over time.

Because the current version of the system models maintenance, repair, and rehabilitation needs for each bridge, the cost of performing preservation work can be compared with the cost of completely replacing a bridge. The NBIAS may determine that replacement of a bridge is needed if replacement is the most cost-effective means to satisfy the existing needs. Alternatively, if the physical condition of the bridge has deteriorated to a point where the bridge is considered unsafe (where the threshold for such a determination is specified by the system user), the system may consider bridge replacement to be the only feasible alternative for the bridge.

Recent NBIAS Enhancements

Through participation in various professional organizations and National committees and from exposure to information while attending national conferences, FHWA staff began to question whether several, if not all, States using the Pontis software had modified the criteria to reflect their individual situations; and, if these State Departments of Transportation (DOTs) had modified the criteria, was the selected criteria acceptable for use in analysis at the national level. It was decided that since the NBIAS analysis was based on the default criteria and conditions developed for Pontis, any change in these criteria by State DOTs should be reviewed and evaluated to determine if the NBIAS default criteria should be modified. In addition, recommendations resulting from the review process described in the Appendix B of the 2006 C&P report were considered for inclusion in the next version of NBIAS.

Based on the research results, six enhancements were made to NBIAS. These are described in the following text.

1) Element, State, and Environmental Definitions

The review of the practices of several States indicated that many had modified the default values provided in Pontis to reflect the conditions existing in their States. The modifications provided a more accurate and useful measure of the performance, over time, of bridge elements. In addition, the modifications took into consideration the climate in different regions of the Nation.

2) Climate Zones and Deterioration Models

The latest version of NBIAS now supports deterioration models for the nine climate zones as defined in the Highway Performance Monitoring System (HPMS). The modification to support nine climate zones was one of the recommendations resulting form the review process.

3) Action Effectiveness

An action is defined as a maintenance activity, rehabilitation work, or some other activity applied to a structure to extend the useful life of the structure. The relative effectiveness of an action is the degree to which the action extends the useful life of the structure.

The relative effectiveness of multiple actions was reviewed to determine if it would be beneficial for NBIAS either to vary action choices by climate zone or to establish one set of actions at a national level but allowing variance when sufficient data from States within a region supporting the variance is available. The research concluded that the choice of an action is not dependent on the environment but on DOT maintenance policy. Therefore, it was decided NBIAS would support the second option.

4) Failure Cost

The selection of elements and materials used in bridge design is influenced by traffic demands. A study was conducted to model average traffic conditions experienced by each bridge element and to determine the average deck area of bridges containing each kind of element. These were instrumental in developing user failure costs by bridge deck type. An example of the results of this study indicated the unit user failure cost for a bridge with a timber deck is much lower than for a bridge with a concrete deck. Timber decks appear primarily on small bridges on low volume roads, while concrete decks are on larger bridges located on high volume roads. Updated failure costs based on this relationship were developed and provided for NBIAS.

5) Functional Improvement Model

NBIAS requires a variety of input to support the functional model analysis. This input comes from a variety of sources including level of service standards; design standards; unit costs; truck height and weight histograms; an accident risk model; and unit user costs of travel time, vehicle operation data, and accident data.

Many of these inputs have been developed for and are included in NBIAS. Two items recommended for addition to NBIAS were truck height/weight histograms and an accident risk model based on research conducted by the Florida DOT. The models generated from this work more closely reflect actual conditions. These enhancements were successfully tested and incorporated in the latest version of NBIAS.

6) Preservation Unit Costs

The unit costs for construction and maintenance activities for bridges were updated in the latest version of NBIAS. The preservation costs were derived during development of improved default preservation models based on additional research. NBIAS adjusts the preservation costs using State-specific cost coefficients calculated from the replacement cost data.

7) Value of a Statistical Live

The value of a statistical life was updated from $3.4 million to $5.8 million, consistent with a recent change in U.S. DOT guidance for benefit-cost analysis.

Appendix C

Transit Investment Analysis Methodology

Transit Investment Analysis Methodology

The Transit Economics Requirements Model (TERM), an analytical tool developed by the Federal Transit Administration (FTA), forecasts transit capital investment needs over a 20-year horizon. Using a broad array of transit-related data, the model generates the forecasts that appear in the biennial C&P report.

This appendix provides a brief technical overview of TERM, describing the various methodologies used to generate the estimates for the 2008 C&P Report.

Transit Economics Requirements Model

TERM forecasts investment needs by estimating the total amount of annual capital expenditures required over a 20-year period to maintain or improve the physical conditions and performance of the Nation's transit infrastructure. The model relies on a wealth of transit-related input data and user-defined parameters, stored in the TERM database, to generate these forecasts. Annual expenditure estimates forecast by TERM fall into one of three distinct capital investment categories: (1) asset rehabilitations and replacements; (2) asset expansions; and (3) performance improvements.

TERM Database

TERM's capital needs forecasts rely on a broad range of input data and user-defined parameters. Gathered from local transit agencies and the National Transit Database (NTD), the input data are the foundation of the model's investment needs analysis, and include information on the quantity and value of the Nation's transit capital stock. The input data in TERM are used to draw an overall picture of the Nation's transit landscape; the most salient data tables in the TERM database are described below.

Asset Inventory Data Table

The asset inventory data table housed in the TERM database contains detailed records of all transit assets used by the Nation's transit operators. These records contain information on each asset's type, mode of transportation, age, and acquisition cost. These data are derived from NTD, local transit agency submissions to FTA data requests, and special FTA studies. The asset inventory data table is the primary data source for the information used in TERM's forecast of rehabilitation and replacement investments.

Urban Area Demographics Data Table

The TERM database also includes a data table that stores demographic information on more than 300 of the largest metropolitan areas in the United States. Fundamental demographic data, such as current and anticipated population and employment levels, in addition to more transit-oriented information, such as current levels of vehicle miles traveled and transit passenger miles, are used by TERM to predict transit asset expansion investments.

Agency-Mode Statistics Data Table

Another component of the TERM database is the agency-mode statistics table, a data table that contains detailed operations and maintenance statistics for every agency-mode combination in the United States. By tracking the consumption of transit services as well as transit maintenance expenditures, the agency-mode statistics data table provides crucial input data to estimate which transit agency-mode combinations are candidates for performance improvement investments. This information also supports the benefit-cost analysis of future investments. All the data in this portion of the TERM database come from NTD.

Asset Types Data Table

This data table identifies all the different types of assets owned and operated by the Nation's public transit systems. Containing one record for each type of asset, this component of the TERM database contains information on asset unit replacement costs, rehabilitation costs, and rehabilitation life expectancies—all data points used in the 20-year investment needs analysis. Some of the asset decay relationships used to estimate asset conditions are also included in this data table. The decay relationships—statistically estimated equations relating asset condition to asset age, maintenance, and utilization—are discussed more in the next section of this appendix.

Benefit-Cost Parameters Data Table

The benefit-cost parameters data table contains values used to evaluate the merit of different types of transit investments forecasted by TERM. Measures in the data table include transit rider values (e.g., value of time and links per trip), auto costs per vehicle miles traveled (e.g., congestion delay, emissions costs, and roadway wear), and auto user costs (e.g., automobile depreciation, insurance, fuel, maintenance, and daily parking costs).

Mode Types Data Table

The mode types data table provides information on transit agencies' operations—including average speed, average headway, and average fare—and estimates of transit riders' responsiveness to changes in fare levels. Similar data are included for non-transit modes, such as private automobile and taxi costs. Information from this data table is also used in TERM's benefit-cost analysis.

New Starts Data Table

This data table, also used in TERM's benefit-cost analysis, contains information on Federal New Starts projects, major capital investment initiatives that are funded by the Federal government. This data table provides estimates of the average length of each New Starts project development phase, the share of total costs devoted to each phase, the average unit costs by investment category (e.g., vehicles, guideway, stations, etc.), and operations and maintenance costs. These data are used by TERM to estimate the costs and benefits associated with performance improvement investments.

The input tables described above, while forming the foundation of TERM, are not the sole source of information used by the model when generating its investment forecasts. In combination with the input data, which are static, meaning that the model user does not manipulate them from one model run to the next, TERM contains user-defined parameters to facilitate its capital expenditure forecasts.

Investment Policy Parameters

As part of its investment needs analysis, TERM predicts the physical condition of U.S. transit assets over a 20-year horizon. The predicted physical conditions are used to forecast rehabilitation and replacement investments. (The methodology for the rehabilitation and replacement aspect of TERM is described in detail below.)

The investment policy parameters data table allows the model user to set the physical condition ratings at which TERM will calculate a rehabilitation or replacement investment. Unique thresholds may be chosen for the following asset categories: guideway elements, facilities, systems, stations, and vehicles.

Financial Parameters

Because TERM is a model that forecasts investment needs, it also contains a number of financial assumptions. The financial parameters table allows the model user to set unique inflation assumptions and discount rates, among other parameters.

The preceding tables form the backbone of TERM, allowing it to estimate different types of capital investments, including rehabilitation and replacement expenditures, expansion investments, and capital projects aimed at performance improvements. These three different investment categories are described below.

Asset Rehabilitation and Replacement Investments

TERM's asset rehabilitation and replacement forecasts are designed to estimate annual funding needs for the ongoing rehabilitation and replacement of the Nation's existing transit assets. Specifically, these needs include the normal replacement of assets reaching the end of their useful life, mid-life rehabilitations, and annual capital expenditures for routine maintenance.

To estimate continuing replacement and rehabilitation investments, TERM assesses the physical conditions of the Nation's transit assets on an annual basis, allowing the model to determine when a particular asset, such as a bus or rail station, has reached a condition that requires it to be repaired or replaced. In TERM, the physical conditions of all assets are measured using a numeric scale of five through one; see *Exhibit C-1* for a description of the scale.

Exhibit C-1

Definitions of Transit Asset Conditions

Rating	Condition	Description
Excellent	5	No visible defects, near new condition.
Good	4	Some slightly defective or deteriorated components.
Adequate	3	Moderately defective or deteriorated components.
Marginal	2	Defective or deteriorated components in need of replacement.
Poor	1	Seriously damaged components in need of immediate repair.

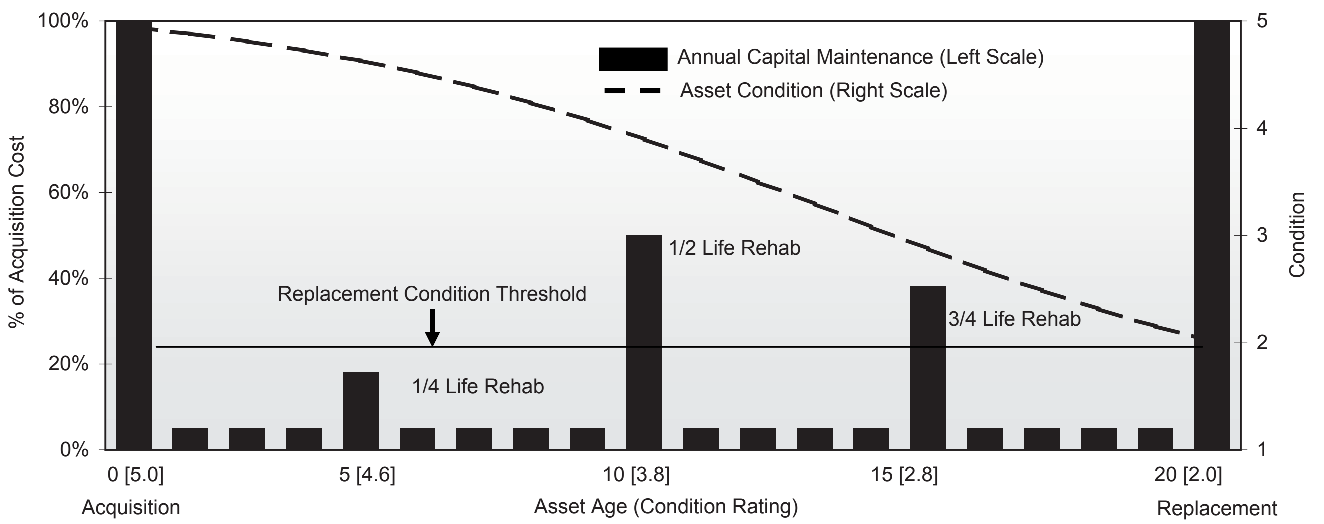
The model performs this aspect of the forecasting process using TERM's asset inventory, which includes the fabrication dates for all assets and an array of asset decay algorithms, equations designed to simulate how the conditions of U.S. transit assets deteriorate over time. During a model run, the condition ratings of the assets stored in TERM's asset inventory will decline, crossing one or more of six potential condition thresholds that each mark a point in the asset lifecycle at which the asset is expected to undergo either rehabilitation or replacement. TERM currently allows an asset to be rehabilitated up to five different times; after the fifth rehabilitation, the model assumes that the asset is replaced. Throughout a simulation, TERM records the cost and timing of these re-investment events as model outputs, and adds them to the tally of national investment needs generated by the model, provided they pass a benefit-cost test. The model also reports the conditions of different transit assets using the scale shown in *Exhibit C-1*.

It is important to note that the model can forecast rehabilitation and replacement investments, as well as asset condition estimates, under either a **Maintain Conditions scenario** or an **Improve Conditions scenario**. Under the **Maintain Conditions scenario**, TERM's five replacement condition thresholds are adjusted until the condition values for each asset category at the end of the model simulation period equal their condition values at the start. Conversely, when conducting estimates under the **Improve Conditions scenario**, the five replacement condition thresholds in TERM are adjusted until the condition values for each asset category at the end of the model simulation period are equal to 4, or "good," according to the scale shown in *Exhibit C-1*.

All investment estimates associated with rehabilitation and replacement needs are represented conceptually for a generic asset in *Exhibit C-2*. In this theoretical example, asset age is represented on the horizontal axis, the cost of life-cycle capital investments on the left-vertical axis (as a percent of acquisition cost), and asset conditions on the right-vertical axis. At the acquisition date each asset is assigned an initial condition rating of 5, or "excellent," while the asset's initial purchase cost is represented by the tall vertical bar at the left of the chart. Over time, the asset's condition begins to decline in response to aging and use, represented by the dotted line, requiring periodic lifecycle improvements including annual capital maintenance and periodic rehabilitation projects. Finally, the asset reaches the end of its useful life, defined in this example as a physical condition rating of 2, at which point the asset is retired and replaced.

Exhibit C-2

Template for Assignment of Asset Condition



Source:

Asset Expansion Investments

In addition to devoting capital to maintain and replace aging assets, transit agencies frequently need to expand their service offerings to cope with rising consumer demand. As more riders take advantage of transit systems, service levels—measured in this case by vehicle occupancy rates—begin to degrade. To stem this type of degradation of service, local transit operators invest in new assets to maintain existing service levels.

TERM is capable of forecasting these types of investments. Specifically, the model assumes that each transit agency-mode combination strives to maintain a constant ratio of passenger miles per peak transit vehicle over time. To do so, agencies must continuously invest in additional transit vehicles at a rate equal to the growth of transit passenger miles for the urban area that they serve.

To forecast the number of new transit vehicles, TERM first projects future transit demand for each urban area contained in the model using a sample of growth rates provided to FTA by several metropolitan planning organizations. If a transit agency operates in an urban area with growing demand, the model assumes that the agency will need to acquire a sufficient number of vehicles to maintain its current vehicle occupancy levels. Cost estimates for these types of investments are derived from historical acquisition records stored in the TERM database.

The model also forecasts expansion investments in other assets needed to support projected new vehicle acquisitions. These investments include maintenance facilities and, in the case of rail systems, additional route miles made up of guideway, trackwork, stations, train control, and traction power systems. It is important to note that TERM does not predict asset expansion investments for agency-mode combinations with current ridership levels that are well below the national average. Like other investments forecast by the model, TERM subjects asset expansion investments aimed at maintaining existing service levels to a benefit-cost analysis.

Because TERM adds the cost of newly acquired vehicles and supporting infrastructure to its tally of investment needs, it also ensures that the cost of rehabilitating and replacing the new assets is accounted for over the 20-year period of analysis.

Performance Improvement Investments

Though transit agencies frequently make investments just to keep pace with growing consumer demand, local operators also look to acquire transit assets that will allow them to the improve the performance of their operations. TERM predicts investments of this nature by forecasting acquisitions aimed at increasing the average operating speed or reducing the average vehicle occupancy rate of a given agency-mode combination.

To forecast investments dedicated to reducing crowding in vehicles, TERM identifies U.S. transit agency-mode combinations with vehicle occupancy rates that are well above the national average. The model then seeks to reduce crowding for these high occupancy agency-mode combinations below some maximum occupancy threshold by investing in new vehicles and related support assets. As with all other investment forecasts, cost estimates are generated using historical data stored in the TERM database.

TERM also forecasts investments focused on increasing the average operating speed for a given agency-mode combination. To do this, the model identifies those U.S. urban areas with average operating speeds well below the national average and seeks to raise those speeds to a minimum threshold through the introduction of new vehicles.

In making these predictions, TERM operates on the premise that average operating speeds for rail and bus rapid transit systems are higher than for regular motor bus systems. Consequently, for large urban areas the model substitutes rail transit capacity in place of existing motor bus capacity. Alternatively, for small urban areas TERM substitutes bus rapid transit systems for motor bus systems. These types of investments are assumed to boost the average operating speed for the urban areas as a whole, improving the overall performance of the transit system being analyzed.

Finally, as with the asset expansion investment forecasts, TERM does not calculate speed-improving investments in urban areas with low ridership. The model makes all cost estimates using historical cost data stored in the asset inventory. Once again, because the model adds the cost of newly purchased vehicles and supporting infrastructure to its tally of investment needs, it also ensures that the cost of rehabilitating and replacing new assets is accounted for over the 20-year period of analysis.

Benefit-Cost Calculations

Before being added to the final tally of the Nation's public transit needs, all of the investments forecast by TERM must pass a benefit-cost test. If an investment fails a benefit-cost test, meaning that the benefit-cost ratio of the investment is less than 1.0, it is rejected and its costs are not added to the model's tally of national transit needs. Conversely, if the benefit-cost ratio of the investment is greater than or equal to 1.0, then the investment needs tally is updated to include the investment costs.

Like all of the other forecasts made by the model, cost estimates in the benefit-cost calculations are prepared using historical cost records stored in the TERM database. Benefit calculations, however, are limited to those that are readily quantifiable using publicly available data such as those available in NTD. Benefits generally fall into two different categories: (1) benefits to transit riders, and (2) benefits to society.

Most of the benefits from investment in public transit accrue to new and existing transit riders. Benefits for riders include travel time savings, reduced costs associated with operating a motor vehicle, improved mobility, and improved quality of service. To quantify these benefits, TERM compares the sum of user costs for a trip when transit investments have been made with the sum of these costs for a trip when no transit investments have been made. In most instances, this means comparing riders' costs on the selected transit mode with the riders' costs on the mode that is the next-best alternative.

Although consumers tend to be the primary beneficiaries of new transit investments, society as a whole often benefits, too, principally in the form of cost reductions. Cost savings to society include those resulting from reductions in highway congestion, air and noise pollution, energy consumption, and automobile accidents. These types of cost reductions are calculated on a per-auto-vehicle-mile of travel basis using publicly available data.

While TERM calculates the value of these types of benefits across investment types, the model uses somewhat different methodologies to evaluate the costs and benefits of different kinds of investments.

Benefit-Cost Calculations for Rehabilitation/Replacement and Expansion Investments

TERM performs two types of benefit-cost tests, depending on the type of investment being analyzed. Expansion investments, in addition to rehabilitation and replacement investments, are evaluated by the model on a mode and agency basis. This means that the model considers the value of investing in a particular transit mode by a particular agency; it does not evaluate the benefit of purchasing each piece of equipment separately or on the basis of the location where the investment will be made within each agency's operating area. In the case of transit, where investments comprise a wide range of capital goods, it is more practical to evaluate transit investments as a package rather than as discrete pieces of equipment.

In performing this type of analysis on these kinds of investments, TERM takes a two-step approach. First, the model evaluates the discounted streams of all agency-mode combination benefits and costs—the sum for existing operations and for proposed capital improvements—within the context of a single benefit-cost calculation. This means that the effectiveness of all the capital investment necessary to maintain an agency's ongoing operations, holding asset conditions and performance levels constant, is evaluated in its entirety rather than the cost effectiveness of individual replacement needs, such as adding single track segments or bus vehicles.

If the benefits exceed the capital expenditures, the benefit-cost ratio is greater than 1.0, and the estimated 20-year capital investment needs for that agency-mode combination are included in TERM's estimate of total U.S. transit capital investment needs. If, in contrast, the agency-mode fails the benefit-cost test, TERM conducts a supplemental analysis to determine if the agency-mode combination will pass the benefit-cost test if TERM's proposed maintain performance investments are excluded from the analysis.

In this supplemental analysis, TERM recalculates the benefit-cost ratio after removing all proposed investment costs and benefits associated with investments designed to maintain current service levels. If the agency-mode combination now passes the benefit-cost test with only the rehabilitation and replacement investments, these remaining capital investment needs are added to the national investment needs tally.

Otherwise, continued capital investment in this agency-mode combination is not considered cost-beneficial and is not included in national investment needs for the balance of the model run. Note that this action assumes that the service provided by the agency-mode is continued, but that capital reinvestment in the agency-mode combination is suspended for the time period covered by the model run. (It is important to note that all agency-modes are included in the condition forecasts made by TERM.)

Benefit-Cost Calculations for Performance Improvement Investments

The second type of benefit-cost calculation performed by TERM assesses the effectiveness of performance improvement investments proposed by the model. Investments intended to improve vehicle occupancy rates are evaluated on an agency-mode combination basis, while investments aimed at increasing average operating speeds are assessed on an urban area basis.

Similar to the first type of benefit-cost calculations, investments with a benefit-cost ratio greater than 1.0 are included in TERM's estimated total national performance improvement investment needs while those with a benefit-cost ratio of less than 1.0 are omitted from this estimate.

At the end of all investment needs forecasts and benefit-cost tests, TERM produces a 20-year cost estimate for capital needs for the Nation's transit agencies.