2006 Status of the Nation's Highways, Bridges, and Transit:

Conditions & Performance

Celebrating 50 Years
1956 50 2006
Eisenhower Interstate System

U.S. Department of Transportation

Federal Highway Administration

Federal Transit Administration

REPORT TO CONGRESS

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

January 22, 2007

The Honorable Nancy Pelosi
Speaker of the House of Representatives
Washington, DC 20515

Dear Madam Speaker:

The enclosed "2006 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance" report (C&P report) is submitted in accordance with the requirements of Section 502(h) of Title 23, United States Code (U.S.C.), and Section 308(e) of Title 49, U.S.C. The report provides Congress with an objective appraisal of highway, bridge, and transit physical conditions, operational performance, and future investment requirements.

This report offers comprehensive, factual background information to support the development and evaluation of legislative and program 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 report consolidates conditions, performance, and financial data provided by States, local governments, and transit operators to provide a national level summary. Some of these data are available through the Department's regular statistical publications. The future investment requirements analyses are developed specifically for this document and provide national level projections only.

Since this edition of the C&P report is based primarily on data through the year 2004, it does not reflect any effects of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). This edition does provide evidence of the impact that funding under the Transportation Equity Act for the 21st Century (TEA-21) has had on the highway and transit system. Significant increases in Federal assistance, combined with large increases in State and local investment, have led to significant transportation improvements. However, significant challenges remain. While highway conditions have improved overall, this improvement was uneven across all functional systems. Highway operational performance, as measured by congestion, has worsened throughout the country. The average condition of all transit assets is estimated to be close to "good," and bus and rail vehicle conditions have improved slightly. However, as passenger travel has increased on rail modes in recent years, average speeds have fallen. Average vehicle utilization has fallen for most transit modes. This report includes a series of scenarios that estimate the investment from all sources that would be required to address some of these challenges, and to increase the benefits of the highway and transit systems to society and our economy.

The Department of Transportation's *National Strategy to Reduce Congestion on America's Transportation Network* provides a blueprint for Federal, State and local officials to follow in addressing critical operational performance issues. Several of the topics identified in the plan are also discussed in this report, including highway operations strategies and intelligent transportation systems; congestion pricing; and initiatives to reduce or remove barriers to private sector investment in the construction, ownership and operation of transportation infrastructure, and to encourage formation of public-private partnerships.

The Department's plan includes six areas of emphasis, five of which deal with surface transportation. The first of these is **relieving urban congestion**. The Department will seek to enter Urban Partnership Agreements with selected cities that will commit to implementing new pricing initiatives, creating or expanding express bus services, working with employers to expand telecommuting and flex-scheduling programs, and expediting the completion of highway capacity projects aimed at congestion bottlenecks.

The plan will **unleash private sector resources** by reducing or removing barriers to private sector investment in transportation infrastructure. The Department will develop an organized effort to encourage States to enact legislation enabling agreements with the private sector. We will conduct outreach and education to overcome institutional resistance to reform, and will utilize existing Federal program authorities to encourage the formation of public-private partnerships.

The Department will **promote operational and technological improvements** that increase information dissemination and incident response capabilities. We will encourage States to use their Federal-aid highway funds to improve operational performance by providing better real-time traffic information to system users. We will emphasize congestion reduction technologies in the Intelligent Transportation Systems program, and promote best practices to improve incident and intersection management.

The Department will **establish a "Corridors of the Future" competition**. The competition will select 3 to 5 multi-state, multi-use major growth corridors in need of long-term investment. We will also convene a multi-state process to advance project development and seek alternative financial opportunities, and will fast-track major congestion-reducing corridor projects that received funding in SAFETEA-LU.

Finally, the Department will **target major freight bottlenecks and expand freight policy outreach**. The existing Gateway Team in Southern California will be transformed to convene the region's freight stakeholder community to forge consensus on immediate and longer term solutions. We will conduct a series of "CEO Summits" to engage shippers from multiple sectors, structured around the Department's National Freight Policy Framework. We will also establish a DHS-DOT border congestion team to prioritize operational and infrastructure improvements at the Nation's most congested border crossings.

An identical letter has been sent to the President of the Senate, and the Senate Committee on Environment and Public Works, the Senate Committee on Banking, Housing, and Urban Affairs and the House Committee on Transportation and Infrastructure.

Sincerely yours,

Mary E. Peters

Enclosure

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Part II: Investment/Performance Analysis

List of Exhibits

Executive Summary

Main Report

Abbreviations

AC	Advance construction
ADA	Americans with Disabilities Act of 1990
ADT	Average daily traffic
ATS	Alternative transportation systems
AVL	Automatic vehicle location
BAC	Blood alcohol concentration
BCA	Benefit-cost analysis
BCR	Benefit-cost ratio
BLM	Bureau of Land Management
BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
BPR	U.S. Bureau of Public Roads (predecessor of U.S. Federal Highway Administration)
BRT	Bus rapid transit
CEV	Capacity-equivalent vehicle
CFR	*Code of Federal Regulations*
CFS	Commodity Flow Survey
CIP	Capital improvement program
Combo	Combination truck
CPI	Consumer Price Index
CTAA	Community Transportation Association of America
DBFO	Design-Build-Finance-Operate
DBOM	Design-Build-Operate-Maintain
DMS	Dynamic message sign
DoD	U.S. Department of Defense
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DVMT	Daily vehicle miles traveled
FAF	Freight Analysis Framework
FARS	Fatality Analysis Reporting System
FHWA	U.S. Federal Highway Administration
FTA	U.S. Federal Transit Administration
FY	Fiscal year

GAN	Grant Anticipation Note
GARVEE	Grant Anticipation Revenue Vehicle
GDP	Gross domestic product
HCM	Highway Capacity Manual
HERS	Highway Economic Requirements System
HERS-ST	Highway Economic Requirements System, State Version
HFCS	High Functional Classification System
HOFM	Office of Freight Management and Operations
HOT	High occupancy toll
HOV	High occupancy vehicle
HPMS	Highway Performance Monitoring System
HPMS-AP	HPMS Analytical Process
HSM	Highway Safety Manual
HTF	Highway Trust Fund
IDAS	ITS Deployment Analysis System
IHSDM	Interactive Highway Safety Design Model
ILEV	Inherently low-emission vehicle
IP	Internet protocol
IRI	International Roughness Index
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITIP	Intelligent transportation infrastructure program
ITS	Intelligent transportation systems
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MPO	Metropolitan planning organization
MR&R	Maintenance, repair, and rehabilitation
MTA	Mass Transit Account
NBI	National Bridge Inventory
NBIAS	National Bridge Investment Analysis System
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NPS	National Park Service
NPTS	Nationwide Personal Transportation Survey

NTD	National Transit Database
NYCT	New York City Transit
OST	Office of the Secretary of Transportation
PMT	Passenger miles traveled
PPP	Public-private partnership
PSR	Present Serviceability Rating
PV	Passenger vehicle
Q&A	Question and answer
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SDDCTEA	Surface Deployment and Distribution Command Transportation Engineering Agency
SDELP	San Diego Expressway Limited Partnership
SEP-15	Special Experimental Project No. 15
SIB	State Infrastructure Bank
SQC	Synthesis, Quantity, and Condition
STRAHNET	Strategic Highway Network
SU	Single-unit truck
SUV	Sport utility vehicle
TDM	Travel demand management
TEA-21	Transportation Equity Act for the 21st Century
TERM	Transit Economic Requirements Model
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIM SA	Traffic Incident Management Self-Assessment
TMA	Transportation Management Area
TMC	Transportation management center
TPMS	Transit Performance Monitoring System
TTC-35	Trans Texas Corridor
TTI	Texas Transportation Institute
USC	*United States Code*
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VIUS	Vehicle Inventory and Use Survey
V/SF	Volume to service flow
VMS	Variable message signs
VMT	Vehicle miles traveled
VRM	Vehicle revenue miles
WZSA	Work Zone Self-Assessment

Introduction

This is the seventh in a series of combined documents prepared by the Department of Transportation 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 *2006 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* report to Congress (C&P report) draws primarily on 2004 data. The 2004 C&P report, transmitted February 16, 2006, was based primarily on 2002 data.

Report Purpose

This document is intended to provide decision makers 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. This report offers a comprehensive, factual 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 Department's regular statistical publications. The future investment scenario analyses are developed specifically for this report and provide national-level projections only.

Report Organization

The report begins with a Highlights section that lists key findings, focusing mainly 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 the period 1998 through 2003. This is followed by an Executive Summary that highlights the key findings in each individual chapter. These sections will also be distributed as a separate stand-alone summary document.

The main body of the report is organized into four major sections. Part I, "Description of Current System," and Part II, "Investment/Performance Analysis," include the core analyses of the report. Parts I and II correspond to the first 10 chapters of the 2004 edition. Chapters 2 through 10 begin with a combined summary of highway and transit issues, followed by separate sections discussing highways and transit in more detail. This structure is intended to accommodate report users who want a multimodal perspective, as well as those who may primarily be interested in only one of the two modes.

The core retrospective analyses of the report are contained in the six chapters in Part I.

- **Chapter 1** discusses the role of highways and transit.
- **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 performance of highways and transit.
- **Chapter 6** outlines highway and transit revenue sources and expenditure patterns for all levels of government.

The four chapters in Part II 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.

- **Chapter 7** projects future highway, bridge, and transit capital investment under certain defined scenarios.
- **Chapter 8** relates the scenario estimates presented in Chapter 7 to the current levels of capital investment for highways, bridges, and transit presented in Chapter 6.
- **Chapter 9** describes the impacts that past investment has had on the conditions and operational performance of highways, bridges, and transit systems and predicts the impacts that different levels of investment would have.
- **Chapter 10** discusses how the future highway and transit investment scenarios presented in Chapter 7 would be affected by changing the assumptions about travel growth, financing mechanisms, 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** discusses the current condition and performance of the Interstate system and projects the future state of this system under alternative future investment scenarios.
- **Chapter 12** provides comparable information for the National Highway System (NHS).
- **Chapter 13** highlights several innovative finance techniques and strategies that are specifically designed to supplement the traditional highway and transit financing sources identified in Chapter 6.
- **Chapter 14** discusses the role of freight transportation and identifies investment/performance issues specific to the freight area.
- **Chapter 15** discusses the potential for operations strategies to address the congestion problems identified in Chapter 4.

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

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 2004 statistics with those for 1997, the last year preceding the 6 years for which Federal highway and transit funding was authorized by the Transportation Equity Act for the 21st Century (TEA-21). The Summary sections at the beginning of Chapters 2 through 8 compare 2004 statistics with those for 2002 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 year reflected in the last five C&P reports (1995, 1997, 2000, 2002, 2004). Other exhibits cover a longer period of time, depending on data availability and years of significance for particular data series. The choice of years for particular comparisons is intended to highlight interesting trends, rather than to manipulate the appearance of any particular indicator in a positive or negative way.

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 over 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 (MPOs).

The HPMS data are collected in accordance with the *Highway Performance Monitoring System Field Manual for the Continuing Analytical and Statistical Data Base.* 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 *2005 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

Bridge inventory and inspection data are obtained from the National Bridge Inventory (NBI) collected annually by the FHWA. The NBI contains information from all bridges covered by the National Bridge Inspection Standards (23 CFR 650) located on public roads throughout the United States and Puerto Rico. For each bridge, inventory information is collected documenting the descriptive identification data, functional characteristics, structural design types and materials, location, age and service, geometric characteristics, navigation data, and functional classifications. Conditions information is recorded documenting the inspectors' evaluations of the primary components of a bridge, such as the deck, superstructure, and substructure. In general, bridges are inspected once every two years, although bridges with higher risks are inspected more frequently and certain low-risk bridges are inspected less frequently. The inspection frequency and last inspection date are recorded within the database. 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 Nationwide Household Travel Survey (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 (TPMS). Information on freight activity is collected by the Census Bureau through the Commodity Flow Survey (CFS) and the Vehicle Inventory and Use Survey (VIUS) and merged with other data in FHWA's Freight Analysis Framework (FAF).

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: 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...." To address the deficiencies in earlier versions of this report and to meet the challenge of this executive order, new analysis approaches have been developed. 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, 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 previous 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. Specifically, 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 and then evaluates these needs in order to select future investments.

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 build off 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 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 this would be newly generated travel; some would be the result of travel shifting from transit to highways. However, HERS does not 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 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 there is no linkage to the 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. The Introduction to Part II and the Part IV, "Afterword: A View to the Future," section both contain information that is critical to putting the future investment scenarios into their proper context. Such 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 on the 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) to improve the estimation of the conditions and performance of highways, bridges, and transit and to 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 2004, it does not reflect any 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 2004 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. During the legislative development process culminating in SAFETEA-LU, a certain figure was widely cited as being the six-year Federal program size recommended by the 2002 C&P report; however, that figure did not actually appear anywhere in the report. 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. Despite this, 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 Department 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 are likely to 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 in their investment decision-making process beyond just economic considerations, 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, the modeling procedures for estimating the highway investment scenarios have been modified to assume that the funding to support increases in highway and bridge investment above 2004 levels would be financed in a manner consistent with the current financing structure, which is primarily supported by user fees. A feedback loop has also been added 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 the future investment scenario estimates.

While the assumption of increased levies on users via the current tax and fee structure draws revenues, investment, and travel demand together, the inherent economic inefficiencies of the current structure would remain, whereby travel on uncongested facilities is charged at the same rate as those with significant congestion issues. Previous editions of this report have identified congestion pricing as an alternative financing and travel demand management tool that could significantly improve economic efficiency and reduce the distortionary effect that the current financing structure has on highway use and investment.

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 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.

For this report, the Highway Economic Requirements System (HERS) has been adapted to illustrate the theoretical impact that more efficient pricing could have on the future highway investment scenario estimates. This preliminary analysis, presented in Chapter 10, assumes that congestion pricing would be implemented universally on all congested roads. As discussed below, improving the economic efficiency of the highway pricing structure would yield significant benefits in the form of reduced congestion and traveler delay. The methodology used for this analysis is presented in greater detail in Appendix A. The "Pricing Effects" section in Part IV of this report also provides a further discussion of other ongoing research activities in this area that will be reflected in future editions of this report.

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 which has been modeled in this analysis is expected to further reduce the level of future capacity investment that would be 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 further improve operating efficiency. This report does 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. A discussion of new technologies is included in Part IV.

What Does it Mean to "Maintain"?

Due to the nature of the different analytical tools to analyze highway, bridge, and transit investment for this report, and the limitations of the underlying data, the "maintain" scenarios are defined differently in this report for different system components. The Cost to Maintain highways reflects the estimated average annual level of investment required so that the physical conditions and operational performance of the highway system will remain at a level such that their impact on highway users (measured in terms of average costs experienced by users) in 20 years would be the same as today. The Cost to Maintain bridges reflects the estimated level of investment that would be sufficient to keep the backlog of economically justifiable bridge improvements in 20 years at the same size as it is today. The Cost to Maintain transit reflects the estimated level of investment that would be sufficient to keep the average transit asset condition in 20 years equal to the average transit asset condition in the base year, and to have the average occupancy rate for each mode, as measured by passenger miles per peak vehicle, the same in 20 years as in the base year.

While the analytical approaches differ, all of these scenarios point to a level of 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. However, it is important to recognize that the conditions of "today" (i.e., 2004) in this report differ from the conditions of "today" (i.e., 2002) as presented in the 2004 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 is also important to note that 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.

What Does it Mean to "Improve"?

In theory, if the estimated Cost to Maintain level is accurate, and the "correct" projects are chosen, then spending $1 more than that level would result in an improved system. In practice, the "Cost to Improve" scenarios in this report have been more aggressive, picking some higher target level of future conditions and performance. The Cost to Improve highways (described as the "Maximum Economic Investment" scenario) reflects the maximum average annual level of investment that could be utilized while still investing only in cost-beneficial highway improvements over 20 years. The Cost to Improve bridges reflects 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 Cost to Improve transit reflects 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. [Note the term agency-mode refers to each mode within each transit agency.] In this report, the Cost to Improve transit comes close to, but does not fully achieve, an average condition of "good" for transit assets, because to do so would require replacing assets that are still in operationally acceptable condition.

Particularly for highways and bridges, the "Cost to Improve" scenarios in this report can be viewed as "investment ceilings" above which it would not be cost beneficial to invest, even if unlimited funding were available. The transit scenario is predicated on the ambitious condition and performance criteria specified above. While these 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 transit 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.

It is important to again note that, 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, if investment rose to the Cost to Improve level, there are few mechanisms to ensure 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 as part of this scenario.

Highlights: Highways and Bridges

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 44.7 percent between 1997 and 2004, to $147.5 billion. This equates to a 22.7 percent increase in constant dollar terms. Highway capital spending alone rose from $48.4 billion in 1997 to $70.3 billion in 2004, a 45.2 percent increase, equating to a 22.9 percent increase in constant dollar terms. Federal cash expenditures for highway capital purposes increased 52.9 percent from 1997 to 2004, while State and local capital investment increased by a smaller (though still robust) rate of 39.9 percent (increases of 29.4 and 18.3 percent in constant dollar terms, respectively). It is important to note that, owing to the nature of the Federal-aid highway program as a multiple-year reimbursable program, the impact of increases in obligation levels phases in gradually over a number of years. The Federally funded portion of total highway capital investment for all levels of government had dipped below 40 percent in 1998 for the first time since 1959, as TEA-21's passage relatively late in fiscal year 1998 reduced its impact on cash expenditures during that initial year. However, this share subsequently rebounded sharply, reaching 46 percent in 2002 (consistent with the high end of the range of 41 to 46 percent that was observed for each year between 1987 and 1997) before tailing off to 44 percent in 2004.

The TEA-21 era has also coincided with a shift in the types of capital improvements being made by State and local governments. The percentage 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 51.8 percent in 2004. The combined result of the increase in total capital investment and the shift in the types of improvements being made was a 58 percent increase (33.9 percent in constant dollar terms) in spending on system rehabilitation, from $23.0 billion in 1997 to $36.4 billion in 2004. Compared with system expansion projects, system rehabilitation projects tend to have shorter lead times and are often less controversial, which made many of them attractive candidates as Federal funding increased over this period. Investment in system expansion (the construction of new roads and bridges and the widening of existing roads) grew more slowly during this period, rising 28 percent (8.3 percent in constant dollar terms) from $21.5 billion in 1997 to $27.5 billion in 2004.

Physical Conditions Have Improved in Some Areas

The large increase in system preservation investment since 1997 has had a positive effect on the overall physical condition of the Nation's highway and bridge infrastructure. The percentage of vehicle miles traveled (VMT) on pavements with "good" ride quality rose from 39.4 percent in 1997 to 44.2 percent in 2004. Rural areas showed the most improvement, as the share of rural VMT on roads with good ride quality rose from 47.9 percent to 58.3 percent over the same period. It should be noted that the share of VMT on roads with "acceptable" ride quality (a lower standard that includes roads classified as "good") has fallen from 86.4 percent to 84.9 percent, mainly due to a decline in urbanized areas. (The preceding figures are based on all arterials and collectors for which data are available).

The percentage of bridges considered deficient dropped from 29.6 percent in 1998 to 26.7 percent in 2004, with most of the progress made on bridges with structural deficiencies, rather than on bridges considered to be functionally obsolete. Bridge condition also differs 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.

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 4.1 percent of total mileage, it carries 44.8 percent of total travel in the United States. The physical conditions of NHS routes are better on average than other roads. The percentage of NHS VMT on pavements with "good" ride quality rose from 37 percent in 1997 to 52 percent in 2004. The percentage of NHS bridges considered deficient dropped from 26.1 percent in 1997 to 20.5 percent; almost three-fourths of these bridges are functionally obsolete, while only one-fourth are structurally deficient.

Operational Performance Has Declined, But at a Slower Rate

Despite the historic investment in highway infrastructure and improving conditions on many roads and bridges, operational performance—the quality of use of that infrastructure—has continued to deteriorate. This is reflected in measures of congestion in all urbanized areas developed for FHWA by the Texas Transportation Institute (TTI). From 1997 to 2004, the estimated percentage of travel occurring under congested conditions has risen from 27.4 percent to 31.6 percent. The average length of congested conditions has risen from 6.2 hours per day in 1997 to 6.6 hours per day. [Note that these statistics are different than those found in TTI's annual *Urban Mobility Study*, which is based on a subset of urbanized areas weighted toward the most heavily populated areas.] On a more positive note, the rate at which these indicators are getting worse has been slowing in recent years.

The Department of Transportation's (DOT) *National Strategy to Reduce Congestion on America's Transportation Network* provides a blueprint for Federal, State, and local officials to follow in addressing critical operational performance issues. Several of the topics identified in the plan are also discussed in this report, including congestion pricing, freight bottlenecks, the deployment of new technologies to improve operations, and private sector partnering and financing opportunities. Congestion mitigation is also a major component of the *Framework for a National Freight Policy* that has been developed by DOT and its public and private partners.

Highway Safety Has Improved

Considerable progress has been made in reducing fatality rates and injury rates over time, including the period from 1997 through 2004. The fatality rate per 100 million VMT has declined from 1.64 to 1.44 over that period, but increased to 1.47 in 2005. The actual umber 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 94 in 2004.

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 Investment Scenarios

Absent increased implementation of congestion pricing, accelerated deployment of operational technologies, or any innovation in construction methods or materials, maintaining the overall conditions and performance of highways and bridges at current levels would require an increase in the combined amount of investment from all levels of government and the private sector, relative to current expenditures. The "Cost to Maintain Highways and Bridges" scenario describes a level of investment at which future conditions and performance would be maintained at a level sufficient to keep average highway user costs from rising above their 2004 levels, based on projections of future highway use. The average annual investment level for this scenario is projected to be $78.8 billion (in constant 2004 dollars) for 2005 to 2024, which is 12.2 percent more than the $70.3 billion of capital spending in 2004. Note that this "gap" reflects future investments stated in constant dollars; additional annual increases in investment would be necessary to offset the effects of inflation. Note also that capital expenditures for bridge preservation in recent years have exceeded the bridge preservation component of the "Cost to Maintain Highways and Bridges" scenario, a trend that has led to reductions in the percentage of bridges classified as deficient. [See the "What Does it Mean to 'Maintain'?" section earlier in these Highlights for critical caveats to consider in evaluating the implications of this scenario.]

Assuming resources are deployed to maximize net benefits as opposed to achieve other non-economic objectives, additional increases in highway capital investment would result in positive net benefits to the American public through further reductions in travel time, vehicle operating costs, crashes, emissions, and highway agency costs. The "Maximum Economic Investment (Cost to Improve Highways and Bridges)" scenario presented in this report describes an "investment ceiling" above which it would not be cost beneficial to invest. The average annual Maximum Economic Investment level is projected to be $131.7 billion for 2005 to 2024 (stated in constant 2004 dollars). This is 87.4 percent higher than the $70.3 billion of total capital investment by all levels of government in 2004. As stated previously, however, current investment methodologies do little to ensure maximization of net benefits. [See the "What Does it Mean to 'Improve'?" section earlier in these Highlights for critical caveats to consider in evaluating the implications of this scenario.]

The investment scenario estimates in this report are slightly higher than the estimates for 2003 to 2022 found in the 2004 edition of this report, due largely to the impact of inflation in highway construction costs between 2002 and 2004. Accounting for inflation, the estimated Cost to Maintain is 2.3 percent greater, while the estimated Maximum Economic Investment level for highways and bridges is 6.2 percent higher. These other changes in projected investment scenario estimates from the 2004 report are 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.

Impacts of Future Investments

In addition to the two main investment scenarios outlined above, this report also predicts the impacts of numerous alternative future investment levels on a variety of condition and performance indicators.

If investment were to remain at 2004 levels in constant dollar terms, and no additional operational strategies or innovations are implemented beyond those assumed as part of the scenarios, it is projected that recent trends observed in the conditions and performance of the highway system would continue. At this range of investment levels, and assuming current tax and fee structures for system users, the operational performance of the highway system is expected to further deteriorate: average speeds would decline and the amount of delay experienced by drivers would increase. Recent trends toward improvements in bridge conditions are expected to continue; however, the aging of the Nation's bridges, particularly on the Interstate System, will present additional challenges in the future.

Composition of Future Investments

The analyses of future investment/performance relationships in this report suggest that (1) there is substantial room for cost-beneficial investment in system rehabilitation that would reduce average highway user costs and (2) if funding levels were to be raised significantly, an increasing number of potential system capacity investments would be among the most cost-beneficial options.

The recommended mix of investments under the "Cost to Maintain" scenario is very similar to current spending patterns in terms of the relative percentages of investments in system rehabilitation compared with system expansion. However, the "Maximum Economic Investment for Highways and Bridges" scenario would devote a larger share of total investment toward capacity expansion than would the "Cost to Maintain" scenario. While capacity improvements are generally more expensive than rehabilitation improvements, proportionally more of them could be economically justified at high levels of investment.

Potential Impacts of Congestion Pricing

This edition of the C&P report includes some preliminary analysis estimating the potential impacts of applying universal congestion pricing to all congested roadways. This underlying analytical approach will be refined further and peer reviewed by outside experts prior to the development of the 2008 C&P report; future reports will include pricing scenarios that may show larger or smaller effects. However, from even this preliminary analysis, it is clear that **congestion pricing has the potential to significantly improve the operational performance of the Nation's highway system, while significantly reducing the level of future capital investment that would be necessary to achieve any specific level of performance**. Instituting congestion pricing on a widespread basis would also send clear signals concerning travelers' willingness to pay to travel in certain corridors at certain times, which would inform decisions about where future capital investment should be directed in order to maximize net benefits. Such signals would be expected to improve the transportation planning process.

The application of universal congestion pricing to the "Cost to Maintain" scenario would reduce the average annual investment level by $21.6 billion (27.5 percent) to $57.2 billion. This is well below the $70.3 billion of capital spending by all levels of government in 2004. The congestion tolls applied under this scenario would average 20.5 cents per mile, based on the estimated economic costs that individual users of congested facilities impose on one another in terms of increased delay. On some extremely congested sections, the optimal congestion tolls would be considerably higher, while the optimal congestion tolls would be lower on less congested sections. No congestion tolls were applied to uncongested highway sections.

The application of universal pricing to the "Maximum Economic Investment" scenario would both reduce the average annual investment level by $20.9 billion (15.9 percent) to $110.8 billion, and improve the overall operating performance of the highway system, reducing the average delay experienced by highway users. Since the overall level of congestion would be lower under this scenario than under the "Cost to Maintain" scenario, individual drivers have less of a negative impact on each other, causing the average congestion tolls applied under this scenario to be lower, averaging 17.4 cents per mile.

The estimated annual revenues produced by the congestion tolls are approximately $34 billion for the "Maintain" scenario and $24 billion for the "Maximum Economic Investment" scenario. Average toll rates and annual revenues would be higher in the latter portions of the 20-year analysis period, as baseline traffic levels increase and contribute to congestion. The larger average tolls and revenues under the "Maintain User Cost" scenario reflect the fact that congestion would be higher under this scenario, so that drivers have larger negative impact on each other. For the "Maximum Economic Investment" scenario, the additional capacity expansion at the higher investment levels result in reduced congestion, so that drivers' impact on each other is not as severe; thus, the efficient congestion toll rates would be lower. This analysis suggests an important dichotomy between the revenues that would be produced under congestion pricing if tolls were levied in the manner assumed in this scenario and the revenues that would be required to support increased investment levels; in fact, the two are in some sense counter to one another. Note that this dichotomy might not exist under alternative approaches to setting congestion-based tolls, such as maximizing the estimated revenue yield. Such alternative approaches would affect the level of revenues produced, but would also change the impact of the congestion tolls on the investment scenario estimates.

Note that this preliminary analysis does not take into account the start-up or administrative costs that would be required to implement a congestion pricing strategy of this nature. The level of these costs could vary significantly, depending on the type of technology employed to collect these tolls.

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 2004. Total funding by Federal, State, and local governments reached its highest level of $28.4 billion in 2002, a 62.6 percent increase in current dollars from $17.5 billion in 1997, equal to a 45.6 percent increase in constant dollar terms. Federal funding in current dollars increased by 46.7 percent, from $4.7 billion in 1997 to $7.0 billion in 2004, equal to a 31.3 percent increase in constant dollar terms. State and local funding in current dollars increased by 68.5 percent, from $12.7 billion in 1997 to $21.5 billion in 2004, equal to a 50.9 percent increase in constant dollar terms. Total funding for transit, including system-generated revenues, increased by 52.2 percent, from $26.0 billion in 1997 to $39.5 billion in 2004, an increase of 36.3 percent in constant dollars.

In 2004, total transit agency expenditures for capital investment were $12.6 billion in current dollars, accounting for 33.2 percent of total transit spending. Federal funds provided $4.9 billion of total transit agency capital expenditures, State funds provided $1.8 billion, and local funds provided $5.9 billion. Capital investment funding for transit from the Federal government increased by 19.1 percent from 1997 to 2004, and capital investment funding for transit from State and local sources increased by 120.0 percent from 1997 to 2004. Due to the sharp increase in transit capital funds from State and local sources, the Federal government's portion of total transit capital investment from all levels of government fell from 54.2 percent in 1997 to 39.0 percent in 2004. Federal funding for transit capital investment was $4.1 billion in 1997 and $4.9 billion in 2004.

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 2004, the number of active urban transit vehicles as reported to the National Transit Database increased by 18.0 percent, from 102,258 to 120,659. Track mileage grew by 9.8 percent, from 9,922 miles in 1997 to 10,892 miles in 2004. The number of stations increased by 10.4 percent, from 2,681 in 1997 to 2,961 in 2004; and the number of urban maintenance facilities increased by 8.8 percent, from 729 in 1997 to 793 in 2004.

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 15.8 percent, from 40.2 billion in 1997 to 46.5 billion in 2004 (compared to an 18.1 percent increase in PMT on highways over the same period). PMT on nonrail transit (primarily buses) increased by 9.6 percent, from 19.0 billion in 1997 to 20.9 billion in 2004. PMT on rail increased by 21.4 percent, from 21.1 billion in 1997 to 25.7 billion in 2004. The distance traveled by all transit vehicles in revenue service, adjusted for differences in carrying capacities, increased by 27.2 percent, from 3.5 billion full-capacity bus miles in 1997 to 4.5 billion equivalent miles in 2004.

Physical Conditions for Most Assets Have Improved

Bus and rail vehicle conditions have improved since 1997. On a rating of 1 (poor) to 5 (excellent), bus vehicle conditions increased from 2.94 in 1997 to 3.08 in 2004, and rail vehicle conditions increased from 3.42 in 1997 to 3.50 in 2004.

Bus facility conditions improved from 3.23 in 2000 to 3.41 in 2004. Average condition is not available for 1997. Sixty-nine percent of bus maintenance facilities were in adequate (3) or better condition in 2004, compared with 67 percent in 2000 and 77 percent in 1997. Rail facility conditions improved from 3.18 in 2000 to 3.82 in 2004. As with buses, average condition is not available for 1997. Ninety-two percent of rail facilities were estimated to be in adequate or better condition in 2004, 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 2002 and 2004, the conditions of track, structures, and yards improved. The percentage of communications systems and traction power systems in adequate or better conditions increased between 2002 and 2004, and the percentage of train control systems in adequate or better condition decreased. The conditions of rail stations improved from 2.87 in 2002 to 3.84 in 2004. The conditions of nonrail stations, which are assumed to follow the same deterioration schedule as light rail stations, declined from 4.37 in 2002 to 4.23 in 2004. 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.

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 2004, average vehicle speed was 20.1 miles compared with 19.9 miles per hour in 2002 and 20.3 miles per hour in 1997. Average nonrail vehicle speed was 13.8 miles per hour in 1997, decreasing to 13.7 miles per hour in 2002, and increasing to 14.0 miles per hour in 2004. Average rail vehicle speed declined from 26.1 miles per hour in 1997 to 24.9 miles in 2000, increasing steadily to 25.4 miles per hour in 2003, and then declining to 25.0 miles per hour 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 increased from 1997 to 2000 and declined from 2001 to 2003, moving inversely with rail speeds. As the utilization of heavy rail and commuter rail continued to increase from 2003 to 2004, average rail speed decreased, outweighing a continued decline in light rail utilization.

Vehicle utilizations of all major nonrail modes were lower in 2002 than in 1997. The utilizations of motorbus and trolleybus vehicles continued to decline from 2002 to 2004, while the utilizations of demand response, vanpool, and ferryboat vehicles increased.

Future Investment Scenarios

The estimated average annual "Cost to Maintain" transit asset conditions and operating performance is estimated to be $15.8 billion, 25.4 percent more than 2004 capital spending. Asset rehabilitation and replacements account for between 49 percent and 66 percent of these projected funding requirements. Asset rehabilitation and replacements would account for a larger portion of total investment if performance is maintained and a smaller portion if performance is improved. These investment scenario estimates have not changed materially from $15.6 billion, the amount estimated for the 2004 C&P report.

This estimated $15.8 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 of 1.57 percent per year. This amount is unlikely to have much of an impact of transit's share of total passenger travel or to draw many passengers from highways to transit given that growth on both is expanding.

Eighty-seven percent of the projected transit investment under this scenario is expected to be in urban areas with populations over 1 million, and 92 percent of PMT on transit systems are in these areas. Fifty-eight percent of the total amount needed to maintain conditions and performance, or $9.0 billion dollars annually, is estimated to be for rail infrastructure. In 2004 PMT on rail accounted for 55 percent of PMT on transit. Vehicles account for the highest proportion, but less than half, of projected capital outlays for both rail and nonrail modes. Guideways account for almost as much of the estimated investment under this scenario as vehicles. Changes in investment needs by asset type have not changed materially from those reported in the 2004 C&P report.

The average annual Cost to Improve both the physical condition of transit assets and transit operational performance to targeted levels by 2024 is estimated to be $21.8 billion in constant 2004 dollars, 73.0 percent higher than transit capital spending of $12.6 billion in 2004. This scenario is an upper limit of the economically justifiable level of transit investments. The scenario assumes that all assets are close to good condition (4) by the end of the investment period. Eighty-seven percent of the additional amount for the Cost to Improve, or $5.2 billion annually, is to increase average operating speeds as experienced by passengers and to lower average vehicle occupancy levels to threshold levels by 2024, by undertaking investments in systems with slower passenger speeds and higher occupancy rates.

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 1.57 percent, an average of transit travel forecasts from 92 metropolitan planning organizations (MPOs). The previous report used projected growth of 1.57 percent per year based on the forecasts of 76 MPOs. The projected rate is above the actual 0.65 percent average annual rate of growth between 2000 and 2002, but below the actual average annual growth of 2.29 percent occurring between 1995 and 2004.

Conclusion

Increased Federal funding for transit capital investment under TEA-21, combined with a substantial increase in State and local government funding, has expanded transit infrastructure and permitted the condition of most transit assets to be maintained or improved between 1997 and 2004. PMT increased substantially from 1997 to 2004, but more slowly between 2000 and 2004. Vehicle utilization rates for most modes peaked in 2000 or 2001, leading to lower passenger travel speeds. Passenger speeds were slightly higher in 2002 and 2004, reflecting utilization levels below the 2000 and 2001 peaks. Since 2003 the utilizations of heavy rail and commuter rail have increased, leading to a decrease in average rail speed. The amount to maintain conditions and performance has increased marginally in current dollars from the amount in the 2004 C&P report, but declined in real dollars; the slight downward revision in amount required to maintain conditions and performance resulted from revisions to maintenance facility replacement costs and station replacement costs, revisions to asset deterioration schedules for stations and systems, and improvements to the benefit-cost analysis and new NTD data. The amount to improve conditions and performance declined by about $3.0 billion from the amount in the 2004 C&P report, principally due to a downward revision in the estimated cost of congestion delay to align more closely with the *1997 Federal Highway Cost Allocation Study* and reflect congestion levels by population stratum.

The Role of Highways and Transit

Highways and transit are crucial components of the U.S. public infrastructure and play vital roles in maintaining the vigor of the U.S. economy.

The use of private automobiles on our large highway network provides Americans with a high degree of personal mobility, continuing to allow people to travel where and with whom they want, but under conditions of increasing system unreliability and declining speeds. In 2001, 87 percent of daily trips involved the use of personal vehicles. Travel to and from work continues to decrease as a proportion of all travel, as trips rise for purposes including shopping, household errands, and recreational activities.

Highways are also a key conduit for freight movement in the United States. Trucks carried 60 percent of total freight shipments by weight and 70 percent by value (not including shipments moved by truck in combination with another mode). Trucks are playing an increasingly important role as businesses turn to just-in-time delivery systems to minimize logistics costs.

Transit plays a vital role in enhancing productivity and the quality of life in the United States. It provides basic mobility and expanded opportunities to people without the use of a car and broader transportation choices to people with cars. Transit plays a key role in economic growth and development, connecting workers and employers.

Transit helps people without cars take advantage of a wider range of job and educational opportunities and access health care and other vital services. It also enables them to be more active members of their communities and to build and maintain social relationships. In 2001, 43 percent of nationwide transit riders lived in households with incomes of less than 20,000 and 44 percent came from households without cars.

The Complementary Roles of Highways and Transit

Highways and transit are complementary, serving distinct but overlapping markets in the Nation's transportation system. A high-quality transit system gives people who prefer living in a dense, urban environment the opportunity to do so without sacrificing their mobility. An adequate highway network does the same for people who prefer a suburban or rural lifestyle.

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

Transit improvements can improve the operational performance of highways by attracting private vehicle drivers off the road during peak periods of congestion. The availability of a transit alternative as a backup mode can increase the attractiveness of carpooling for commuters.

The Evolving Federal Role

The Federal-aid highway program is a Federally assisted, State-administered program. Federal, State, and local transportation partners work together to deliver the Nation's highway program. In recent years, Congress has increased statutory authority for States to assume certain Federal-aid highway project oversight responsibilities, where appropriate, while the Federal Highway Administration has maintained responsibilities for program-level oversight, research, and deployment of new technologies and methods.

The Federal transit program is a Federally assisted and administered program, operated through a program of formula and discretionary grants to urban areas and, through States, to rural communities. Over time, the focus of the Federal government has shifted from formula to discretionary programs, such as the New Starts Program, which provides funds for the construction of new fixed guideway systems or extensions to existing systems. The Federal Transit Administration works with grantees to ensure that projects meet a range of criteria for both project justification and local financial commitment.

System Characteristics: Highways and Bridges

The mobility needs of the American people were served by a network of 4.0 million miles of public roads in 2004. About 75.1 percent of this mileage was located in rural areas (those with populations less than 5,000). While urban mileage constitutes only 24.9 percent of total mileage, these roads carried 64.1 percent of the 3.0 trillion vehicle miles traveled (VMT) in the United States in 2004. In 2004 there were 594,101 bridges over 6.1 meters (20 feet) in length; approximately 76.8 percent of these were in rural areas.

Rural local roads made up 51.3 percent of total mileage, but carried only 4.4 percent of total VMT. In contrast, urban Interstate highways made up only 0.4 percent of total mileage but carried 15.5 percent of total VMT.

Percentage of Highway Miles, Lane Miles, and Vehicle Miles Traveled by Functional System, 2004

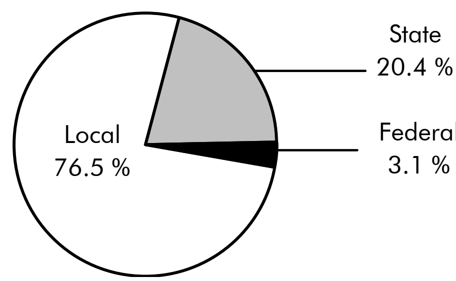
Functional System	Miles	Bridges	VMT
Rural Areas			
Interstate	0.8%	4.7%	9.0%
Other Principal Arterials	2.4%	6.1%	8.1%
Minor Arterial	3.4%	6.8%	5.7%
Major Collector	10.5%	15.8%	6.7%
Minor Collector	6.7%	8.3%	2.0%
Local	51.3%	35.1%	4.4%
Subtotal Rural	**75.1%**	**76.8%**	**35.9%**
Urban Areas			
Interstate	0.4%	4.7%	15.4%
Other Freeway & Expressway	0.3%	2.9%	7.0%
Other Principal Arterials	1.5%	4.1%	15.2%
Minor Arterial	2.5%	4.2%	12.3%
Collector	2.6%	2.6%	5.5%
Local	17.7%	4.7%	8.6%
Subtotal Urban	**24.9%**	**23.2%**	**64.1%**
Total	100.0%	100.0%	100.0%

Total highway mileage grew at an average annual rate of 0.2 percent between 1995 and 2004, while total VMT grew at an average annual rate of 2.5 percent. Rural road mileage has been declining since 1997, partly reflecting the reclassification of some Federal roads as nonpublic and the expansion of urban area boundaries as a result of the decennial Census.

Rural VMT grew at an average annual rate of 1.4 percent from 1995 to 2004, compared with an average annual increase of 1.8 percent in small urban areas (population 5,000 to 50,000) and 2.3 percent in urbanized areas. Rural VMT declined from 2002 to 2004 primarily as a result of boundary changes associated with the decennial Census; boundary changes also tend to inflate urban VMT growth.

In 2004, about 76.5 percent of highway miles were locally owned, States owned 20.4 percent, and 3.1 percent were owned by the Federal government.

Highway Mileage by Jurisdiction, 2004



In 2004, approximately 50.6 percent of bridges were locally owned, States owned 47.6 percent, 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. Bridges are, on average, 40 years old with an average year of construction of 1964.

Based on surveys of 78 of the largest metropolitan areas, the deployment of intelligent transportation systems (ITS) has advanced steadily over time. Real-time data collection sensors have been deployed on more than one-third of the total freeway mileage in these areas, and on-call service patrols cover half of the freeway mileage.

Progress has also been made in the deployment of integrated ITS infrastructure. Among the 75 metropolitan areas tracked since 1997, the number with a "High" level of progress in the integrated deployment of ITS has risen from 11 to 30 in 2004, while the number of areas ranked "Low" has fallen from 39 to 12 (the remainder are ranked "Medium").

System Characteristics: Transit

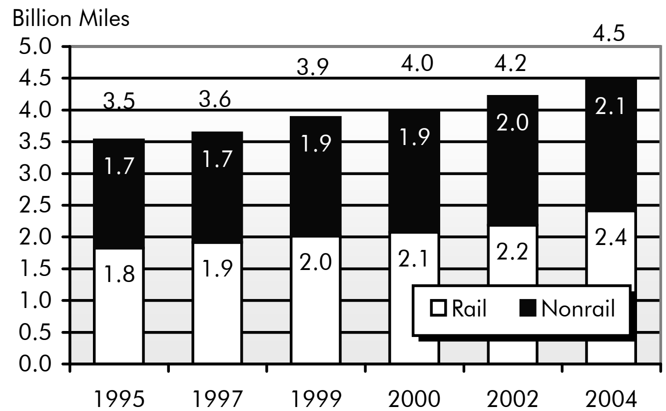
Transit system coverage, capacity, and use in the United States continued to increase between 2002 and 2004. In 2004, there were 640 transit operators serving urbanized areas, of which 600 were public agencies. A public transit provider may be a unit of a regional transportation agency, a State, a county, or a city government or it may be independent. In 2002, the most recent year for which information is available, there were 4,836 providers of special services to older adults and persons with disabilities receiving Federal Transit Administration (FTA) funds; and in 2000, the most recent year for which information is available, there were 1,215 transit operators serving rural areas.

In 2004, transit agencies in urban areas operated 120,659 vehicles (5 percent more than in 2002) of which 92,520 were in areas of more than 1 million people. Rail systems comprised 10,892 miles of track and 2,961 stations. There were 793 bus and rail maintenance facilities and 2,961 stations in urban areas, compared with 769 maintenance facilities and 2,862 stations in 2002. The most recent survey of rural operators in 2000 estimated that 19,185 transit vehicles operated in rural areas. The FTA estimates that in 2002 there were 37,720 special service transit vehicles for older adults and persons with disabilities, of which 16,219 were funded by FTA.

In 2004, transit systems operated 226,402 directional route miles, of which 216,620 were nonrail and 9,782 were rail route miles. Total route miles decreased by 3.8 percent between 2002 and 2004. Nonrail route miles decreased by 4.1 percent and rail route miles increased by 3.1 percent during this period.

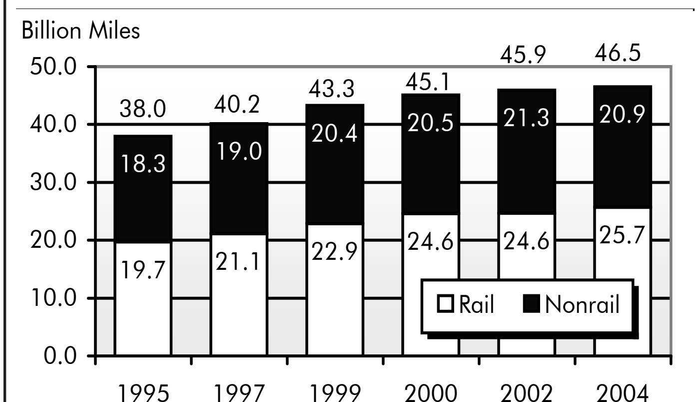
Transit revenue miles adjusted for capacity increased by 3.9 percent between 2002 and 2004. Rail capacity increased by 6.1 percent and nonrail capacity by 1.3 percent. Rail provided 2.4 billion capacity-equivalent miles in 2004, and nonrail provided 2.1 billion miles.

Urban Capacity-Equivalent Revenue Vehicle Miles (Billions)



Transit passenger miles traveled (PMT) increased by 1.3 percent between 2002 and 2004, from 45.9 billion to 46.5 billion. PMT traveled on nonrail modes decreased from 21.3 billion in 2002 to 20.9 billion in 2004, or by 2.1 percent. PMT on rail transit modes increased from 24.6 billion in 2002 to 25.7 billion in 2004, or by 4.3 percent.

Urban Passenger Transit Miles (Billions)



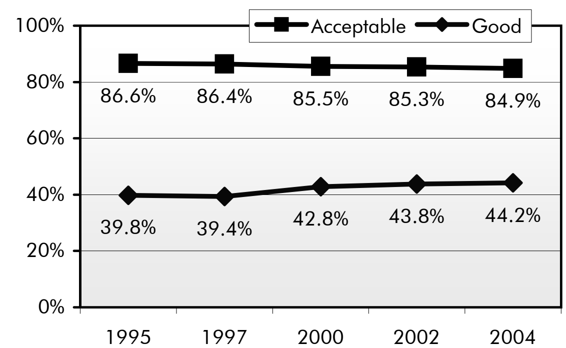
In 2004, 41 percent of PMT was on motorbus, 31 percent was on heavy rail, 21 percent was on commuter rail, and 3 percent was on light rail. The remaining modes accounted for 4 percent.

System Conditions: Highways and Bridges

Poor road surfaces impose costs on the traveling public 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 highway agencies generally consider a variety of pavement distresses in assessing their overall condition, surface roughness most directly affects the ride quality experienced by drivers.

In 2004, 44.2 percent of travel on arterials and collectors for which data are available occurred on pavements with "good" ride quality, up from 39.8 percent in 1995. The percentage of VMT on roads with "acceptable" ride quality (a lower standard that includes roads classified as "good") fell from 86.6 percent to 84.9 percent over the same period of time.

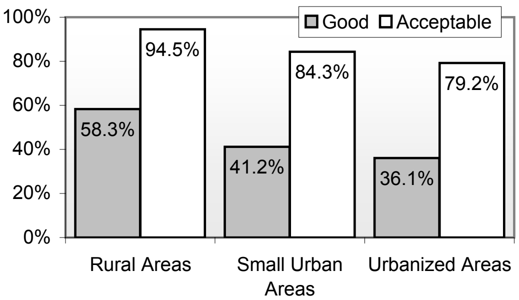
Percentage of VMT on Roads with Acceptable Ride Quality



Pavement ride quality is generally better on higher functional class roads and is better in rural areas than in urban areas. For example, approximately 97.8 percent of rural Interstate VMT in 2004 was on pavements with acceptable ride quality, compared with 72.4 percent for urbanized collectors.

In 2004, 58.3 percent of rural VMT occurred on roads with good ride quality, while 94.5 percent occurred on roads with acceptable ride quality. The comparable percentages for VMT in small urban areas were 41.2 percent good and 84.3 percent acceptable; for VMT in urbanized areas, 36.1 percent was on pavements with good ride quality, while 79.2 percent had acceptable ride quality.

Percentage of VMT on Roads with Acceptable Ride Quality, by Urban Area Size, 2004



Most bridges are inspected every 2 years 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. Functional obsolescence is a function of the geometrics of the bridge not meeting current design standards. Neither type of deficiency indicates that a bridge is unsafe. 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 percentage of bridges classified as deficient fell from 27.5 percent in 2002 to 26.7 percent in 2004. Most of this decline was the result of reductions in the percent of structurally deficient bridges.

Percentage of Rural and Urban Bridge Deficiencies, by Number of Bridges

Year		2002	2004
Rural Bridges	Structurally Deficient	15.1%	14.4%
	Functionally Obsolete	11.4%	11.0%
	Total Deficiencies	**26.5%**	**25.4%**
Urban Bridges	Structurally Deficient	9.2%	8.8%
	Functionally Obsolete	21.9%	21.6%
	Total Deficiencies	**31.2%**	**30.4%**
Total Bridges	Structurally Deficient	13.7%	13.1%
	Functionally Obsolete	13.8%	13.6%
	Total Deficiencies	**27.5%**	**26.7%**

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).

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.

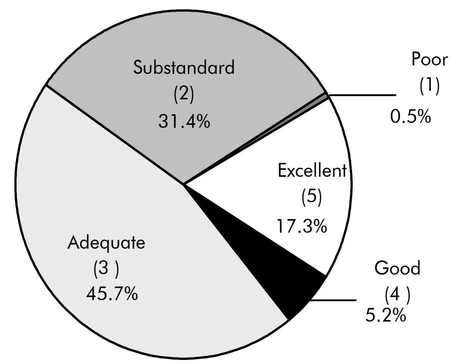
Definitions of Transit Asset Conditions

Rating	Condition	Description
Excellent	5	No visible defects, near new condition.
Good	4	Some slightly defective or deteriorated components.
Fair	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 average condition of urban bus vehicles has remained about the same, increasing from 3.07 in 2002 to 3.08 in 2004. The average age of urban bus vehicles decreased from 6.2 to 6.1 years. The average condition of bus maintenance facilities increased from 3.34 in 2002 to 3.41 in 2004. In 2004, 69 percent of bus maintenance facilities were in adequate or better condition, unchanged from 2002.

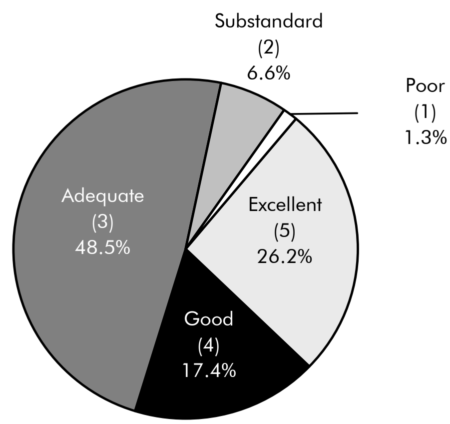
The average condition of rail vehicles increased from 3.47 in 2002 to 3.50 in 2004. The average age of rail vehicles declined from 20.4 years in 2002 to 19.7 in 2004. The condition of rail maintenance facilities increased from 3.56 in 2002 to 3.82 in 2004, primarily based on updated data collected

Conditions of Bus Maintenance Facilities 2004



directly from agencies. In 2004, 92 percent of rail maintenance facilities were estimated to be in adequate or better condition.

Conditions of Rail Maintenance Facilities 2004



The condition of rail stations increased from 2.87 in 2002 to 3.37 in 2004, based on new deterioration curves estimated from on-site surveys in 2004 and on updated data collected directly from transit agencies. Condition estimates in this report also reflect updated deterioration curves for signaling, traction power, and communications systems for rail systems developed from on-site surveys in 2005. In 2004, 100 percent of communications systems, 74 percent of train control systems, and 99 percent of traction power systems were in adequate or better condition. The conditions of elevated structures, underground tunnels, track, and rail vehicle storage yards improved between 2002 and 2004.

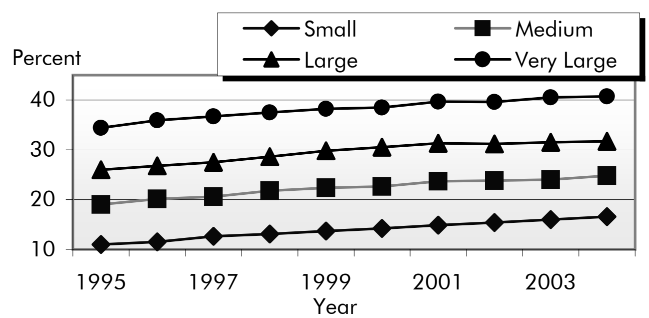
Operational Performance: Highways

Congestion on the Nation's highways imposes significant costs on drivers and society as a whole in the form of added travel time, vehicle operating costs, and emissions. Congestion results when traffic demand approaches or exceeds the available capacity of the highway system. It is clear that traffic demands vary significantly by time of day, day of the week, season of the year, and for special events. However, the available capacity at any given time is also variable, affected by weather, work zones, traffic incidents, and other nonrecurring events. Of the total congestion experienced by Americans, it is estimated that roughly half is "nonrecurring," associated with temporary disruptions in traffic demand and/or in available capacity.

There is no universally accepted definition or measurement of exactly what constitutes a congestion "problem," and this report uses a variety of different metrics to explore different aspects of congestion. The Texas Transportation Institute (TTI) has computed data for the FHWA for several measures, based on data for all 428 urbanized areas in 2004. (Note that the values shown for these same measures in TTI's 2005 *Urban Mobility Study* are different, since that study was based on a subset of 85 urbanized areas that is weighted more heavily to the most heavily populated areas.)

The Average Daily Percent of VMT under Congested Conditions is an indicator of the portion of daily traffic on freeways and other principal arterials in an urbanized area that moves at less than free-flow speeds. This percentage increased from 25.9 percent to 31.6 percent from 1995 to 2004 for the average urbanized area, and rose for each of four subsets based on population size reported by TTI; Small (population less than 500,000) rose from 15.4 percent to 16.6 percent, Medium (population 500,000 to 999,999) rose from 19.0 percent to 24.8 percent, Large (population 1 million to 3 million) rose from 26.0 percent to 31.7 percent, and Very Large (population greater than 3 million) rose from 34.4 percent to 40.7 percent. While the percent of VMT under congested conditions rose from 2002 to 2004, it rose at a lower rate than it had from 1995 to 2002.

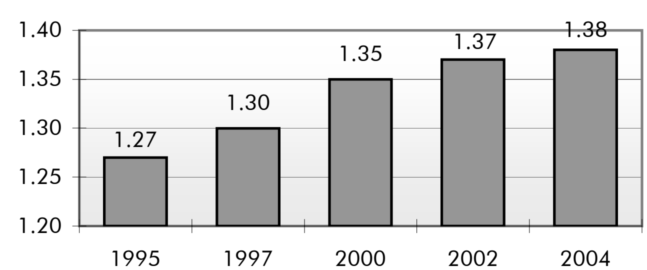
Percent of VMT Under Congested Conditions, by Urbanized Area Size, 1995–2004



The Average Length of Congested Conditions, a measure of the typical duration of congested travel conditions in urbanized areas, stabilized at approximately 6.6 hours per day in 2002 and 2004, after rising from 5.9 hours per day in 1995.

The Travel Time Index measures the amount of additional time required to make a trip during the congested peak travel period, rather than at other times of the day. The average travel time index for all urbanized areas for 2004 was 1.38, indicating that congestion caused travel times to be 38 percent longer. This is up slightly from the 1.37 value reported for 2002; the value for 1995 was 1.27.

Average Travel Time Index for All Urbanized Areas, 1995–2004



In 2004, the average delay experienced by the peak period travelers for all urbanized areas was 45.7 hours, up slightly from 45.4 hours in 2002. The average annual delay per capita (including all residents of a given area, not just peak travelers) rose from 23.8 hours in 2002 to 24.4 hours in 2004.

Operational Performance: Transit

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

Average operating speed in 2004 was higher than in 2002, and above its 10-year average. 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. In 2004, the average operating speed for all transit modes was 20.1 miles per hour, up from 19.9 in 2002, and above its 10-year average of 20.3. The average speed of nonrail modes was 14.0 miles per hour in 2004, up from 13.7 in miles per hour in 2002. The average speed for rail was 25.0 miles per hour in 2004, down from 25.3 in 2002.

Average vehicle utilization levels were lower in 2004 than in 2002 for all modes except demand response, ferryboat, and vanpool. 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.

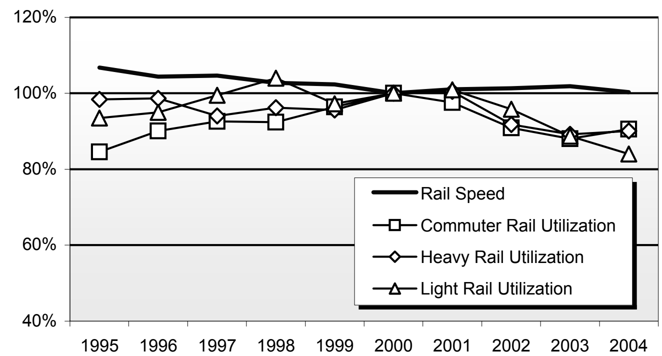
Vehicle Utilization Passenger Miles per Capacity-Equivalent Vehicle

(Thousands of Passenger Miles)

	Utilization	
Mode	**2002**	**2004**
Commuter Rail	769	755
Heavy Rail	655	652
Vanpool	498	502
Light Rail	533	468
Motorbus	389	373
Ferryboat	297	328
Trolleybus	246	237
Demand Response	168	181

Changes in the capacity utilization of rail vehicles influence these vehicle operating speeds through changes in dwell times. As the capacity utilization of commuter rail, heavy rail, and light rail declined

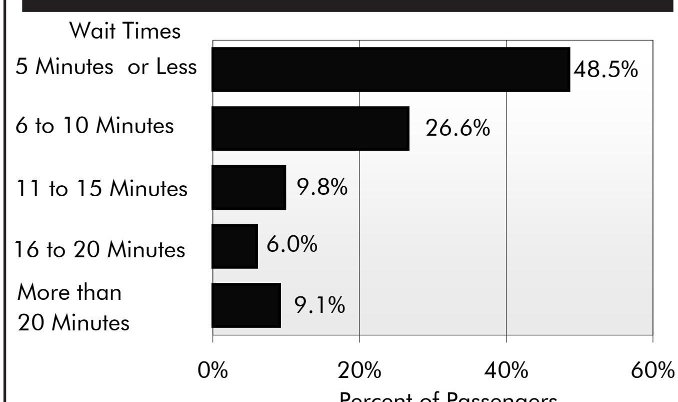
Index of Rail Speed and Capacity Utilization of Rail Vehicles (2000=100%)



from 2001 to 2003, average rail speed increased; and as the capacity utilization of heavy and commuter rail increased from 2003 to 2004, average rail speed decreased.

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.

Passengers by Waiting Times

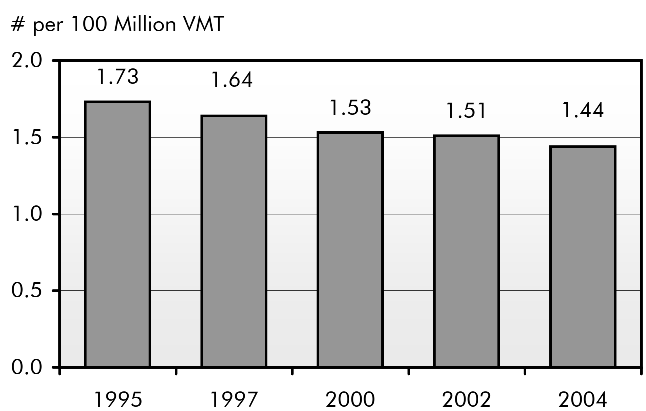


Safety Performance: Highways

Considerable progress has been made 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 43,005 in 2002 to 42,636 in 2004.

The fatality rate per 100 million 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 had dropped to 1.73 in 1995, 1.51 in 2002, and 1.44 in 2004.

Fatality Rate, 1995–2004



Fatality rates are generally lower in urban areas than rural areas, and on higher-ordered functional systems than lower-ordered functional systems. For example, in 2004, the fatality rate per 100 million VMT on urban Interstate highways was 0.55, while the fatality rate on rural roads functionally classified as local was 3.08.

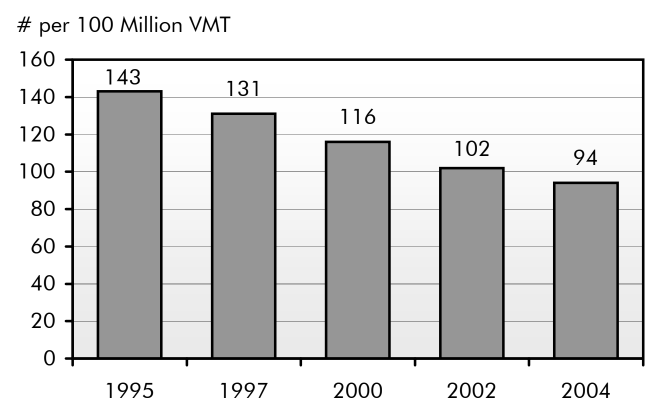
Of the 42,636 total fatalities in 2004, a reported 25,676 involved a roadway departure, in which a vehicle had left its lane. This includes 10,553 that involved a vehicle rollover, a 10.8 percent increase since 1997. The number of rollover fatalities among sport utility vehicles (SUVs) rose by 96.1 percent over that same time period.

About 9,117 highway fatalities occurred at intersections in 2004, down slightly from the 9,148 reported in 1995. Pedestrian fatalities have shown a steady decrease over time, dropping from 6,256 in 1995 to 5,494 in 2004.

Approximately 6.2 million crashes were reported in 2004. Only 0.6 percent of these crashes were severe enough to result in a fatality; 69.3 percent of these crashes resulted in property damage only, while 30.1 percent resulted in injuries.

The number of traffic-related injuries has declined over time, from 3.4 million in 1988, the first year for which statistics are available, down to 2.9 million in 2002 and 2.8 million in 2004. There were approximately 169 injuries per 100 million VMT in 1988; this figure declined to 143 in 1995, 102 in 2002, and 94 in 2004.

Injury Rate, 1995–2004



Alcohol-impaired driving is a serious public safety problem in the United States. Alcohol was a contributing factor in an estimated 16,694 fatalities in 2004 (39 percent of the total) and 7 percent of all crashes.

Speeding is one of the most prevalent factors contributing to traffic crashes. The estimated annual economic costs of speed-related crashes exceeded $40.4 billion in 2004. Speeding was a contributing factor in an estimated 13,192 fatalities in 2004 (31 percent of the total).

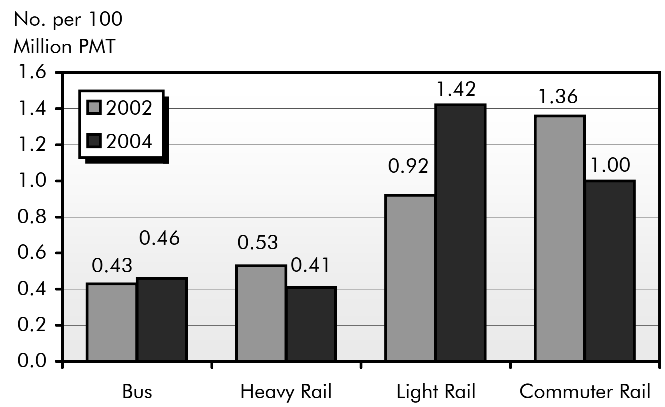
Safety Performance: Transit

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 result 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, trepassings, other assaults, etc.). Injuries and fatalities may occur not just 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.

In 2002, the definitions of an incident and an injury were revised. The threshold for a reportable safety incident was raised from $1,000 to $7,500. An injury was redefined to be an occurrence that required immediate transportation for medical care away from the scene of the incident. Before 2002, any event for which the FTA received a report was classified as an injury. These adjustments to incident and injury definitions led to a decrease in reported incidents and injuries in 2002. These adjustments preclude the direct comparison of incident and injury statistics with those for earlier years.

The definition of fatalities has remained the same. Fatalities decreased from 282 in 2002 to 248 in 2004, and fell from 0.66 per 100 million PMT in 2002 to 0.55 per 100 million PMT in 2004. Fatalities, adjusted for PMT, are lowest for motorbuses and heavy rail systems. 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

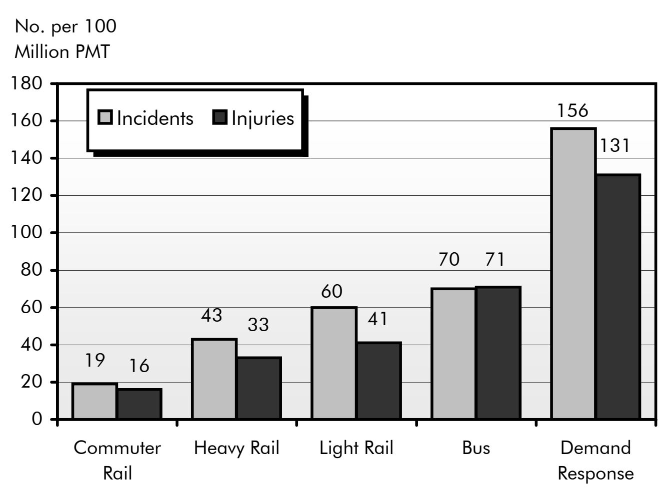
Fatalities per 100 Million PMT, 2002 and 2004



shares track with freight rail vehicles; light rail is often at grade level and has minimal barriers between streets and sidewalks. There were no fatalities on demand response vehicles operated directly by public transit agencies in either 2002 or 2004.

Incidents (safety and security combined) and injuries per 100 million PMT declined for all modes combined from 2002 to 2004. Incidents and injuries, when adjusted for PMT, are consistently the lowest for commuter rail and highest for demand response systems.

Incidents and Injuries per 100 Million PMT, 2004

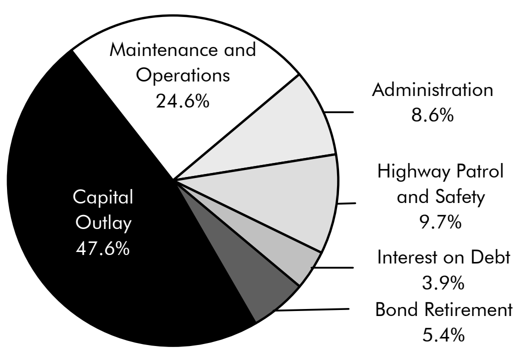


Finance: Highways

Taken together, all levels of government spent $147.5 billion for highways in 2004. Cash outlays by the Federal government for highway-related purposes were $33.1 billion (22.4 percent of the combined total for all levels), including both direct highway expenditures and amounts transferred to State and local governments for use on highways. States funded $72.9 billion (49.4 percent). Counties, cities, and other local government entities funded $41.5 billion (28.1 percent). **Private sector investment is playing an increasingly important role in highway finance**; this subject is discussed in Chapter 13.

Of the total $147.5 billion spent for highways in 2004, $70.3 billion (47.6 percent) was used for capital investments. Spending on maintenance and operations totaled $36.3 billion (24.6 percent); administrative costs (including planning and research) were $12.7 billion; $14.3 billion was spent on highway patrol functions and safety programs; $5.8 billion was used to pay interest; and $8.0 billion was used for bond retirement.

Highway Expenditures by Type, 2004

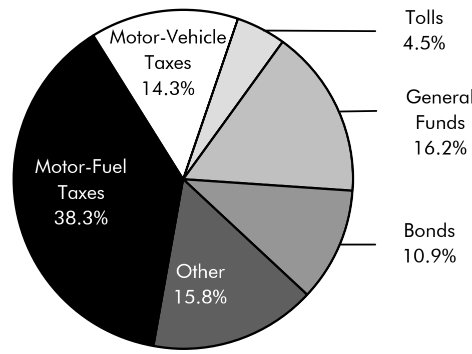


Total highway expenditures by all levels of government increased 44.7 percent between 1997 and 2004. Highway spending rose faster than inflation over this period, growing 22.7 percent in constant dollar terms. Capital spending grew by 45.2 percent between 1997 and 2002. Federal cash expenditures for capital purposes rose 52.9 percent, while State and local capital investment increased by 39.9 percent. As a result of Federal capital spending rising more quickly, the portion of total capital outlay funded by the Federal government rose from 41.6 percent in 1997 to 43.8 percent in 2004. The Federal percentage in 2002 was 46.1 percent, the highest level since 1986.

Of the $70.3 billion of capital spending by all levels of government in 2004, $36.4 billion (51.8 percent) was spent for system rehabilitation, the resurfacing, rehabilitation, and reconstruction of existing roadways and bridges. An estimated $14.7 billion (20.9 percent) was used to construct new roads and bridges; $12.8 billion (18.3 percent) went for adding new lanes to existing roads; and $6.4 billion (9.0 percent) went for system enhancements such as safety, operational, or environmental enhancements.

Highway-user revenues—the total amount generated from motor-fuel taxes, motor-vehicle fees, and tolls imposed by Federal, State, and local governments—were $105.8 billion in 2004. Of this, $83.0 billion (78.4 percent) was used for highways. This represented 57.1 percent of the total revenues generated by all levels of government in 2004 for use on highways. Other major sources of revenues for highways included bond proceeds of $15.8 billion (10.9 percent) and general fund appropriations of $23.6 billion (16.2 percent). Other sources such as property taxes, other taxes and fees, lottery proceeds, and interest income totaled $23.0 billion (15.8 percent).

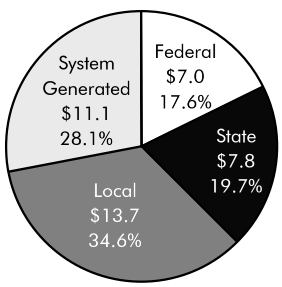
Revenue Sources for Highways, 2004



Finance: Transit

In 2004, $39.5 billion was available from all sources to finance transit capital investments and operations, compared with $36.5 billion in 2002. 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 2004, Federal funds accounted for 18 percent of all transit revenue sources, State funds for 20 percent, local funds for 35 percent, and system-generated funds for 28 percent.

2004 Transit Revenue Sources (Billions of Dollars)

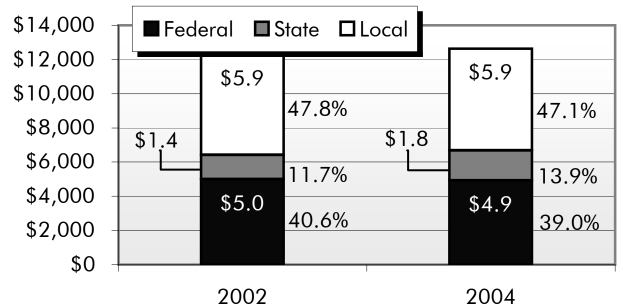


Eighty percent of the Federal funds allocated to transit are from a dedicated portion of the Federal motor-fuel tax receipts, and 20 percent are from general revenues. Federal funding for transit increased from $6.3 billion in 2002 to $7.0 billion in 2004, and State and local funding increased from $20.3 billion in 2002 to $21.5 billion in 2004.

In 2004, $12.6 billion, or 32 percent of total available transit funds, was spent on capital investment. Federal capital funding was $4.9 billion, or 39 percent of total capital expenditures; State capital funding was $1.8 billion, or 14 percent of total capital expenditures; and local capital funding was $5.9 billion, or 47 percent of total capital expenditures. Between 2002 and 2004, Federal capital funding decreased by 1.3 percent and State and local capital funding increased by 5.4 percent.

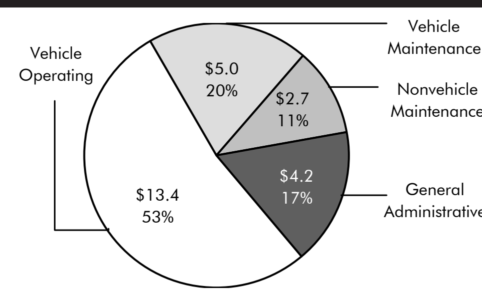
In 2004, $4.0 billion or 32 percent of total capital expenditures was for guideway; $3.4 billion or 27 percent of the total was for rolling stock, $2.1 billion or 16 percent of the total was for systems, and $1.1 billion or 9 percent of the total was for stations.

Sources of Transit Capital Investment Funding, 2002 and 2004 (Billions of Dollars)



In 2004, actual operating expenditures were $25.4 billion. Vehicle operating expenses were $13.4 billion, 53 percent of total operating expenses and 35 percent of total expenses; vehicle maintenance expenses were $5 billion, 20 percent of total operating expenses and 13 percent of total expenses; nonvehicle maintenance expenses were $2.7 billion, or 11 percent of total operating expenses and 7 percent of total expenses; and general administrative expenses were $4.2 billion, or 17 percent of total operating expenses and 11 percent of total expenses.

2004 Transit Operating Expenditures (Billions of Dollars)



In 2004, $26.9 billion was available for operating expenses, accounting for 68 percent of total available funds; the Federal government provided $2.0 billion or 8 percent of total operating expenses; State governments $6.0 billion or 22 percent of total operating expenses; local governments $7.9 billion or 29 percent of total operating expenses; and system-generated revenues $10.9 billion or 41 percent of total operating expenses.

Investment/Performance Analysis

Chapters 7 through 10 present and analyze estimates of 20-year capital investment scenarios for highways, bridges, and transit. The 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. Separate estimates of investments for highways, bridges, and transit are generated independently by separate models and techniques. While the Highway Economic Requirements System (HERS), National Bridge Investment Analysis System (NBIAS), and Transit Economic Requirements Model (TERM) all utilize benefit-cost analysis, their methods for implementing this analysis are very different. Each model relies on separate databases, making use of the specific data available for only one part of the transportation system and addressing issues unique to each mode. **These three models have not yet evolved to the point where direct multimodal analysis would be possible**.

Chapter 7 presents estimates of future investment for specific scenarios, which are defined differently for each mode. These scenarios are intended to be illustrative only; **this report does not endorse any particular level of future highway, bridge, or transit investment.** While estimates are made of the cost to maintain future indicators of conditions and performance and current year levels, and the cost to improve performance based on standards unique to each model, these represent only two points on a continuum of alternative investment levels. Chapter 9 analyzes the impacts different levels of future investment might have on various measures of physical condition, operating performance, and system use.

Chapter 8 compares 2004 spending with the average annual investment scenario levels for the 2005–2024 period stated in constant 2004 dollars in Chapter 7 for the benchmark scenarios. The investment scenario estimates reflect the total capital investment required from **all sources**—Federal, State, local, and private—to achieve certain levels of performance. While the analyses in Chapter 8 identify the magnitude of the differences between current spending and the investment scenarios, they do not directly address which revenue sources might be used to finance additional investment, nor do they suggest how much might be contributed by each level of government. **This report makes no recommendations concerning future levels of Federal investment.**

As in any modeling process, simplifying assumptions have been made in HERS, NBIAS, and TERM to make analysis practical and to meet the limitations of available data. (See Appendices A, B, and C for more details on the individual models.) The accuracy of the projections of future investment scenarios depends in large part on the underlying assumptions used in the analysis. Chapter 10 explores the impact that varying some of these key assumptions would have on the overall results.

The HERS, NBIAS, and TERM models all have a broader focus than traditional engineering-based models, looking beyond transportation agency costs to consider the benefits that transportation provides to users of the system and some of the impacts that transportation investment has on nonusers. From an economic perspective, the cost of an investment in transportation infrastructure is simply the straightforward capital cost of implementing an improvement project. The benefits of transportation capital investments are generally characterized as the attendant reductions in costs faced by (1) transportation agencies (such as for maintenance), (2) users of the transportation system (such as savings in travel time and vehicle operating costs), and (3) others who are affected by the operation of the transportation system (such as reductions in environmental or other societal costs).

Investment/Performance Analysis

While the economic-based approach 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, **in reality other factors influence Federal, State, and local decisionmaking** that may result in a different outcome. 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 identified as the 'Cost to Maintain" would not guarantee that conditions and performance would actually be maintained**. Similarly, while the HERS, NBIAS, and TERM models all screen out potential improvements that are not cost-beneficial, simply increasing spending to the "Cost to Improve" level would not in itself guarantee that these funds would be expended in a cost-beneficial manner. Further, 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. As a result, the supply of feasible cost-beneficial projects could be exhausted at a lower level of investment than is indicated by this scenario, and the projected improvements to future conditions and performance under this scenario may not be fully obtainable in practice.

This report has traditionally identified the amount of additional spending above current levels that would be required to achieve certain performance benchmarks, without considering the types of revenues required to support this additional spending. The implicit assumption has been that the financing mechanisms would not have any impact on the investment scenario estimates. In reality, however, increased 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, the highway investment modeling procedures have been modified to assume that any increase in highway and bridge investment above 2004 levels would be funded entirely by increases in user charges, and a feedback loop has been added to account for the impact that this increase in the "price" of travel would have on deterring future travel and, by extension, reducing future investment scenario estimates.

While the assumption of increased levies on users via the current tax structure draws revenues, investment, and travel demand together, the inherent economic inefficiencies of the current structure would remain, whereby travel on uncongested facilities is charged at the same rate as those with significant congestion issues. In an ideal (from an economic point of view) world, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby reducing peak traffic volumes and increasing net benefits to all users combined.

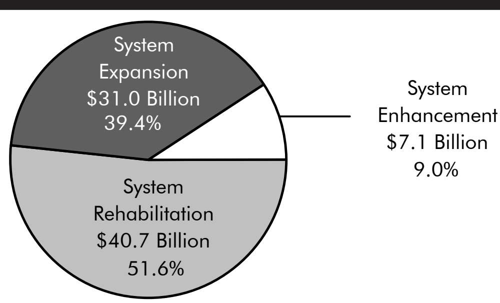
For this report, the HERS model has been adapted to illustrate the maximum, theoretical impact that efficient pricing could have on the estimates of future highway investment scenarios. This highly stylized analysis, presented in Chapter 10, assumes that congestion pricing would be implemented universally on all congested roads. **This analysis demonstrates that congestion pricing has considerable potential for reducing peak period congestion and future investment scenario estimates**. However, this analysis should be viewed as an interim product that will be refined in future editions of the C&P report. Importantly, it does not account for the considerable costs that could be associated with implementing and administering such a comprehensive pricing system. The methodology used for this analysis is presented in Appendix A. The "Pricing Effects" section in Part IV provides a further discussion of ongoing research in this area.

Capital Investment Scenarios: Highways and Bridges

Chapter 7 presents two illustrative future investment scenarios for highways and bridges. The Introduction to Part II (summarized on pages ES-12 and ES-13) includes critical background material required to properly interpret these scenarios. These scenarios assume the continuation of current highway financing mechanisms and current trends in the deployment of certain operations strategies and deployments; Chapter 10 explores the impacts of changing these and other key scenario assumptions.

The average annual **Cost to Maintain Highways and Bridges for the 20-year period 2005–2024 is estimated to be $78.8 billion**, stated in constant 2004 dollars. This scenario represents the level of investment **by all levels of government** required to (1) maintain the existing level of bridge deficiencies in constant dollar terms, and (2) keep the physical condition and operational performance of the highway system at a level sufficient to prevent average highway user costs (including travel time costs, vehicle operating costs, and crash costs) from rising above the existing level in constant dollar terms.

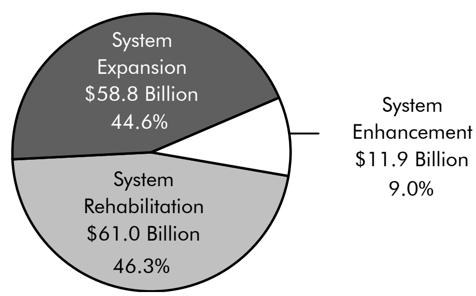
Cost to Maintain Highways and Bridges Distribution by Improvement Type



Agency costs, such as maintenance, and societal costs, such as emissions, are considered in the benefit-cost analysis for future highway investments, but are not included in the calculation of the maintain user cost performance goal. Taxes are also excluded from the user cost target, since they are not a reflection of system conditions or performance. User taxes would rise under this scenario to cover the additional investment required above 2004 spending levels, so the total costs including taxes experienced by individuals under this scenario would increase.

The average annual **Maximum Economic Investment Level for Highways and Bridges for the 20-year period 2005–2024 is estimated to be $131.7 billion,** stated in constant 2004 dollars. This scenario represents the level of investment **by all levels of government** required to implement all cost-beneficial improvements on highways and bridges. This scenario can be viewed as an "investment ceiling" above which it would not be cost-beneficial to invest, even if unlimited funding were available.

Maximum Economic Investment for Highways and Bridges Distribution by Improvement Type



System rehabilitation improvements make up 51.6 percent of the Cost to Maintain and 46.3 percent of the Maximum Economic Investment level. This includes all capital investment aimed at preserving the existing highway and bridge infrastructure. System expansion improvements (adding capacity to the system through widening or other means) make up 39.4 percent of the Cost to Maintain and 44.6 percent of the Maximum Economic Investment level. The remaining 9.0 percent of each scenario is not directly modeled; this represents the current share of capital spending on system enhancements such as safety, traffic control facilities, and environmental enhancements.

Capital Investment Scenarios: Transit

Transit capital investment estimated under the "Maintain Conditions and Performance" scenario and estimated under the "Improve Conditions and Performance" scenario are 1.3 percent higher and 9 percent lower than in the 2004 report; the amount to improve performance has declined due to revisions in the benefit-cost analysis. Current investment estimates are for the period 2005–2024. 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. The Improve Conditions and Performance scenario projects the level of invesment 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. The Improve Conditions and Performance scenario defines an upper limit above which additional investment in transit is unlikely to be economically justifiable.

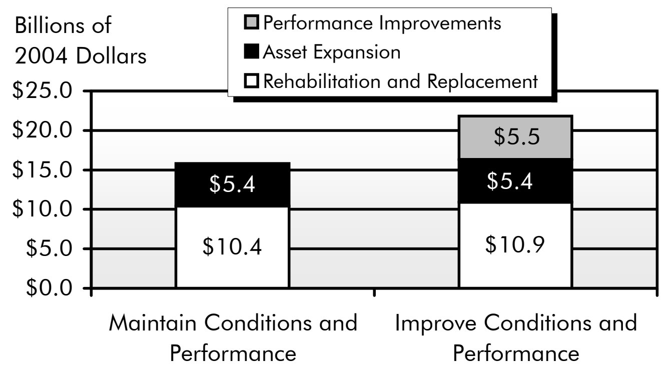
Transit Average Annual Investment Scenario Estimatess, 2003–2022 and 2005–2024

(Billions of Dollars)

	Average Annual Cost 2003–2022	2005–2024
Conditions & Performance	**2002 Dollars**	**2004 Dollars**
Maintain	$15.6	$15.8
Improve	$24.0	$21.8

Average annual investment is estimated to be $15.8 billion to maintain conditions and performance ($15.6 billion in 2002) and $21.8 billion to improve conditions and performance ($24.0 billion in 2002). Under the "Maintain" scenario, $10.4 billion annually would be needed for asset rehabilitation and replacement and $5.4 billion for asset expansion. Under the "Improve" scenario, $10.9 billion would be needed annually for replacement and rehabilitation, $5.4 billion for asset expansion, and $5.5 billion for performance improvements. Eighty-seven percent

Annual Cost to Maintain and Improve Conditions and Performance by Investment Type, 2005–2024



of the investment under the "Maintain" scenario, or $13.8 billion, would be required in urban areas with populations of over 1 million, reflecting the fact that in 2004, 92 percent of the Nation's passenger miles were in these areas.

Of the investment required to maintain conditions and performance, vehicles account for 45 percent ($7.1 billion annually), guideway elements for 18 percent ($2.9 billion), facilities for 12 percent ($1.9 billion), stations for 9 percent ($1.4 billion), systems for 9 percent ($1.4 billion) and other project costs for 6 percent ($1.0 billion). Of the investment under the Improve Conditions and Performance scenario, vehicles account for 42 percent ($9.2 billion annually), guideway elements for 19 percent ($4.2 billion), facilities for 11 percent ($2.4 billion), stations for 10 percent ($2.1 billion), systems for 7 percent ($1.6 billion) and other project costs for 11 percent ($2.3 billion).

Average Annual Transit Investment Scenario Estimates by Asset Type, 2005–2024

(Billions of 2004 Dollars)

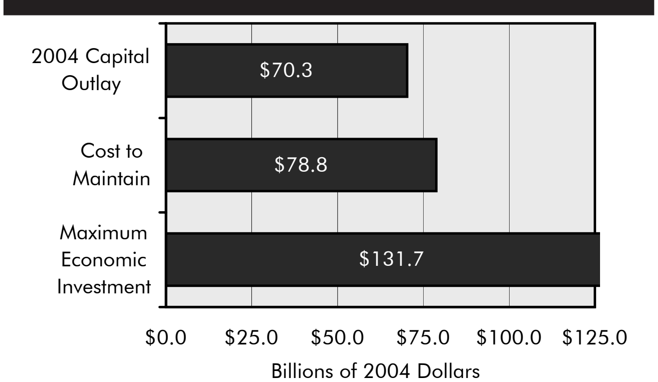
	Maintain	Improve
Vehicles	$7.1	$9.2
Guideway Elements	$2.9	$4.2
Facilities	$1.9	$2.4
Stations	$1.4	$2.1
Systems	$1.4	$1.6
Other Project Costs	$1.0	$2.3

Comparison of Spending and Investment Scenario Estimates: Highway and Bridge

Chapter 8 compares the investment estimates for the two illustrative scenarios introduced in Chapter 7 with current and projected spending levels. **This report does not endorse either of these two scenarios as a target level of funding**, nor does it make any recommendations concerning future levels of Federal funding.

Federal, State, and local capital expenditures for highways and bridges totaled $70.3 billion in 2004. **Capital outlay by all levels of government would have to increase by 12.2 percent above this level to reach the $78.8 billion Cost to Maintain Highways and Bridges level.** The percentage gap for highway resurfacing and reconstruction (part of the system rehabilitation component of the Cost to Maintain) is larger, at approximately 23.0 percent. In contrast, capital expenditures for bridge rehabilitation and replacement (also part of system rehabilitation) were 16.6 percent higher than the estimated annual cost to maintain the current economic backlog of bridge improvements in constant dollar terms. This is consistent with the reduction in the number of deficient bridges observed in recent years.

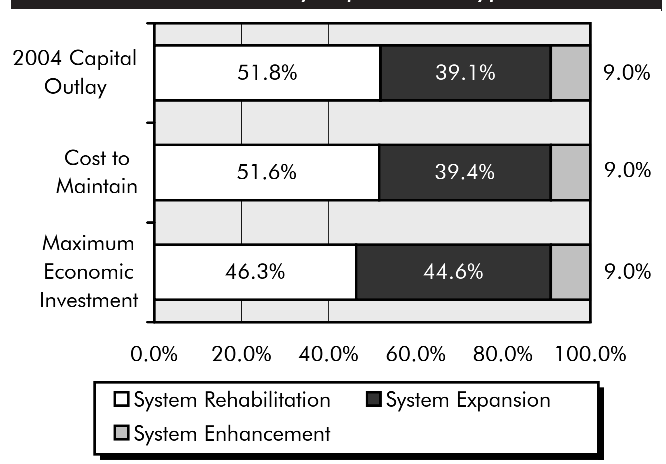
2004 Capital Outlay by All Levels of Government vs. Highway and Bridge Investment Scenario Estimates



An increase in capital outlay of 87.4 percent above current levels would be required to reach the projected $131.7 billion Maximum Economic Investment level for highways and bridges.

The distribution of funding by investment type suggested by the investment scenarios developed using the HERS and NBIAS models depends on the level of funding. In 2004, 39.1 percent of highway capital outlay went for system expansion, including the construction of new roads and bridges and the widening of existing facilities. This is very close to the percentage suggested by the "Cost to Maintain" scenario to be used for capacity expansion investments (39.4 percent). However, if funding levels were to rise significantly above this level, the analysis identifies a number of cost-beneficial potential investments to combat highway congestion, so that at the Maximum Economic Investment level, 44.6 percent of total investments are for capacity expansion.

Investment Scenarios and 2004 Capital Outlay Distribution by Improvement Type



The estimated gaps between current spending and the two investment scenarios are higher than the estimates shown in the 2004 edition of this report, which compared 2002 highway capital outlay with investment scenarios for 2003 to 2022. The estimated Cost to Maintain in that report was 8.3 percent higher than 2002 spending, and the gap between 2002 spending and the Maximum Economic Investment level was 74.3 percent.

Comparison of Spending and Investment Scenario Estimates: Transit

Transit capital expenditures from Federal, State, and local governments totaled $12.6 billion in 2004, below the annual investment amounts estimated by the TERM scenarios for the 20-year period from 2005–2024. **The annual capital investment estimated by the Maintain Conditions and Performance scenario is $15.8 billion, 25 percent above actual spending in 2004.** The investment estimated by the Improve Conditions and Performance scenario is $21.8 billion, 73 percent above actual 2004 capital spending.

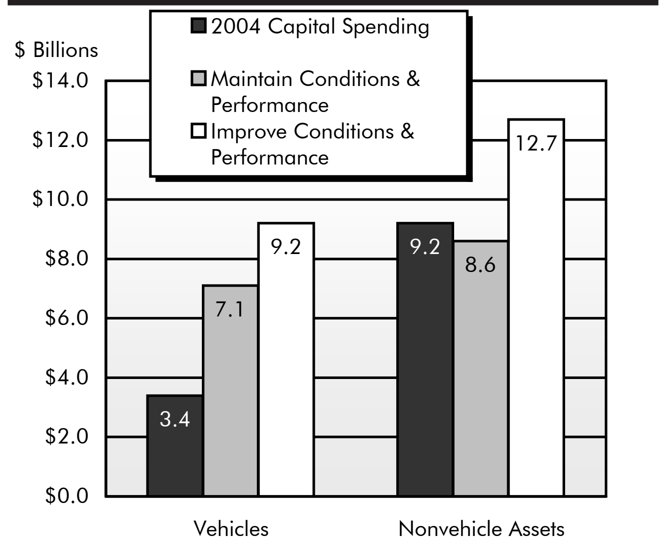
The gap between actual vehicle capital investment and the amount to maintain and improve the conditions of vehicle assets has widened since the last report and the gap between actual nonvehicle asset investment and the amount to maintain and improve the conditions of nonvehicle assets has declined, in part, due to a decrease in the share of capital spending on vehicles from 31 percent in 2002 to 27 percent in 2004, and an increase in the share of capital spending on nonvehicles from 69 to 73 percent.

The estimated average annual amount to maintain the conditions and performance of the Nation's transit vehicle assets of $7.1 billion is 109 percent above actual spending of $3.4 billion in 2002. The estimated average annual amount to improve conditions and performance of transit vehicles is $9.2 billion, 171 percent above the 2004 investment.

The average annual amount to maintain the conditions and performance of the Nation's nonvehicle transit infrastructure of $8.6 billion is 7 percent below the $9.2 billion spent in 2004. The average annual amount to improve the conditions and performance of the nonvehicle infrastructure is $12.7 billion, 38 percent above actual spending in 2004.

In addition to continually replacing existing transit assets, the annual investment scenarios estimates include the expansion of existing assets to meet projected demand and improve operational performance. To maintain performance, TERM estimates that an additional 26,000 buses and 5,500 rail vehicles would need to be purchased between 2005 and 2024 to meet a projected ridership growth of 1.57 percent. This would be roughly a 24 percent increase in the 2004 bus fleet size, and a 21 percent increase in the 2004 rail fleet size. To improve performance, TERM estimates that an additional 3,000 rail vehicles would be needed, or about a 12 percent increase in the 2004 rail fleet size.

A Comparison of 2004 Capital Spending with Average Annual Investment Scenario Estimates (Billions of Dollars)



The gap between the annual investment estimated by the Maintain Conditions and Performance scenario and actual investment is similar to what was reported in the 2004 edition. The gap between the annual investment estimated by the Improve Conditions and Performance scenario and actual investment is about 20 percent lower than reported in the 2004 report due to a decrease in the estimate required to improve conditions and performance. This decline was primarily due to a decrease in investment needed to improve performance resulting from a reduction in the assumed hourly cost of congestion delay.

Impacts of Investment: Highways and Bridges

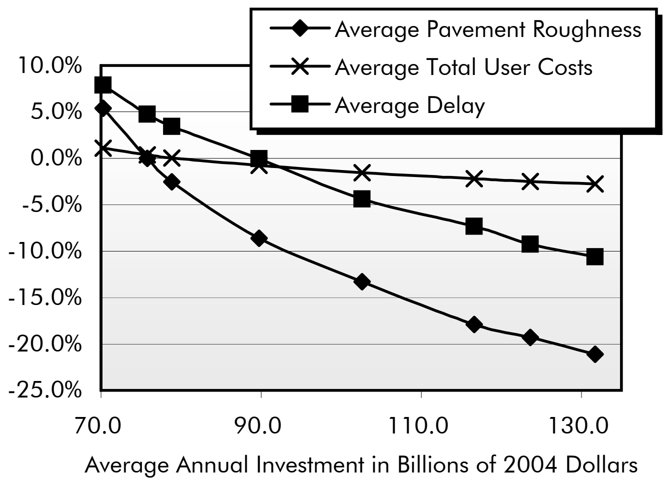
Spending by all levels of government on system rehabilitation rose by 58.0 percent between 1997 and 2004, from $23.0 billion to $36.4 billion. This increased investment in roadway resurfacing and reconstruction and bridge rehabilitation and replacement is reflected in the increases in the percent of VMT occurring on pavements with good ride quality and the decreases in bridge deficiencies that are described in Chapter 3.

Investment in system expansion has also increased from 1997 to 2004, but at a much lower rate relative to outlays for system preservation. While the rate of deterioration in various measures of operational performance has decreased, the level of investment has not stopped the overall growth in congestion levels that is described in Chapter 4.

If annual highway capital investment from 2005 to 2024 averages the $131.7 billion (in constant 2004 dollars) level specified by the "Maximum Economic Investment" scenario, and is applied in the manner suggested (devoting a larger share of investment toward capacity expansion to address congestion problems), then average highway user costs would be expected to decline by 2.8 percent per VMT in constant dollar terms. While this percentage appears relatively low, by the year 2024 it would translate into approximately $116 billion in annual user cost savings. (There is a practical limit on the ability of highway investments to cause dramatic reductions in total user costs, since they include the time costs associated with getting from point A to point B in uncongested conditions). Average delay per VMT would decline by 10.6 percent under the "Maximum Economic Investment" scenario. (Delay due to incidents would decline much more sharply, as the level of future investments in operations and intelligent transportation systems assumed in these scenarios would have a greater effect on nonrecurring delay.) Average pavement ride quality would be expected to improve by 21.1 percent relative to 2004 levels.

If all levels of government combined invested at the projected Cost to Maintain level of $78.8 billion, average highway user costs in 2024 would by definition match those in 2004. Average pavement ride quality would improve by 2.5 percent, while delay per VMT would worsen by 3.4 percent.

Projected Changes in 2024 Highway Condition and Performance Measures Compared with 2004 Levels, at Different Possible Funding Levels



The amount of travel growth on a highway segment may be affected by the level of investment on that segment. Investments that reduce the economic cost of using the facility will tend to encourage additional use, while increasing congestion on an unimproved roadway can cause travel growth to be lower than it otherwise would be. The travel growth forecasts used in the analysis of highway investment in this report are dynamic, in the sense that they allow feedback between the level of future investment and future VMT growth.

Relative to previous editions, the difference between the projected average annual VMT growth rate in the two scenarios is narrower (1.94 percent versus 1.88 percent), due to the imposition of user charges to cover the increased spending associated with each scenario.

Impacts of Investment: Transit

Funding levels between 2002 and 2004 have been sufficient to maintain conditions. The investment estimated by the "Maintain Conditions" scenario assumes that an average condition of 3.6 will be reached in 2024, compared with an average condition of 3.9 in 2004. To reach an average condition of 3.9 in 2024 would require the maintain conditions investment estimate to include replacement expenditures for some assets not needing replacement over the 2003 to 2024 period.

If the amount spent on capital investment is 10 percent lower than the amount estimated to be needed to maintain conditions in urban areas ($8.89 billion annually instead of $9.88 billion annually), the average condition of transit assets is estimated to fall from 3.6 in 2004 to 3.5 in 2024. If this amount is lowered by 30 percent to $6.92 billion annually, average asset conditions are estimated to fall to 3.4 in 2024.

Effect of Capital Spending Constraints on Transit Conditions

	2004 Condition	Percent of Recommended Rehabilitation and Replacement Expenditures to Maintain Conditions			
Asset Type		**100%**	**90%**	**80%**	**70%**
Guideway Elements	4.4	4.1	4.0	4.0	3.9
Facilities	3.6	3.2	2.9	2.9	2.9
Systems	3.9	3.7	3.7	3.5	3.4
Stations	3.4	3.1	3.1	3.1	3.1
Vehicles	3.4	3.4	3.3	3.3	3.1
All Assets	**3.9**	**3.6**	**3.5**	**3.5**	**3.4**
Replacement Expenditure Scenarios [1]		$9.88	$8.89	$7.91	$6.92

[1] Excludes rural vehicles and facilities.

Funding levels between 2002 and 2004 have also been sufficient to maintain performance as measured by passenger travel time and vehicle occupancy. TERM estimates that for urban areas $5.2 billion annually will be needed to maintain current performance if PMT increases annually at the projected rate of 1.57 percent, or about 850 million new passengers per year.

TERM considers, in its benefit-cost analysis, the effect of capital investment on transit user costs and the effect of change in these costs on transit ridership. Transit user costs are composed of two components: the out-of-pocket transit fare cost and the time spent making the trip or "travel-time cost." Travel-time savings are realized by adding or expanding an existing rail or BRT service or by adding vehicles to reduce crowding. Out-of-pocket savings occur when passengers switch from automobiles to transit.

TERM estimates that $5.2 billion annually is required to improve transit performance in urban areas, $2.01 billion annually for asset expansion in new rail or BRT service to increase speed, and $3.16 billion annually for asset expansion in new vehicles to reduce occupancy levels. The average ridership estimated to result from increasing speed is 22.9 million passengers annually; the average annual ridership estimated to result from decreasing occupancy levels is 51.6 million passengers annually.

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 these analyses, this report includes an analysis of the sensitivity of the baseline analyses presented in Chapter 7 to changes in these assumptions.

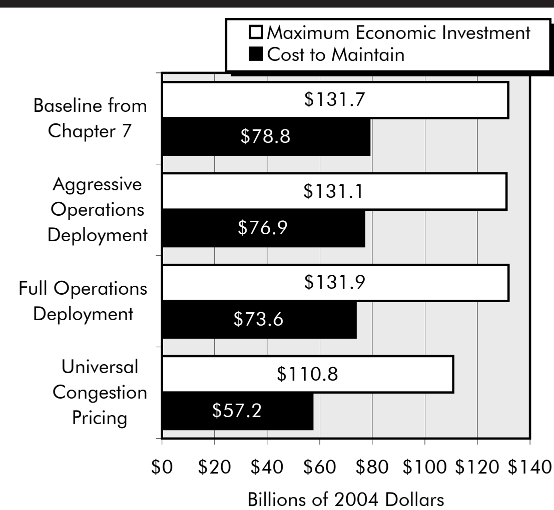
While previous editions of the C&P report have examined the effects of a 25 percent constant dollar increase in highway construction costs, this alternative analysis has taken on additional significance due to recent spikes in the costs of various construction materials and petroleum products. Such an increase would lead to a comparable increase in the average annual Cost to Maintain highways and bridges; the Maximum Economic Investment level would rise by only 11.2 percent, as some potential improvements would no longer be cost-beneficial.

This edition of the report also includes theoretical scenarios involving alternative congestion reduction strategies. The baseline scenarios in Chapter 7 reflect the effects of selected operations strategies and intelligent transportation systems (ITS), assuming existing deployment trends continue. However, if the deployment rates were to accelerate significantly, the Cost to Maintain could decline by 2.4 percent. Assuming full immediate deployment in all applicable locations would bring down the Cost to Maintain by 6.6 percent. The Maximum Economic Investment level would not change significantly, as many of these operations deployments would complement, rather than substitute for, other cost-beneficial highway investments. However, under these alternative assumptions, projected future operational performance would be significantly improved; highway users would save an extra $10 billion annually by 2024 in terms of reduced delay and other costs assuming aggressive deployment rates; assuming full immediate deployment, these savings would rise to $27 billion per year by 2024.

The baseline scenarios in Chapter 7 also assume the continuation of existing financing structures, with their inherent economic inefficiencies. In an ideal (from an economic point of view) world, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby reducing peak traffic volumes and increasing net benefits to all users combined. **A preliminary analysis of universal congestion pricing using the HERS model suggests that such a strategy could significantly reduce the level of future highway investment that would be required to maintain or improve highway operational performance.**

Applying congestion tolls along the principles outlined above to all congested roads could reduce the Cost to Maintain by $21.6 billion per year (27.5 percent), leaving it well below the $70.3 billion level of capital spending in 2004. The Maximum Economic Investment level would be reduced by $20.9 billion (15.9 percent) even while generating a better level of system performance than the baseline scenario. Note that this analysis does not reflect the startup or administrative costs that would be associated with implementing a pricing strategy of this nature. This analysis will be refined in future editions of the C&P report, which might increase or decrease these estimated impacts.

Impact of Congestion Reduction Strategies on Average Annual Investment Scenario Estimates



Sensitivity Analysis: Transit

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

Sensitivity to Changes in Passenger Miles Traveled

The Transit Economic Requirements Model (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).

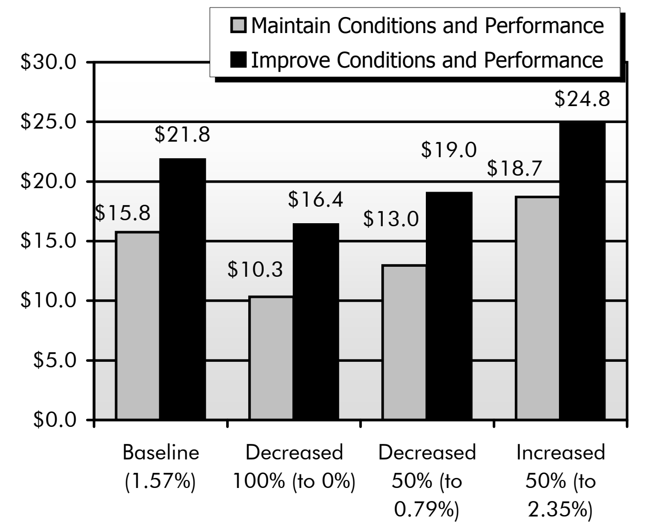
PMT forecasts are generally made by metropolitan planning organizations (MPOs) in conjunction with projections of vehicle miles traveled (VMT). The average annual growth rate in PMT of 1.57 percent used in this report is a weighted average of the most recent MPO forecasts available from 92 of the Nation's largest metropolitan areas. Transit investment estimates in the 2004 report were based on a projected PMT growth rate of 1.5 percent, based on projections from 76 MPOs. (PMT increased at an average annual rate of 2.29 percent between 1995 and 2004 and by 0.65 percent between 2002 and 2004.)

Varying the assumed rate of growth in PMT affects estimated transit investment both for the "Maintain" and "Improve" scenarios. A 50 percent increase/decrease in growth will increase/decrease the cost to maintain conditions and performance by 18 to 19 percent and the cost to improve conditions and performance by 13 to 14 percent. Investment estimated by both the "Maintain" and "Improve" scenarios would decrease significantly if PMT was assumed to remain constant.

Sensitivity to a 25 Percent Increase in Capital Costs

Given the uncertainty of capital costs, a sensitivity analysis was performed to examine the effect of

The Effect of Variations in PMT Growth on Transit Annual Investment Scenario Estimates (Billions of 2004 Dollars)



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 18 percent and increases the investment estimated by the Improve Conditions and Performance scenario by 15 percent.

Sensitivity to Changes in the Value of Time

The value of time is used to determine the total benefits accruing to transit users from transit investments that reduce passenger travel time. Variations in the value of time were found to have a limited effect on the investment estimates, since changes in the value of time have inverse effects on the demand for transit services.

Sensitivity to Changes in the User Cost Elasticities

TERM uses user cost elasticities to estimate the changes in ridership that will result from changes in 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 almost no effect on projected investment.

CHAPTER 11: *Executive Summary*

Interstate System

In 2006, the Dwight D. Eisenhower National System of Interstate and Defense Highways, commonly known as the Interstate System, turned 50 years old. The 46,747 miles of Interstate highways serve as the backbone of transportation and commerce in the United States. About 67.1 percent of this 2004 mileage was in rural areas, 4.5 percent was in small urban areas, and 28.3 percent was in urbanized areas. In 2004, Americans traveled approximately 267 billion vehicle miles on rural Interstates, 26 billion on small urban Interstates, and 434 billion on urbanized Interstates. Taken together, this represents approximately 24.5 percent of all U.S. travel in 2004.

The Interstate System is growing more crowded; Interstate VMT grew at an average annual rate of 2.8 percent from 1995 to 2004, outpacing the 0.5 percent average annual growth in lane miles over that period. On rural Interstates, 73.7 percent of VMT in 2004 was on pavements with good ride quality; comparable figures for small urban and urbanized Interstates were 65.6 percent and 48.5 percent, respectively. Current spending on rural Interstate highways appears adequate to further improve pavement ride quality and reduce overall highway user costs, if sustained in constant dollar terms. On urban Interstates, significant increases in funding for rehabilitation and expansion would be required to prevent both average physical conditions and operational performance from becoming degraded.

The Interstate System included 55,315 bridges in 2004, 27,648 in rural areas and 27,667 in urban areas. In 2004, about 15.9 percent of rural Interstate bridges were considered to be deficient, including 4.2 percent classified as structurally deficient and 11.7 percent classified as functionally obsolete. Among urban Interstate bridges, about 26.5 percent were considered to be deficient in 2004, including 5.1 percent classified as structurally deficient and 20.5 percent classified as functionally obsolete.

CHAPTER 12: *Executive Summary*

National Highway System

The National Highway System (NHS) has five components, including (1) the Interstate System, (2) selected other principal arterials deemed most important for commerce and trade, (3) the Strategic Highway Network (STRAHNET), (4) STRAHNET connectors, and (5) intermodal connectors that provide access between major intermodal passenger and freight facilities and other NHS components. The NHS includes 87.5 percent of urban other freeways and expressways, 35.9 percent of urban other principal arterials, and 83.8 percent of rural other principal arterials. While the NHS makes up only 4.1 percent of total U.S. mileage, it carries 44.8 percent of total travel.

In 2004, 68.0 percent of rural NHS travel was on pavements with good ride quality, compared with 42.5 percent of urban NHS travel. Approximately 97 percent of rural NHS travel was on pavements with acceptable ride quality, compared with 86.9 percent of urban NHS travel.

In 2004, 19.4 percent of all U.S. bridges were located on the NHS, but these bridges had 49.5 percent of the total deck area on all bridges and carried 71.1 percent of the traffic on all bridges. Approximately 20.5 percent of NHS bridges were considered deficient in 2004, including 5.6 percent classified as structurally deficient and 14.9 percent classified as functionally obsolete.

In 2004, all levels of government spent a combined $34.6 billion for capital improvements to the NHS, which was 49.2 percent of total capital expenditures on all roads. If current spending for NHS bridge rehabilitation and replacement were sustained in constant dollar terms over 20 years, the current backlog of deficient bridges could be reduced, but not eliminated. If current spending levels on the urban NHS for system expansion plus pavement resurfacing and reconstruction were sustained, urban pavement condition and operational performance would be expected to decline. Current spending on the rural NHS is adequate to improve rural conditions and performance.

Innovative Finance

While the traditional financing mechanisms discussed in Chapter 6 provide most of the funding that supports surface transportation, innovative financing mechanisms are playing an increasingly important role. This report defines "Innovative Finance" broadly, reflecting a wide array of techniques designed to supplement traditional financing mechanisms, including credit assistance, innovative debt financing and public-private partnerships.

The **Transportation Infrastructure and Finance Innovation Act** (TIFIA) program is administered by the DOT and offers eligible applicants the opportunity to compete for secured (direct) loans, loan guarantees, and standby lines of credit for up to one-third of the cost of construction for nationally and regionally significant projects, provided that the borrower has an associated revenue stream, such as tolls or local sales taxes, that can be used to repay the debt issued for the project. Since the program's inception in 1999 through July of 2006, TIFIA has provided almost $3.2 billion in credit assistance to projects representing more than $13.2 billion in infrastructure investment.

The **State Infrastructure Bank (SIB) Pilot Program** provides increased financial flexibility for infrastructure projects by offering direct loans and loan guarantees. SIBs are capitalized with Federal and State funds. 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. As of June 2005, $5.1 billion in loan agreements had been made by 33 States, of which $3.7 billion had been disbursed for 457 loan agreements. SIB loans are being used to fund both highway and transit projects; 21 States have signed SIB cooperative agreements with the FTA and eight have executed at least one public transit loan. SIB transit loans of $94.5 million are assisting $318.7 million in transit projects.

States are increasingly looking to the private sector as another potential source of highway and transit funding, either in addition to or in concert with new credit and financing tools. The private sector often has expertise that may not be readily available in the public sector that can bring innovation and efficiency to many projects.

A variety of institutional models are being used including (1) concessions for the long-term operation and maintenance of individual facilities or entire highway systems; (2) purely private sector highway design, construction, financing, and operation; and (3) **Public-Private Partnerships (PPPs)** in designing, constructing, and operating major new highway systems.

Options for PPPs stretch across a spectrum of increased private responsibilities and range from transferring tasks normally done in-house to the private sector, to combining typically separate services into a single procurement or having private sector partners assume owner-like roles.

SAFETEA-LU amended the Internal Revenue Code to include highway facilities and surface freight transfer facilities among the types of privately developed and operated projects that can utilize tax-exempt **private activity bond** financing.

The FHWA has a number of initiatives underway to help remove barriers to greater private sector involvement in highway construction, operation, and maintenance. These include workshops to provide States with resources to overcome barriers to PPP implementation; development of model legislation for States to use in drafting new or more flexible State laws and regulations; the development and launch of the PPP Web site, **http://www.fhwa.dot.gov/ppp**, which contains links to many PPP resources, both domestic and international; and case studies of how States and local governments have overcome institutional barriers to PPP implementation.

CHAPTER 14: *Executive Summary*

Freight Transportation

Freight transportation enables economic activity, and trucking is a key element of freight transportation. Trucks carried 70 percent of the value and 60 percent of the tons of commodities shipped in 2002, not including shipments moved by truck in combination with another mode.

Trucking is both a critical component of the Nation's economy and a concern to the traveling public, who share increasingly crowded highways with freight-hauling vehicles. Commercial truck travel doubled over the past two decades. On one-fifth of the mileage of the Interstate Highway System, trucks account for more than 30 percent of all vehicles. Truck travel has been exceeding the growth in passenger travel over time, suggesting that the percentage of trucks in the traffic stream is likely to grow substantially if current trends continue. Freight tonnage is forecast to increase by 70 percent between 1998 and 2020, and trucking is expected to account for the majority of the projected increase.

Highway congestion affects motorists, freight carriers, and freight shippers. Shippers are affected through an increase in logistics costs made up of transportation costs, inventory costs, and order costs (involving the size and frequency of an order of goods). Slower and more unreliable transportation increases transportation costs directly, but also increases order costs and inventory costs.

A recent study for FHWA has identified over 2,000 truck bottlenecks throughout the United States, which cause more than 243 million hours of delay to truckers annually, translating into direct user costs of $7.8 billion per year. Of the four major types of bottlenecks analyzed, 227 urban freeway interchange bottlenecks accounted for an estimated 124 million truck hours of delay. Other types of bottlenecks include 859 steep grades (66 million hours of delay), 517 signalized intersections (43 million hours of delay), and 507 lane drops (11 million hours of delay).

CHAPTER 15: *Executive Summary*

Operations Strategies

Highways are traditionally viewed as transportation facilities with fixed capacity, carrying traffic that peaks with commuters twice each weekday. However, increased traffic demand does not occur just twice daily or on a predictable schedule. It can occur several times during the day and can be driven by temporary and less predictable events.

Reductions in maximum capacity caused by crashes, work zones, bad weather, and other incidents create at least as much delay as the recurring overload of traffic from commuting. This situation is especially costly to the freight transportation community and affects the economy and the American consumer.

To overcome constraints on maximum capacity and temporary capacity losses, operations strategies are a critical tool. For freeways and other major arterials, strategies include monitoring roadway conditions; detecting, verifying, responding to, and clearing incidents quickly; providing traveler information through variable message signs, 511 telephone service, and other means; implementing lane management strategies; controlling flows onto freeways with ramp meters; and restricting some facilities to high occupancy vehicles. On minor arterials and major collectors, the timing and coordination of traffic signals are essential to facilitate the flow of traffic. States and local governments are making progress in the adoption of these strategies, but much work in this area remains to be done.

Without greater attention to operations, travelers and goods moving on the Nation's highways will continue to waste many hours as a result of delay caused by recurring congestion, incidents, work zones, weather, and poor traffic control. Lives will be ruined or lost because unsafe conditions and crashes are not detected and countered in a timely fashion. Through the effective implementation of correct operations strategies, transportation system reliability, safety, and security can be improved and productivity increased.

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 point of departure for the prospective analyses contained in Part II and other sections of the report.

Chapter 1, **The Role of 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 the report.

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 Performance,** describes the safety performance of highways and transit systems.

Chapter 6, **Finance,** describes the levels and types of highway and transit expenditures made by Federal, State, and local governments and identifies the sources of revenue that support these programs.

CHAPTER 1

The Role of Highways and Transit

The Role of Highways and Transit

Highways and transit are crucial components of the U.S. public infrastructure and play vital roles in maintaining the vigor of the U.S. economy. By connecting people and places, they provide citizens with access to a wide array of economic, social, and cultural opportunities, thereby strengthening the fabric of our society. This chapter describes some of the roles that these two modes of transportation perform, including the ways that these roles complement one another, and discusses the Federal role in surface transportation in the United States.

The Role of Highway Transportation

Highways form the backbone of America's transportation system, connecting all regions and States to one another. Transporting people and goods across this network is critical to meeting the everyday needs of the Nation's people, and its effectiveness depends on inputs and investment from both public and private sectors. While most highway infrastructure in the United States is funded and maintained by the public sector, with the private sector playing a smaller but increasing role, most of the vehicles used on highways are owned and operated by private individuals and firms. This stands in contrast to freight railroads, where both vehicles and infrastructure are owned and operated by private firms, and to mass transit, which is generally provided by public agencies, either directly or through contracted private operators. Understanding this dual nature of highway travel is important in understanding how public policy affects the efficient use of the highway network.

Personal Mobility

The use of private automobiles on our large highway network provides Americans with a high degree of personal mobility. Automobile transportation allows people to travel where they want, when they want, and with whom they want. The freedom accorded by autos and highways accounts in large part for the enormous popularity of automobile travel. The 2001 National Household Travel Survey (NHTS) found that there is nearly one vehicle (0.97) for every

Q&A

Where can I go for more information on highways?

The Federal Highway Administration (FHWA) has produced or sponsored numerous reports and publications regarding surface transportation in general and Federal transportation programs in particular, including the following:

- *Financing Federal-Aid Highways*

http://www.fhwa.dot.gov/reports/finfedhy.htm

- *Highway History Web Site*

http://www.fhwa.dot.gov/infrastructure/history.htm

- *Interstate 50th Anniversary Web Site*

http://www.fhwa.dot.gov/interstate/homepage.cfm

- *Public Private Partnerships*

http://www.fhwa.dot.gov/ppp/

- *Highway Statistics*

http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm

- *Freight Transportation and Highways*

http://www.ops/fhwa.dot.gov/freight/index.cfm

- *The Federal Role in Surface Transportation—A Report of a Public Policy Forum*

ENO Transportation Foundation

December 2002

- *Title 23, United States Code, Highways*

http://www.access.gpo.gov/uscode/title23/title23.html

- *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)*

http://www.fhwa.dot.gov/safetealu/index.htm person 16 years and older in the U.S. The NHTS also found that 87 percent of daily trips were taken by personal vehicle.

Freight Movement

Highways are the keystone of the U.S. freight transportation system and the national economy supported by that system. Trucks carried 60 percent of the 19 billion tons of goods shipped in 2002 and accounted for about 70 percent of the value of freight shipments. Trucks provide direct service for both long-distance and local shipments, as well as local pickup and delivery for long-distance shipments by other modes. Trucks are playing an increasingly important role as businesses turn to just-in-time delivery systems to minimize logistics costs and improve responsiveness to customers.

The Role of Transit

Transit plays a vital role in enhancing productivity and the quality of life in the United States. It provides basic mobility and expanded opportunities to people without the use of a car, and broader transportation choices to people with cars. It also facilitates economic growth and development, and helps to support environmentally sustainable communities.

Basic Mobility and Expanded Opportunities

Transit provides basic mobility to people with limited incomes and without cars. The 2001 NHTS found that 43 percent of nationwide 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 job and educational opportunities, and access health care and other vital services. It also enables them to be more active members of their communities and to build and maintain social relationships with family and friends.

Broader Transportation Choices

Many of the people who use transit are choice riders. These people come from households that own cars, but use transit because it offers a more convenient, reliable, and less expensive transportation alternative. These people may live in a densely developed area with highly accessible and frequent transit service or in a suburb with a transit system providing a cheaper, more comfortable, or more convenient way of traveling to and from a downtown city center or central business district.

Economic Growth and Development

Transit plays a key role in economic growth and development, connecting workers and employers. Dense business and commercial centers in the Nation's largest cities depend on transit to move large numbers of people during peak travel periods. Corridors with well-functioning transit systems attract business, retailers, restaurants, and theaters and encourage higher-density development.

Q&A

Where can I go for more information on transit?

The Federal Transit Administration (FTA) produces and sponsors numerous reports and publications on transit issues, including the following:

- *Annual Report on New Starts*

http://www.fta.dot.gov/planning/newstarts/planning_environment_2618.html

- *Statistical Summaries-Grants Assistance Programs*

http://www.fta.dot.gov/funding/data/grants_financing_1090.html

- *National Transit Summaries and Trends*

http://www.ntdprogram.com/ntdprogram/pubs.htm

- *The Transit Performance Monitoring System*

http://www.fta.dot.gov/publications/reports/publications_5677.html

- Title 49, United States Code, Section 53, Mass Transportation

http://www.access.gpo.gov/uscode/title49/subtitleiii_chapter53_.html

The Environment, Security, and Safety

Transit can help to protect the environment and conserve energy. Each trip that is shifted from a car to a transit vehicle in operation helps to reduce automotive emissions and meet local air quality goals. Transit can also play a key role in emergency situations by helping to evacuate people and provide temporary shelters. Transit is a very safe mode of transport so that transit use promotes overall transportation safety.

The Complementary Roles of Highways and Transit

Highways and transit are complementary, serving distinct but overlapping markets in the Nation's transportation system. Transit provides basic mobility to riders for whom car ownership is not a viable option, while highways are vital for people and firms in areas that are not well served by transit. Others may choose between transit and highway travel based on a variety of factors, including cost, travel time, flexibility, and convenience. These choices may vary, even for the same individual, based on the timing or purpose of the trip. It is clear, however, that the needs of all citizens are best served by access to both high-quality transit and high-quality highways.

Investment in highways and transit expands people's travel choices and allows them to use the modes of transportation that best meet their needs. A high-quality transit system gives people who prefer living in a dense, urban environment the opportunity to do so without sacrificing their mobility. An adequate highway network does the same for people who prefer a suburban or rural lifestyle. Highways provide a principal means of intercity passenger travel, particularly on shorter trips that are not well served by air transportation. Transit and highways both provide ground-side access to airports. Since most shipments in the Nation are bound for final destinations that are accessible only by roads, adequate highway transportation to and from ports and intermodal terminals is essential for freight movement, even for many shipments carried primarily by air, water, or rail.

Q&A

How are tradeoffs and complementarities between highway and transit handled in the investment analyses found in this report?

While the complementary and alternative roles that highways and transit play in our surface transportation system are relatively easy to identify, they are much more difficult to quantify analytically. The investment analyses presented later in this report are based on separate methodologies for highways and transit. Multimodal analysis issues, and the challenges that FHWA and FTA face in attempting to develop an integrated approach to modeling transit and highway investments, are discussed in the Introduction to Part II and in the Afterword found in Part IV of this report.

Highway investment benefits both transit operations and auto users. Buses, vanpools, and demand response services typically share roadways with private autos and, hence, are affected by highway pavement and traffic conditions. Conversely, transit improvements can attract private vehicle drivers, freeing up road capacity. Transit can also increase the effectiveness of highways by encouraging and supporting carpooling, and serving as a backup mode for riders in both formal and informal arrangements on occasions when carpools don't meet their needs.

Highway investment can support transit usage and help improve operating efficiency. An area served by both a good road network and good transit service is likely to be more attractive to firms than one served by transit or highways alone, and can thus encourage development served by transit. Good highway access to

Trends in Travel Behavior Observed from the National Household Travel Survey (NHTS) Data Series (1969, 1977, 1983, 1990, 1995, 2001)

The National Household Travel Survey (NHTS) is the nation's inventory of personal travel. The survey collects demographics on households and people, detailed information on daily and long-distance trips for all purposes, use of household vehicles, and public attitudes about various transportation issues.

Trip Making No Longer Growing

Average daily person trips per person grew from 2.0 in 1969 to 4.3 in 1995, but declined slightly to 4.1 in 2001. Daily vehicle trips per driver show a similar pattern.

Trip Lengths Increasing

Average vehicle trip lengths had remained in the 8- to 9-mile range between 1969 and 1995, but increased to 9.9 miles in 2001.

Time Spent Driving on the Rise

The time spent driving increased by just over a minute per year during the last decade. American drivers now spend more than an hour (61 minutes) behind the wheel in an average day. While congestion worsened over that period, some of that additional time was spent in traveling additional miles. While driving time increased 24 percent, average daily miles per driver increased by 15 percent over the same period (1990-2001).

Other Types of Trips Growing Faster than Commuting

Commuting to and from work continues to decrease as a proportion of all travel, not because fewer people are working but because trip-making for other purposes is growing faster. These other types of trips include shopping, family errands, dining out, household maintenance, and social and recreational activities. Because of the long lengths of commutes, however, work trips represent a high percentage of the total miles traveled.

More Midday Trips

While peak periods continue to be congested, and have lengthened as workers leave earlier or later to avoid the most congested times, the biggest change during the week has been the significant increase in midday travel. More vehicle trips are now taken midday on Saturday than during any peak hour during the week (except Friday evening).

Vehicle Ownership on the Rise

In the 1983, 1990, and 1995 surveys, the number of household vehicles and the number of licensed drivers were almost the same. By 2001, almost 9 million households were without a vehicle, but over 22.7 million U.S. households, or 21.2 percent, had more vehicles than drivers, resulting in 12 million more vehicles than licensed drivers.

Vehicle Occupancy Rates Have Stabilized

The huge growth in vehicle ownership and the changes in the mix of trip purposes resulted in a steady decline from 1969 in average vehicle occupancy of 2.2 person miles per vehicle mile. However, the figure remained consistent at 1.6 person miles per vehicle mile in 1995 and 2001.

Transit Principally Serves Those with Easy Access

In 2001, 65 percent of transit passengers using transit as their primary mode of travel were able to access transit within 5 minutes of starting their trip.

Many Transit Trips Made by People Without Cars

In 2001, 44 percent of the people who used transit for their principal mode of travel on their day trip were from households without cars.

Transit's Importance to People with Limited Incomes

In 2001, 43 percent of all transit users lived in households with incomes of less than $20,000.

The 2001 NHTS report may be found at http://nhts.ornl.gov/2001/index.shtml.

transit stations in outlying areas, coupled with sufficient parking capacity, 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 transit modes. According to the 2001 NHTS, over 3.4 billion vehicle trips are made annually to access other modes of transportation.

The Evolving Federal Role in Highways and Transit

Well-maintained and functioning highway and transit networks are fundamental to America's economic growth and well-being. Over its history, the United States has demonstrated a long-standing public commitment to highways and transit. State and local governments and businesses are full partners with the Federal government in the development and operation of the Nation's transportation system. The Federal government's role is to balance diverse needs and interests in order for the transportation concerns facing the Nation as a whole to be systematically and cohesively addressed. The Federal government has played a key role in shaping the transportation system, both in regulating interstate commerce and in funding and facilitating transportation improvements. This role has evolved over the years to meet changing needs and priorities. One thing that remains constant, however, is the importance of national leadership—in short-term and long-term transportation decision-making that transcends state boundaries, in ensuring that America's transportation infrastructure supports and enhances our position in the global economy, and in advancing the state-of-the-art technology and practices through high-risk research.

As mandated by law, the Federal-aid highway program is a Federally assisted, State administered program. Federal, State, and local transportation partners work together to deliver the Nation's highway program.

As State and local expertise has developed, Congress has increased statutory authority for States to assume certain Federal-aid highway project oversight responsibilities, where appropriate. This in turn frees up Federal resources for programmatic stewardship, research, and deployment of new technologies and methods. As mandated by law, the Federal transit program is a Federally assisted and administered grant program, operated through a program of formula and discretionary grants to urban areas and, through States, to rural communities. As grantee experience has developed, the focus of the Federal government has shifted from the formula to the discretionary programs. The New Starts Program, providing funds to metropolitan areas for the construction of new fixed guideway systems or extensions to existing systems, is the largest FTA discretionary program. The FTA works closely with grantees to ensure that these projects meet a full range of criteria for both project justification and local financial commitment. The FTA also evaluates projects from their initial consideration to final grant award, and continues to monitor them through construction and operation.

To meet the Nation's increasing, and increasingly complex, transportation infrastructure needs and demands, FHWA and FTA continue to explore innovations in financing and technology. For example, the Highways for LIFE Pilot Program is designed to help States deliver and deploy innovative technologies, manufacturing processes, performance standards, and business practices in the highway construction process to improve quality and safety and to reduce congestion associated with work zones. Financial innovation is increasingly focusing on the potential role of the private sector in transportation infrastructure innovation and investment. Leveraging Federal investments through public-private partnerships (including joint development around transit stations), other innovative financing techniques, value pricing and high-occupancy toll (HOT) lanes are a few of the initiatives that will expedite project completion, produce cost savings, and improve system performance. These new financing options are discussed in greater detail in Chapter 15 of this report.

The FHWA and FTA provide leadership and expertise to States in transportation planning to ensure that transportation decisions are made in an environmentally sensitive way, using a comprehensive planning process that includes the public and considers land use, development, safety, and security. National leadership is also provided in asset management principles. Asset management is a systematic approach to maintaining, upgrading, and operating physical assets cost-effectively, and provides a framework for handling both short- and long-range planning decisions. The FHWA also provides leadership in establishing national standards for intelligent transportation system (ITS) technology, preventing fuel tax evasion, facilitating the flow of goods at borders and trade gateways, and building and maintaining roads on Federal lands.

The FTA has developed the Lessons Learned Program to increase the effectiveness of transit capital investment by facilitating a way for transit operators to share their experiences in undertaking these projects. This program is part of FTA's Project Management Oversight Program, which actively oversees capital investment projects receiving FTA funds to ensure that they are on time, within budget, conform to the grantee's approved plans and specifications, and are efficiently and effectively implemented.

This report focuses on the infrastructure quality and operating characteristics of highways (and their component bridges) and transit (including buses and urban rail). These two modes are closely linked in their function and funding sources. The FHWA and FTA work closely with each other, other Federal, State, and local agencies, and other partners to maximize the benefits of the public investment in highways and transit, and to prepare to meet America's future transportation needs.

CHAPTER 2

System Characteristics

Summary

Exhibit 2-1 summarizes the key findings in this chapter, comparing system and use characteristics data in this report with the 2002 values shown in the 2004 Conditions and Performance (C&P) Report. Some of the 2002 values have subsequently been revised, which is reflected in the second column as appropriate. The third column contains comparable values based on 2004 data.

Exhibit 2-1

Comparison of System and Use Characteristics with Those in the 2004 C&P Report

Statistic	2002 Data: 2004 C&P Report	2002 Data: Revised	2004 Data
Percentage of Total Highway Miles Owned by Local Governments	77.5%		76.5%
Percentage of Total Highway Miles Owned by State Governments	19.5%		20.4%
Percentage of Total Highway Miles Owned by the Federal Government	3.0%		3.1%
Local Transit Operators in Urbanized Areas	610		640
Rural and Specialized Transit Service Providers	6,051		6,051
Total Rural Highway Miles (Population under 5,000)	3.08 million		3.00 million
Total Urban Highway Miles (Population equal to or above 5,000)	0.90 million		0.99 million
Total Highway Miles	3.98 million		3.99 million
Transit Route Miles (Rail)	9,484		9,782
Transit Route Miles (Nonrail)	225,820		216,620
Total Transit Route Miles	235,304		226,402
Total Rural Highway Lane Miles (Population under 5,000)	6.31 million		6.15 million
Total Urban Highway Lane Miles (Population equal to or above 5,000)	2.02 million		2.23 million
Total Highway Lane Miles	8.33 million		8.37 million
Urban Transit Capacity-Equivalent Miles (Rail)	2.18 billion	2.27 billion	2.41 billion
Urban Transit Capacity-Equivalent Miles (Nonrail)	2.03 billion	2.04 billion	2.06 billion
Urban Transit Capacity-Equivalent Miles (Total)	4.21 billion	4.31 billion	4.48 billion
Vehicle Miles Traveled on Rural Highways (Population under 5,000)	1.13 trillion		1.07 trillion
Vehicle Miles Traveled on Urban Highways (Population equal to or above 5,000)	1.74 trillion		1.91 trillion
Vehicle Miles Traveled on All Highways	2.87 trillion		2.98 trillion
Transit Passenger Miles (Rail)	24.6 billion		25.7 billion
Transit Passenger Miles (Nonrail)	21.3 billion		20.9 billion
Transit Passenger Miles (Total)	45.9 billion		46.5 billion

Highway

There were almost 4 million miles of public roads in the United States in 2004, of which 3.0 million miles were in rural areas (rural areas are defined as locations with less than 5,000 people, and urban communities are defined as those areas with 5,000 or more people). Local governments controlled 76.5 percent of total highway miles in 2004; States controlled 20.4 percent; and the Federal government owned 3.1 percent. Hence, the Nation's highway system is overwhelmingly *rural* and *local.*

Total highway lane mileage was almost 8.4 million in 2004. Total lane miles have increased at an average annual rate of about 0.2 percent since 1995, mostly in urban areas. Urban lane mileage grew to more than 2.2 million by 2004, while rural lane mileage decreased to nearly 6.2 million.

The total number of vehicle miles traveled (VMT) between 1995 and 2004 maintained the same growth rate, an average annual rate of 2.5 percent, as for the period from 1993 to 2002 as presented in the previous C&P report. Approximately 1.1 trillion VMT were on rural highways with 1.9 trillion VMT on urban roads. The total VMT in rural areas decreased from 2002 to 2004 by 0.06 trillion VMT. Total traffic increased in metropolitan areas by 0.17 trillion VMT between 2002 and 2004.

> **Q&A**
>
> **Is the increase in urban lane mileage entirely due to new construction?**
>
> No. While some of the additional lane miles are attributable to new road construction or the widening of existing roads, a significant percentage is attributable to functional reclassification due to population growth and the adjustment of urban boundaries due to the results of the 2000 census.
>
> As urban boundaries have expanded to encompass areas formerly classified as rural, the mileage within those boundaries has been reclassified as small urban mileage. The same situation has occurred as urbanized area boundaries have expanded to subsume areas that were formerly classified as rural or small urban.
>
> Since the 2000 census, States have been gradually updating their reported mileage data in the Highway Performance Monitoring System (HPMS) to reflect these new urban boundaries.

Bridge

There were 594,101 bridges in excess of 6 meters (20 feet) in total length on public roads in the United States in 2004. While 76.8 percent of bridges are located in rural areas, 72.6 percent of the daily traffic on bridges is carried by the urban structures. Responsibility for and ownership of bridges is split primarily between State agencies (47.6 percent) and local governments (50.6 percent). Federal agencies own less than 8,500 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 higher functional classifications, such as principal arterials; the majority of local government bridges are located on local and collector roadways.

> **Q&A**
>
> **Are the 2004 HPMS data cited in this report fully consistent with those reported in the *Highway Statistics 2004* publication?**
>
> The data reflected in this report represent the latest available HPMS data as of the date the chapters were written. As the data submitted by the States are reviewed for omissions or inconsistencies, revisions are submitted by the States to correct these items. The statistics presented in this report are not fully consistent with comparable information presented in the *Highway Statistics 2004* publication, since certain States have subsequently revised their data. The HPMS database is subject to further change 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 on the following Web site: http://www.fhwa.dot.gov/policy/ohpi/hpms/index.htm

Transit

Transit system coverage, capacity, and use in the United States continued to increase between 2002 and 2004. In 2004, there were 640 transit operators serving urbanized areas compared with 610 operators in 2002. In 2002, the most recent year for which information is available, there were an estimated 4,836 providers of special service transit services to the elderly and disabled in both urban and rural areas. In 2000, the most recent year for which information is available, there were 1,215 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 2004, transit agencies in urban areas operated 120,659 vehicles, of which 92,520 were in areas of more than 1 million people. Rail systems had 10,892 miles of rail track and 2,961 rail stations, compared with 10,722 miles of track and 2,862 stations in 2002. The number of bus and rail maintenance facilities in urban areas increased from 769 in 2002 to 793 in 2004, and the number of stations increased from 2,862 in 2002 to 2,961 in 2004. The most recent survey of rural transit operators, undertaken in 2000, estimated that 19,185 transit vehicles operated in rural areas; the Federal Transit Administration (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 2004, transit systems operated 226,402 directional route miles, of which 216,620 were nonrail and 9,782 were rail route miles. Total route miles decreased in total by 3.8 percent between 2002 and 2004. Nonrail route miles decreased by 4.1 percent, and rail route miles increased by 3.1 percent.

Transit system capacity as measured by capacity-equivalent vehicle revenue miles (VRM) increased by 3.9 percent in total between 2002 and 2004. 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 6.1 percent between 2002 and 2004 in total, and the capacity of nonrail modes by 1.3 percent. In 2004, 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 2002 and 2004, reflecting New Starts openings and extensions, increasing in total by 19.3 percent.

Transit passenger miles increased by 1.3 percent in total between 2002 and 2004, from 45.9 billion to 46.5 billion. Passenger miles traveled on nonrail modes decreased from 21.3 billion in 2002 to 20.9 billion in 2004, or by total of 2.1 percent. Passenger miles on rail transit modes increased in total by 4.3 percent, from 24.6 billion in 2002 to 25.7 billion in 2004.

Highway System Characteristics

Highways are typically classified by either *ownership* or *purpose,* a distinction used in previous editions of the C&P report. Ownership can be determined by which jurisdiction has primary responsibility over a particular portion of the infrastructure, while purpose and level of service are identified by the item's function. This section presents highway miles by jurisdiction as well as system and use characteristics by functional classification.

Highways by Ownership

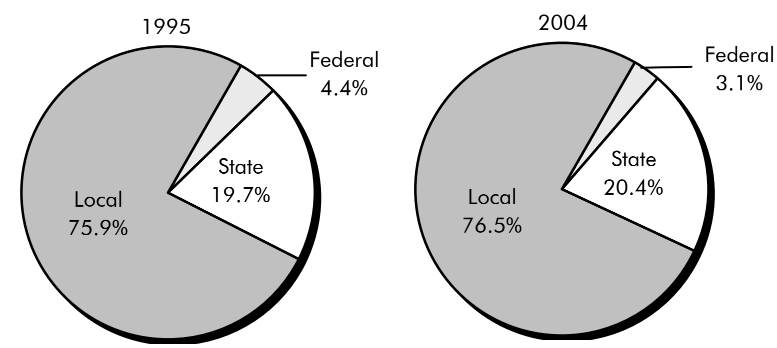
Ownership is largely split among the Federal, State, and local governments. Roads owned by these governments are considered "public." States own almost 20 percent of the Nation's public road mileage. The Federal government has control over about 3 percent, primarily in National parks and forests, on Indian reservations, and on military bases.

In 2004 over 76 percent of American roads were locally owned, although some intergovernmental agreements may authorize States to construct and maintain locally owned highways. Approximately 1,050 counties in the United States had at least 1 mile of public roads owned by the Federal Government. Most of these counties are in the Western United States.

As *Exhibit 2-2* demonstrates, the share of locally owned roads has shown slight growth over the past decade. The share of local public road mileage increased from 75.9 to 76.5 percent between 1995 and 2004. During that same period, the share of State-owned public road mileage grew slightly, from 19.7 to 20.4 percent.

Exhibit 2-2

Highway Mileage by Owner, 1995 and 2004



Source: Highway Performance Monitoring System.

The Federally owned public road mileage has declined from 1995 to 2004 from 4.4 to 3.1 percent. 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, until reaching the current 3.1 percent in 2004. As noted in the previous C&P report, much of the change occurred as the result of Federal land management agencies reclassifying some of their mileage from public to nonpublic status.

Highways by Ownership and Size of Area

Highway mileage in urban areas has continued to increase in recent years, accompanied by a decrease in rural mileage. This is depicted in *Exhibit 2-3,* which shows that total mileage in small urban areas grew by

Exhibit 2-3

Highway Mileage by Owner and by Size of Area, 1995–2004

	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural Areas (under 5,000 in population)						
Federal	170,574	167,368	116,707	117,775	118,866	-3.9%
State	660,666	661,473	663,763	664,814	683,789	0.4%
Local	2,259,064	2,280,042	2,308,842	2,295,006	2,200,786	-0.3%
Subtotal Rural	**3,090,304**	**3,108,883**	**3,089,312**	**3,077,595**	**3,003,441**	-0.3%
Small Urban Areas (5,000–49,999 in population)						
Federal	494	482	458	980	723	4.3%
State	27,442	27,455	27,596	27,639	30,719	1.3%
Local	139,825	143,848	148,094	154,869	155,406	1.2%
Subtotal Small Urban Areas	**167,761**	**171,785**	**176,148**	**183,488**	**186,848**	1.2%
Urbanized Areas (50,000 or more in population)						
Federal	982	980	1,026	1,840	2,847	12.6%
State	83,016	83,428	83,944	84,135	101,881	2.3%
Local	574,319	587,426	597,837	632,025	702,446	2.3%
Subtotal Urbanized Areas	**658,317**	**671,834**	**682,807**	**718,000**	**807,173**	2.3%
Total Highway Miles						
Federal	172,050	168,830	118,191	120,595	122,436	-3.7%
State	771,124	772,356	775,303	776,588	816,388	0.6%
Local	2,973,208	3,011,316	3,054,773	3,081,900	3,058,638	0.3%
Total	**3,916,382**	**3,952,502**	**3,948,267**	**3,979,083**	**3,997,462**	0.2%
Percent of Total Highway Miles						
Federal	4.4%	4.3%	3.0%	3.0%	3.1%	
State	19.7%	19.5%	19.6%	19.5%	20.4%	
Local	75.9%	76.2%	77.4%	77.5%	76.5%	
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	

Source: Highway Performance Monitoring System.

an average annual rate of 1.2 percent between 1995 and 2004. In larger urbanized areas, 50,000 or greater in population, the annual growth was 2.3 percent between 1995 and 2004. In rural areas, however, highway mileage decreased at an average annual rate of 0.3 percent over the same time period.

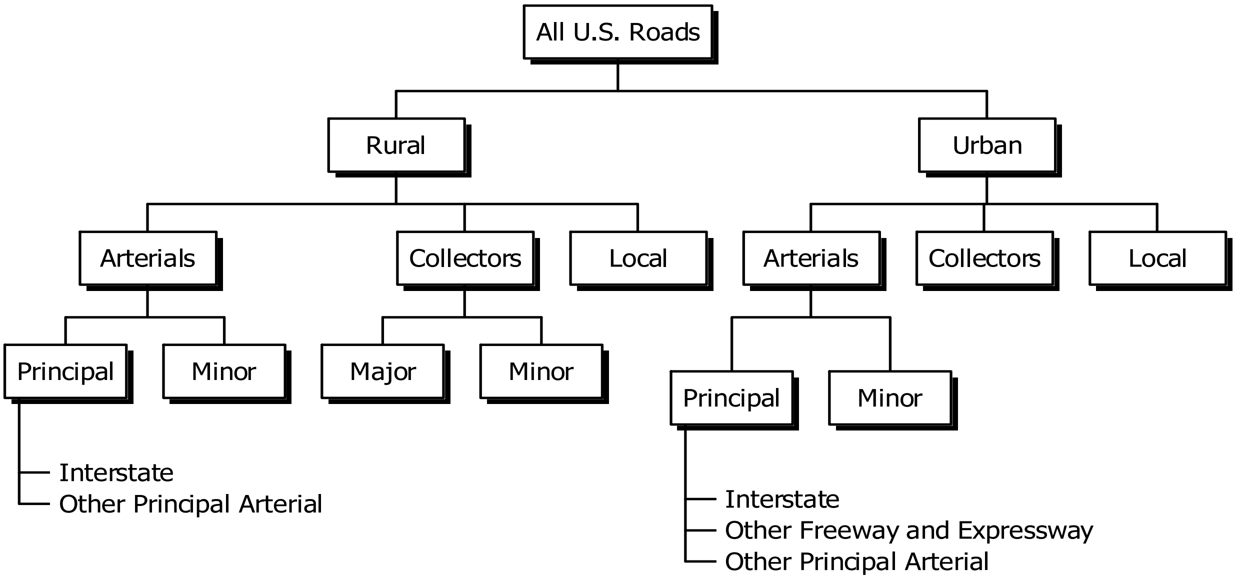
Two factors have contributed to the apparent increase in urban highway mileage, in addition to the construction of new roads. First, the redefinition of urban boundaries based on the 2000 decennial census has resulted in an expansion of urban areas, and thus has moved some rural mileage into urban areas. Also, the FHWA has recently focused on achieving a more complete reporting of highways owned by Federal agencies that are not primarily transportation oriented. The result has been a significant increase in the Federal mileage in urban areas shown in Exhibit 2-3.

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 2-4* shows the hierarchy of the HFCS pictorially.

Exhibit 2-4

Highway Functional Classification Hierarchy



Review of Functional Classification Concepts

The overarching principle of functional classification is interconnectedness or system. That is, 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).

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

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 network provides interstate and intercounty service so that all developed areas are within a reasonable distance of an arterial highway. This network 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 network is divided into two subgroups, Interstate highways and other principal arterials.**

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 network 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.

Functional Classification Data

Exhibit 2-5 summarizes the *percentage* of highway miles, lane miles, and VMT stratified by functional system. The share of mileage on rural systems declined from 2002 to 2004 from 77.3 to 75.1 percent, a trend shown earlier in Exhibit 2-3. The share of lane miles on rural highways also decreased during this same period of time, from 75.7 to 73.4 percent and the share of VMT in rural areas decreased from 39.4 percent to 35.9 percent. These declines are due, in large part, to the results of urban boundary changes based on the results of the 2000 census.

The share of urban mileage, for both small urban and urbanized areas, increased between 2002 and 2004, from 22.6 to 24.9 percent. Total lane mileage for both types of urban areas also increased, from 24.3 to 26.6 percent. The share of VMT in small urban and urbanized areas increased from 60.6 percent to 64 percent from 2002 to 2004

In 2004, the rural Interstate and the rural other principal arterial systems accounted for approximately 0.8 percent and 2.4 percent of total miles in the United States, respectively, while carrying 9.0 percent and 8.1 percent, respectively, of total travel. These two systems carried a total of 47.5 percent of all rural travel (rural Interstate—25 percent, rural other principal arterials—22.5 percent). Rural minor arterials represented 3.4 percent of total U.S. miles but carried 5.7 percent of total travel in the United States, or 15.8 percent of rural travel.

Exhibit 2-5

Percentage of Highway Miles, Lane Miles, and VMT by Functional System and by Size of Area, 2004

Functional System	Miles	Lane Miles	VMT
Rural Areas (under 5,000 in population)			
Interstate	0.8%	1.5%	9.0%
Other Principal Arterial	2.4%	3.0%	8.1%
Minor Arterial	3.4%	3.4%	5.7%
Major Collector	10.5%	10.1%	6.7%
Minor Collector	6.7%	6.4%	2.0%
Local	51.3%	49.0%	4.4%
Subtotal Rural	**75.1%**	**73.4%**	**35.9%**
Small Urban Areas (5,000–49,999 in population)			
Interstate	0.1%	0.1%	0.9%
Other Freeway and Expresswa	0.0%	0.1%	0.3%
Other Principal Arterial	0.3%	0.5%	2.1%
Minor Arterial	0.5%	0.5%	1.4%
Collector	0.6%	0.6%	0.7%
Local	3.2%	3.0%	1.1%
Subtotal Small Urban Area	**4.7%**	**4.8%**	**6.5%**
Urbanized Areas (50,000 or more in population)			
Interstate	0.3%	0.9%	14.6%
Other Freeway and Expresswa	0.2%	0.5%	6.7%
Other Principal Arterial	1.2%	2.0%	13.2%
Minor Arterial	2.0%	2.5%	10.9%
Collector	2.0%	2.0%	4.8%
Local	14.5%	13.9%	7.5%
Subtotal Urbanized Areas	**20.2%**	**21.8%**	**57.5%**
Total	**100.0%**	**100.0%**	**100.0%**

Source: Highway Performance Monitoring System.

During 2004 the urban Interstate and the urban other freeway and expressway systems comprised slightly less than 1.6 percent of the total highway lane-miles in the Nation. These two systems carried approximately 22.5 percent of the total travel in the Nation and 35 percent of the total VMT in small urban and urbanized areas. The small urban and urbanized minor arterial networks represented 3.0 percent of total U.S. lane-miles. This system carried 19.1 percent of total travel for the Nation, or 12.3 percent of urban travel.

Rural major collectors accounted for 10.1 percent of total U.S. lanes-miles in 2004. They carried 6.7 percent of total travel, in the United States, or 18.8 percent of rural travel. The rural minor collector system accounted for 6.4 percent of total U.S. lane-miles in 2004. These roads carried 2.0 percent of total travel, in the United States, or 5.6 percent of rural travel.

Q&A

Does the decrease in rural lane mileage signify roadway abandonment?

Public road mileage rarely is abandoned. Rural mileage near metropolitan areas is routinely functionally reclassified as urban mileage as urban boundaries expand, resulting in a decrease in the rural mileage without an abandonment of any roadway. The results of the 2000 census have caused many urban boundaries to expand, thereby removing amounts of highway mileage from the rural category and reclassifying it as urban in the HPMS database. This change does not occur immediately as the individual States do not complete their adjustments at the same time and therefore submit their new data over a period of time. The majority of mileage adjustments in the rural and urban categories associated with the 2000 census appears in this edition of the C&P report.

In 2004, the small urban and urbanized collector networks accounted for 2.6 percent of U.S. lane-miles but carried 5.5 percent of total travel, in the United States, or 8.6 percent of urban travel.

In 2004, rural local roads represented 49.0 percent of total U.S. lane-miles. This is a decrease from 52.9 percent from 2002. Local roads carried only 4.4 percent of total travel, in the United States, or only 7.8 percent of rural travel. Roads classified as local roads in small urban areas, 5,000 to 49,999 population, and local roads in urbanized areas, 50,000 or more in population, accounted for 16.9 percent of total lane-miles in the Nation for the year 2004, an increase from 16.2 percent in 2002. The functional classification local roads in the small urban and urbanized areas carried approximately 8.6 percent of total travel, in the United States, or 3.5 percent of urban travel.

Exhibit 2-6 shows the total public road route mileage in the United States. In 2004, there were slightly more than 3.99 million route miles in the United States. Approximately 75.1 percent of this mileage, or just over 3 million route miles, was in rural areas. The remaining 24.9 percent of route mileage, or approximately 994,000 miles, was in urban communities. Overall route mileage increased by an average annual rate of

Exhibit 2-6

Highway Route Miles by Functional System and by Size of Area, 1995–2004

Functional System	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural Areas (under 5,000 in population)						
Interstate	32,703	32,919	33,152	33,107	31,477	-0.4%
Other Principal Arterial	98,039	98,358	99,023	98,945	95,998	-0.2%
Minor Arterial	137,440	137,791	137,863	137,855	135,683	-0.1%
Major Collector	432,492	433,500	433,926	431,754	420,293	-0.3%
Minor Collector	274,750	273,043	272,477	271,371	268,088	-0.3%
Local	2,125,054	2,141,111	2,115,293	2,106,725	2,051,902	-0.4%
Subtotal Rural	**3,100,478**	**3,116,722**	**3,091,733**	**3,079,757**	**3,003,441**	-0.4%
Small Urban Areas (5,000–49,999 in population)						
Interstate	1,731	1,744	1,794	1,808	2,088	2.1%
Other Freeway and Expressway	1,282	1,253	1,219	1,227	1,218	-0.6%
Other Principal Arterial	12,432	12,477	12,474	12,590	13,532	0.9%
Minor Arterial	19,538	19,635	19,800	19,926	19,956	0.2%
Collector	21,301	21,338	21,535	21,813	23,706	1.2%
Local	111,566	115,420	119,342	126,140	126,348	1.4%
Subtotal Small Urban Areas	**167,850**	**171,867**	**176,163**	**183,503**	**186,848**	1.2%
Urbanized Areas (50,000 or more in population)						
Interstate	11,569	11,651	11,729	11,832	13,270	1.5%
Other Freeway and Expressway	7,740	7,864	7,977	8,150	9,087	1.8%
Other Principal Arterial	40,622	40,993	41,084	41,090	46,556	1.5%
Minor Arterial	69,475	70,050	70,502	70,996	78,491	1.4%
Collector	66,623	67,312	67,263	68,033	79,680	2.0%
Local	462,537	474,044	484,650	518,309	580,088	2.5%
Subtotal Urbanized Areas	**658,566**	**671,914**	**683,205**	**718,409**	**807,173**	2.3%
Total Highway Route Miles	**3,926,894**	**3,960,503**	**3,951,101**	**3,981,670**	**3,997,462**	**0.2%**

Source: Highway Performance Monitoring System.

about 0.2 percent between 1995 and 2004. On an average annual basis, mileage decreased by 0.4 percent in rural America and increased at an average annual rate of 1.2 percent in small urban communities and in urbanized areas at an average annual rate of 2.3 percent from 1995 to 2004.

Exhibit 2-7 shows the number of highway lane miles by functional system. In 2004, there were 8.3 million lane miles in the United States. Lane miles have grown at an average annual rate of about 0.2 percent since 1995, mostly in urban areas (lane mileage in rural areas having decreased overall by 0.3 percent per year during the same time period). In small urban areas (those with between 5,000 and 49,999 residents) lane miles grew at 1.2 percent while in urbanized areas (those with 50,000 or more residents), lane miles grew at 2.2 percent annually between 1995 and 2004. **It must be noted that part of the increase in mileage in small urban and urbanized areas is the result of the expansion of the boundaries of these areas due to the results of the 2000 census, rather than to the construction of new roads.**

Exhibit 2-7

Highway Lane Miles by Functional System and by Size of Area, 1995–2004

Functional System	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural Areas (under 5,000 in population)						
Interstate	132,346	133,573	135,000	135,032	128,012	-0.4%
Other Principal Arterial	245,164	248,921	253,586	256,458	249,480	0.2%
Minor Arterial	288,222	288,872	287,750	288,391	283,173	-0.2%
Major Collector	872,767	875,393	872,672	868,977	845,513	-0.4%
Minor Collector	549,500	546,085	544,954	542,739	536,177	-0.3%
Local	4,250,107	4,282,222	4,230,588	4,213,448	4,103,804	-0.4%
Subtotal Rural	**6,338,106**	**6,375,066**	**6,324,550**	**6,305,044**	**6,146,159**	-0.3%
Small Urban Areas (5,000–49,999 in population)						
Interstate	7,269	7,365	7,626	7,776	8,890	2.3%
Other Freeway and Expressway	4,828	4,747	4,627	4,685	4,754	-0.2%
Other Principal Arterial	37,135	37,618	37,806	38,275	41,015	1.1%
Minor Arterial	44,390	44,982	45,212	45,682	45,335	0.2%
Collector	43,755	44,216	44,525	45,095	48,977	1.3%
Local	223,132	230,839	238,684	252,279	252,697	1.4%
Subtotal Small Urban Areas	**360,509**	**369,767**	**378,482**	**393,793**	**401,667**	1.2%
Urbanized Areas (50,000 or more in population)						
Interstate	64,865	65,603	67,020	68,088	75,127	1.6%
Other Freeway and Expressway	35,705	36,655	37,428	38,782	43,016	2.1%
Other Principal Arterial	143,572	146,585	149,224	150,250	169,491	1.9%
Minor Arterial	183,595	185,273	184,199	187,512	205,434	1.3%
Collector	143,517	145,927	145,313	147,020	171,201	2.0%
Local	925,073	948,087	969,300	1,036,619	1,160,175	2.5%
Subtotal Urbanized Areas	**1,496,327**	**1,528,130**	**1,552,484**	**1,628,271**	**1,824,444**	**2.2%**
Total Highway Lane Miles	**8,194,942**	**8,272,963**	**8,255,516**	**8,327,108**	**8,372,270**	**0.2%**

Source: Highway Performance Monitoring System.

Highway Travel

This section describes highway infrastructure use, which is typically defined by VMT. During the 1990s, Americans traveled at record levels, a phenomenon prompted by the booming economy, population growth, and other socioeconomic factors. As *Exhibit 2-8* shows, VMT grew by an average annual rate of 2.3 percent between 1995 and 2004. By the end of that period, Americans were traveling almost 3.0 trillion vehicle miles annually. Approximately 1.1 trillion vehicle miles were on rural highways, and 1.9 trillion vehicle miles were on urban roads.

Exhibit 2-8

Vehicle Miles Traveled (VMT) and Passenger Miles Traveled (PMT), 1995–2004

(Millions of Miles) Functional System	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural Areas (under 5,000 in population)						
Interstate	224,705	241,451	269,533	281,461	267,397	2.0%
Other Principal Arterial	215,988	229,133	249,177	258,009	241,282	1.2%
Minor Arterial	156,253	164,129	172,772	177,139	169,168	0.9%
Major Collector	194,420	202,588	210,595	214,463	200,926	0.4%
Minor Collector	50,386	52,809	58,183	62,144	60,278	2.0%
Local	105,819	113,248	127,560	139,892	132,474	2.5%
Subtotal Rural	**947,571**	**1,003,358**	**1,087,820**	**1,133,107**	**1,071,524**	1.4%
Small Urban Areas (5,000–49,999 in population)						
Interstate	17,310	18,393	21,059	22,578	25,784	4.5%
Other Freeway and Expressway	8,854	9,251	9,892	10,442	10,245	1.6%
Other Principal Arterial	53,202	55,359	58,170	59,490	61,426	1.6%
Minor Arterial	39,270	40,845	43,035	44,566	41,961	0.7%
Collector	18,710	19,749	20,412	21,492	21,761	1.7%
Local	27,970	30,368	33,277	34,241	33,439	2.0%
Subtotal Small Urban Areas	**165,317**	**173,965**	**185,845**	**192,808**	**194,616**	1.8%
Urbanized Areas (50,000 or more in population)						
Interstate	327,329	346,376	376,116	389,903	433,982	3.2%
Other Freeway and Expressway	141,980	151,231	168,293	180,199	198,840	3.8%
Other Principal Arterial	313,676	332,448	343,186	351,436	392,442	2.5%
Minor Arterial	251,470	263,296	283,854	297,393	323,846	2.9%
Collector	104,453	111,874	116,596	122,129	142,569	3.5%
Local	179,392	176,268	202,774	207,480	224,178	2.5%
Subtotal Urbanized Areas	**1,318,300**	**1,381,495**	**1,490,819**	**1,548,540**	**1,715,857**	3.0%
Total VMT	**2,431,188**	**2,558,818**	**2,764,484**	**2,874,455**	**2,981,998**	**2.3%**
Total PMT	**3,868,070**	**4,089,366**	**4,390,076**	**4,667,038**	**4,832,394**	**2.5%**

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

While highway mileage is mostly rural, a majority of highway travel (almost 64 percent) occurred in urban areas in 2004. In the 2004 C&P report it was noted that rural travel had grown faster than urban over the period from 1993 to 2002; however, in looking at the period from 1995 to 2004, that trend has reversed. The average annual rate of change for rural travel was 1.4 percent between 1995 and 2004. For the same period the average annual rate of change in small urban areas was 1.8 percent and for urbanized areas the rate was 2.9 percent. **Again, it must be noted, the portions of these increases are the result of the**

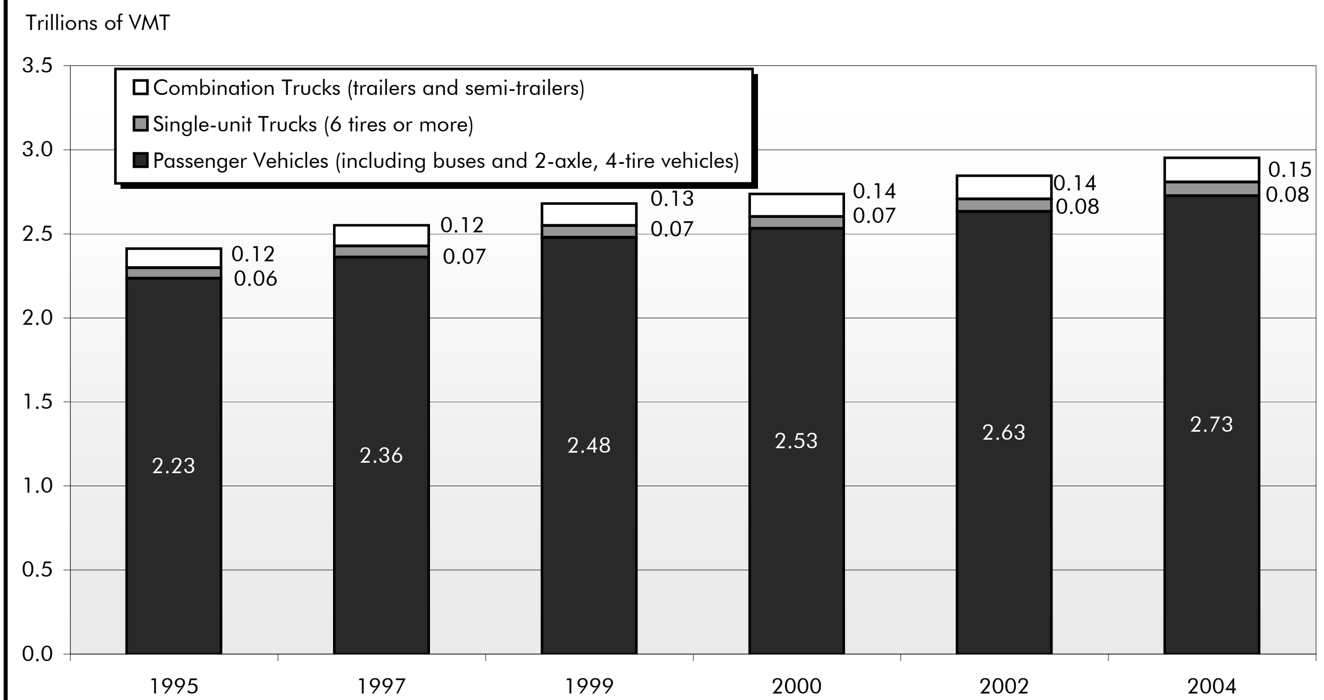
expansion of the boundaries of these areas due to the results of the 2000 census and the inclusion of travel that was previously recorded in the rural category.

Exhibit 2-8 shows that, in rural areas, travel grew the fastest on the local roadways while the highest VMT was still on the Interstate system. The highest growth in travel in small urban areas was on the Interstate system at an average annual rate of 4.5 percent. The most travel was on the other principal arterials in small urban areas. For urbanized areas the most growth was on other freeways and expressways with 3.8 percent. The most travel in urbanized areas was on the Interstate system.

Exhibits 2-9 and *2-10* expand on the information in Exhibit 2-8. They depict highway travel by functional classification and vehicle type. Three types of vehicles are identified: passenger vehicles (PV), including buses and 2-axle, 4-tire models; single-unit (SU) trucks having 6 or more tires; and combination (combo) trucks, including trailers and semi-trailers. The totals in Exhibit 2-9 include all vehicles, whereas those in Exhibit 2-10 exclude motorcycles.

Exhibit 2-9

Highway Travel by Vehicle Type, 1995 –2004



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

For the period from 1995 to 2004, travel among all vehicle types and on all functional classifications grew fastest among single-unit and combination trucks. Between 1995 and 2004, for example, combination truck traffic grew by 2.5 percent per year on rural Interstates and single-unit truck traffic grew by 2.7 percent per year on the rural Interstate system. The largest rates of growth have been on the urban Interstate system with single-unit trucks having an average annual growth of 4.4 percent from 1995 to 2004 and combination trucks having an average annual growth of 4.1 percent for the same period. Overall, passenger vehicle travel grew by an average annual rate of 2.2 percent between 1995 and 2004. Single-unit trucks grew by 2.9 percent per year and combination trucks grew by 2.6 percent per year for the same period.

Exhibit 2-10

Highway Travel by System and Vehicle Type, 1995–2004

Functional System Vehicle Type	1995	1997	2000	2002	2004	Annual Rate of Change 2004/2002	Annual Rate of Change 2004/1995
Rural Interstate							
PV	178,973	189,869	214,532	224,375	211,369	-2.9%	1.9%
SU	6,708	7,671	8,236	8,745	8,548	-1.1%	2.7%
Combo	36,643	41,665	44,248	45,633	45,754	0.1%	2.5%
Other Arterial							
PV	330,029	351,313	377,270	389,758	365,951	-3.1%	1.2%
SU	12,980	13,688	13,644	14,606	14,771	0.6%	1.4%
Combo	24,076	25,505	28,005	27,818	27,817	0.0%	1.6%
Other Rural							
PV	314,158	341,323	366,433	383,724	361,080	-3.0%	1.6%
SU	12,948	13,698	13,722	14,963	15,611	2.1%	2.1%
Combo	12,676	12,471	12,555	14,090	15,035	3.3%	1.9%
Total Rural							
PV	823,160	882,505	958,235	997,857	938,400	-3.0%	1.5%
SU	32,636	35,057	35,602	38,314	38,930	0.8%	2.0%
Combo	73,395	79,641	84,808	87,541	88,606	0.6%	2.1%
Urban Interstate							
PV	314,422	331,343	359,592	373,957	415,254	5.4%	3.1%
SU	7,148	7,906	8,716	9,106	10,512	7.4%	4.4%
Combo	18,491	20,643	23,465	23,887	26,481	5.3%	4.1%
Other Urban							
PV	1,097,161	1,146,289	1,213,109	1,259,859	1,372,307	4.4%	2.5%
SU	22,921	23,930	26,182	28,467	31,665	5.5%	3.7%
Combo	23,565	24,300	26,747	27,215	30,310	5.5%	2.8%
Total Urban							
PV	1,411,583	1,477,632	1,572,701	1,633,816	1,787,561	4.6%	2.7%
SU	30,069	31,836	34,898	37,573	42,177	5.9%	3.8%
Combo	42,056	44,943	50,212	51,102	56,791	5.4%	3.4%
Total							
PV	2,234,743	2,360,137	2,530,936	2,631,673	2,725,961	1.8%	2.2%
SU	62,705	66,893	70,500	75,887	81,107	3.4%	2.9%
Combo	115,451	124,584	135,020	138,643	145,397	2.4%	2.6%

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

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

Combo=Combination Trucks (trailers and semi-trailers).

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

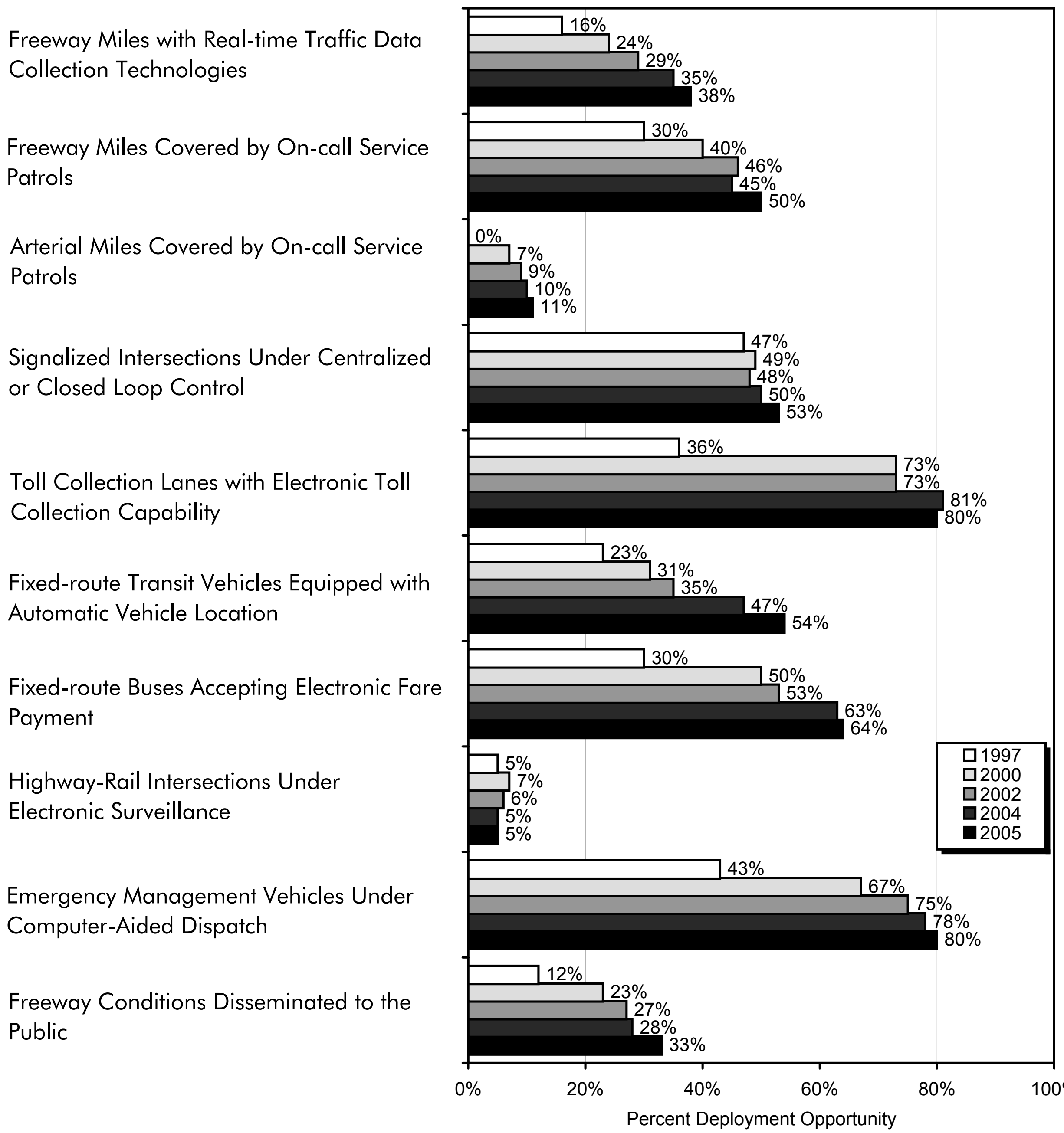
Intelligent Transportation Systems (ITS)

All of the previous exhibits represent a traditional look at the highway system—its mileage, ownership, functional classification, and use. This section looks at the extent of ITS deployment and integration in metropolitan areas. ITS uses advanced technology to improve highway safety and efficiency. The deployment of ITS for freight and operations management are discussed more fully in Chapters 14 and 15.

Exhibit 2-11 describes the deployment of ITS devices in 78 of the largest metropolitan areas, based on a survey by the U.S. Department of Transportation Intelligent Transportation Systems Joint Program Office. The exhibit shows that freeway deployment has advanced steadily, with real-time data collection sensors deployed on more than one-third of the total freeway mileage, and on-call service patrols covering half of the freeway mileage. Arterial deployment of service patrols lags behind that seen on freeways, but is advancing steadily. Transit agencies have advanced rapidly in deployment of ITS, with more than half of the buses equipped with automatic vehicle location capability by 2005. Other well-established ITS technologies are electronic fare payment for transit vehicles, computer-aided dispatch on emergency vehicles, and electronic toll collection.

Exhibit 2-11

Deployment of Intelligent Transportation Systems (ITS) in 78 of the Largest Metropolitan Areas, 1997 –2005

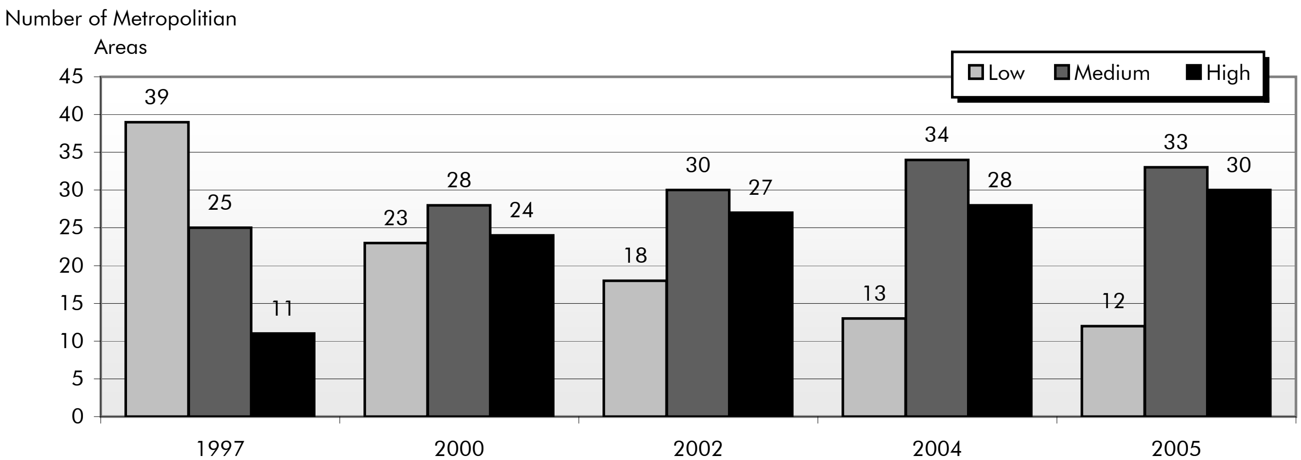


Source: "Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 2004 Results, July 2005."

Exhibit 2-12 shows the progress of deployment of an integrated ITS infrastructure in 75 of the largest metropolitan areas. The measure incorporates both deployment and integration. Progress in deployment is measured by tracking outputs for five key infrastructure components: freeways, arterials, transit, public safety, and information dissemination. Integration is measured by assessing links between agencies, chosen to involve key levels of government and transit agencies. Crossing a threshold value for either deployment or integration means that a metropolitan area has made a significant commitment to deploy and integrate the metropolitan ITS infrastructure. However, it does not mean that deployment or integration is complete. Progress has been tracked through a series of national surveys covering 1997 through 2005. The exhibit shows that substantial progress was made in deploying integrated infrastructures in this period, with the number of areas ranked low going from 39 to 12, and the number ranked high going from 11 to 30.

Exhibit 2-12

Progress in Integrated Deployment of ITS in 75 of the Largest Metropolitan Areas, 1997 –2005



Source: "Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 2004 Results, July 2005," and subsequent updates.

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 594,101 bridges over 6.1 meters (20 feet) in total length located on public roads in the United States in 2004. As discussed in Chapter 3, the National Bridge Inspection Standards require biennial safety inspections of bridges that exceed this length; as part of these inspections, information is collected concerning both the characteristics and physical conditions of the structures.

Bridges by Owner

Exhibit 2-13 shows the number of highway bridges by owner from 1996 to 2004. State and local ownership includes highway agencies; park, forest, and reservation agencies; toll authorities; and other State or local agencies, respectively. The vast majority of State and local bridges are owned by highway agencies. Federal ownership includes a number of agencies, mostly from 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.

Exhibit 2-13

Bridges by Owner, 1996–2004

	Number of Bridges by Year				
Owner	**1996**	**1998**	**2000**	**2002**	**2004**
Federal	6,171	7,748	8,221	9,371	8,425
State	273,198	273,897	277,106	280,266	282,552
Local	299,078	298,222	298,889	299,354	300,444
Private/Railroad	2,378	2,278	2,299	1,502	1,497
Unknown/Unclassified	1,037	1,131	415	1,214	1,183
Total	**581,862**	**583,276**	**586,930**	**591,707**	**594,101**

Source: National Bridge Inventory.

Local agencies own 300,444 bridges on the Nation's roadways, or 50.6 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 282,552 of the Nation's bridges on all functional roadway classifications. State and local agencies, when combined, own 582,996 of the total 594,101 of the Nation's bridges or 98.2 percent of all bridges on the Nation's roadway system.

Deeper insight into the condition or the composition of bridges can be obtained by considering the size of the structure and/or the traffic carried. Consideration of the structure size

Q&A

Is information on railroad bridge inspections included in the NBI?

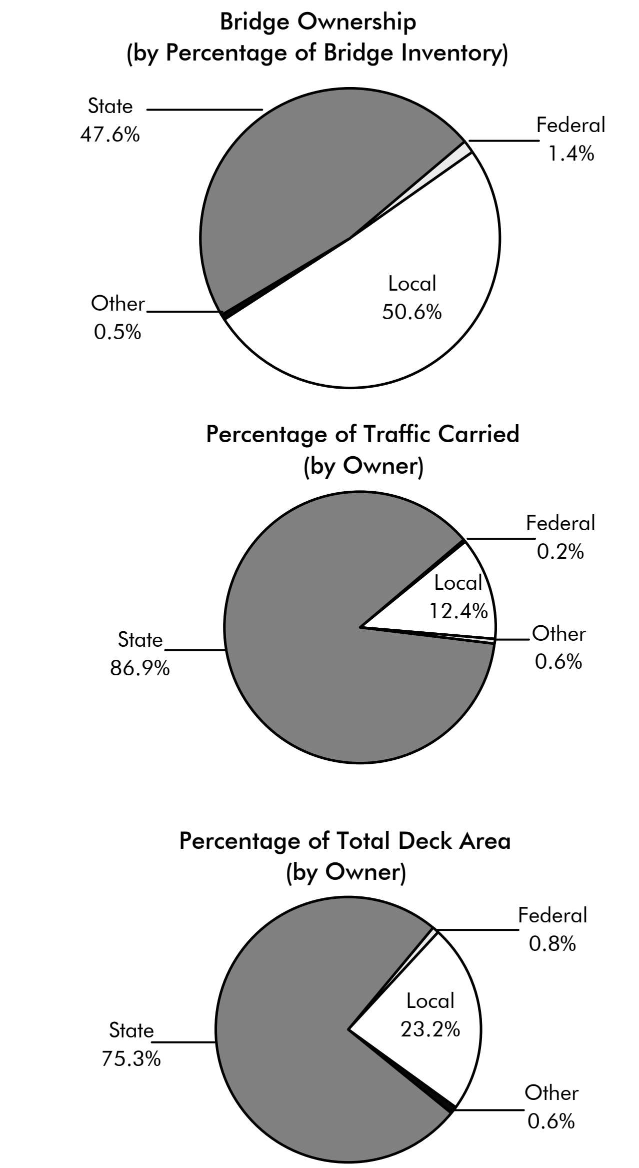
Bridges carrying railroads are not included in the database unless they also carry a public road or cross a public road where information of certain features, such as vertical or horizontal clearances, is required for management of the highway system.

Some bridges carrying highway traffic are owned by railroads. For instance, a public road that crosses railroad tracks may be owned by the railroad if built within the railroad right-of-way. Ownership in these cases depends on the agreements made between the political jurisdiction and the railroad.

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 2-14* 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.

Exhibit 2-14

Percent Bridge Inventory, Traffic, and Deck Area by Owner



Source: National Bridge Inventory.

Q&A

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

The majority of bridges (98 percent) and roadways (97 percent) are owned by State and local agencies. Bridge ownership is nearly equally divided between State (47 percent) and local agencies (51 percent). The vast majority of roadways, however, are owned by local agencies (77 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.

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.

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 2-15*. Overall percentages of each functional classification tend to remain relatively constant over time, although bridges are functionally reclassified as urban boundaries change.

Rural bridges are predominant based on the number of bridges on the Nation's roadway systems as 76.8 percent of all structures are located in a rural environment. Urban bridges comprise 23.2 percent of the inventory but carry 72.6 percent of all daily

Exhibit 2-15

Number of Bridges by Functional System, 1996–2004

Functional Classification	1996	1998	2000	2002	2004
Rural					
Interstate	28,638	27,530	27,797	27,316	27,648
Other Arterial	72,970	73,324	74,796	74,814	76,456
Collector	144,246	143,140	143,357	144,101	143,470
Local	211,059	210,670	209,415	209,722	208,641
Subtotal	456,913	454,664	455,365	455,953	456,215
Urban					
Interstate	26,596	27,480	27,882	27,929	27,929
Other Arterial	59,064	60,901	63,177	65,667	66,443
Collector	14,848	14,962	15,038	15,171	15,548
Local	24,441	24,962	25,684	26,609	27,940
Subtotal	124,949	128,305	131,781	135,376	137,860
Total	**581,862**	**582,969**	**587,146**	**591,329**	**594,075**

Source: National Bridge Inventory.

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 52.5 percent of all total deck area on bridges in the inventory.

Exhibit 2-16 shows the relationship between the number of bridges, functional class, ADT carried, and deck area. The deck area for rural bridges is 47.5 percent versus 52.5 percent for urban bridges. The major difference is the amount of ADT carried by rural bridges versus urban bridges.

Urban Interstate bridges comprise 18.8 percent of the total bridge deck area of bridges on the Nation's roadway system but carry 34.7 percent of the ADT. Bridges on urban other freeways and expressways account for 9.3 percent of the total deck area and carry 14.7 percent of the ADT. Bridges on urban other principal arterials carry 11.7 percent of the ADT but have only 10.7 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 133,215 bridges, 22.4 percent of the total bridges by number, they carry close to 78.3 percent of all daily traffic and account for approximately 56.3 percent of the deck area.

Bridges by Traffic Carried

Many bridges carry relatively low volumes of traffic on a typical day. Approximately 27 percent of these structures in terms of numbers have an ADT of 100 or less. Over 50 percent of bridges have an ADT lower than 700. Only 3 percent of bridges have an ADT higher than 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. There are approximately 21,000 structures with ADT values in excess of 40,000 vehicle crossings daily. 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. Weighting the number of

Exhibit 2-16

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

Functional Class	Number of Bridges	% by Total Number.	% of Total ADT	% of Total Deck Area
Rural				
Interstate	27,648	4.7%	10.6%	8.0%
Other Principal Arterials	36,259	6.1%	6.7%	9.4%
Minor Arterial	40,197	6.8%	3.8%	6.6%
Major Collector	94,079	15.8%	3.7%	9.8%
Minor Collector	49,391	8.3%	0.9%	3.5%
Local	208,641	35.1%	1.6%	10.1%
Rural Total	**456,215**	76.8%	27.4%	47.5%
Urban				
Interstate	27,667	4.7%	34.7%	18.8%
Other Expressways	17,112	2.9%	14.7%	9.3%
Other Principal Arterials	24,529	4.1%	11.7%	10.7%
Minor Arterial	24,802	4.2%	6.9%	7.0%
Collectors	15,548	2.6%	2.3%	2.8%
Local	27,940	4.7%	2.3%	3.7%
Urban Total	**137,598**	23.2%	72.6%	52.5%
Unclassified	288	0.0%	0.0%	0.1%
Total	**594,101**	**100.0%**	**100.0%**	**100.0%**

Source: National Bridge Inventory.

bridges by ADT values provides a mechanism for evaluating the impacts of the composition and conditions of bridges in terms of their impact on the highway user.

Bridges by Age

Peak periods of construction are seen mainly before World War II and during the Interstate construction era. The latter period saw an intense period of construction of bridges across the Nation. Half of all bridges in the country were built before 1964. The mean year of construction is approximately 1971 where structures are weighted by deck area. This indicates that recent structures tend to be larger than their older counterparts. This change is the result of design standards having improved and becoming stricter over time.

Bridges in the national inventory are, on average, 40 years old, with an average year of construction of 1964. Urban structures are slightly younger than rural structures, with an average year of construction of 1968. Comparing rural bridges across ownership classifications shows that State, local, and Federal owners have values within a few years of the mean for all rural bridges. Rural bridges owned by others, which are primarily private owners and railroads, are on average 10 years older than the general population. With urban bridges, State and locally owned bridges are slightly younger or slightly older than average, respectively. Federally owned urban bridges and urban structures owned by others are 5 to10 years older than State and local counterparts on average. It is important to note, however, that the number of bridges owned by Federal and other agencies is much smaller.

Considering functional classifications, only small variations are seen in the average age of construction between the owners. For all functional classifications and for all material types, the average year of construction is 1964 or 1965. This average is effectively equivalent for State, local, and Federal owners. There is also minimal variation between the functional classifications with average ages for all functional classifications for State, local, and Federal owners in the 1960s.

Bridges by Material

Superstructure material types are maintained in the NBI database for the main span and for the approach spans. Predominant materials used for bridge superstructures are steel, concrete, prestressed concrete, and timber. Other materials, such as aluminum, iron, and composite materials, are utilized on less than 1 percent of the structures. Bridges carrying Interstate, other principal arterial, and minor arterial routes are predominantly constructed of reinforced concrete, steel, and prestressed concrete. Timber superstructures and other materials become more significant within the population of bridges carrying collectors and local roadways.

Concrete and steel superstructure bridges on the Interstate are, on average, 35 to 40 years old. Prestressed designs were introduced more recently and have become the predominant superstructure material employed today, with over 50 percent of new structures employing prestressed concrete. Today, there are over 45,000 prestressed superstructure bridges carrying Interstates, other principal arterials, and minor arterials in the United States. There are also sizable numbers of prestressed concrete bridges carrying collector and local roadways. Bridges constructed of this material are, on average, 25 years old. The average age of timber superstructure bridges is approximately 45 years, while the average age of other materials is in excess of 65 years. Other materials are used on many older designs that used iron and masonry or on newer structures employing composites or other new materials.

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 2004, there were 640 active reporters in urbanized areas reporting to the National Transit Database (NTD), of which 600 were public agencies, including 6 State Departments of Transportation. Of the 640 active reporters, 93 received a reporting exemption for operating nine or fewer vehicles, or else received a temporary reporting waiver. The remaining 547 reporting agencies provided service on 1,042 different modal systems; 142 agencies operated a single mode and 405 transit agencies operated more than one mode.

In 2000, the most recent year for which information is available, there were an additional 1,215 transit operators serving rural areas.

The Nation's motorbus and demand response systems are much more extensive than the Nation's rail transit system. In 2004, there were 468 motorbus systems and 438 demand response systems in urban areas, compared with 14 heavy rail systems, 19 commuter rail systems, and 27 light rail systems. While motorbus and demand response systems were found in every major urbanized area in the United States, only 31 urbanized areas had service on at least one of the three primary rail modes, including 11 urbanized areas with service on the heavy rail mode. In addition to these modes, there were 43 transit vanpool systems, 17 ferryboat systems, 4 trolleybus systems, 3 automated guideway systems, 3 inclined plane systems, and 2 jitney systems 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.)

Q&A

What are jitney, 'aiga bus, and público services?

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.

Q&A

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

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).

Transit Fleet

Exhibit 2-17 provides an overview of the nation's transit fleet in 2004 by type of vehicle. 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 motorbus services.

The Nation's transit system continues to grow. In 2004, urban transit systems, excluding special service providers, operated 120,659 vehicles compared with 114,564 vehicles in 2002, an increase of 5.3 percent. The Nation's transit fleet is primarily composed of buses, which in 2004 accounted for 57 percent of all regular service urban transit vehicles. Seventy-one percent of the buses were found in urbanized areas with more than 1 million people. Sixteen percent of regular urban transit vehicles were rail vehicles, of which 99 percent were found in urbanized areas with more than 1 million people.

Q&A

What is vanpool service, and when is vanpool service considered to be transit?

A vanpool is considered to be part of the Nation's transit system if the vanpool is either run by or under contract to a transit agency.

Under a transit vanpool, the transit agency provides or leases a vehicle to a group of commuters, which due to certain tax benefits, is usually a van. One or more members of this group of commuters is trained and certified as a "primary driver" for the pool, and he or she then operates the van in regular service for the group of commuters between their homes and places of employment. Primary drivers typically pay a reduced fare or lease payment, or often pay nothing. Primary drivers also usually have limited use of the vehicle for personal trips.

Q&A

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

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 2-17, both as rural service vehicles, and as vehicles in urbanized areas.

Demand response systems are commonly used to meet transit agencies' obligations under the Americans with Disabilities Act. 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 in some urban neighborhoods with limited transit demand.

The Federal Transit Administration (FTA) grants funding to some private organizations and 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.

Exhibit 2-17

Transit Active Fleet by Vehicle Type, 2004

	Areas Over 1 Million in Population	Areas Under 1 Million in Population	Total
Urbanized Area Regular Vehicles			
Heavy Rail Vehicles	10,965	0	10,965
Self-Propelled Commuter Rail	2,441	0	2,441
Commuter Rail Passenger Cars	3,361	78	3,439
Commuter Rail Locomotives	664	75	739
Other Commuter Rail Vehicles [1]	23	0	23
Light Rail Vehicles	1,564	101	1,665
Busses	49,043	19,746	68,789
Other Motorbus Mode Vehicles [2]	0	25	25
Vans	16,029	6,519	22,548
Other Regular Vehicles [3]	8,430	1,595	10,025
Total Urbanized Area Regular Vehicles	**92,520**	**28,139**	**120,659**
Rural Service Regular Vehicles (2000) [4]	0	19,185	19,185
Total Regular Vehicles	**92,520**	**47,324**	**139,844**
Special Service Vehicles [5]	10,107	27,613	37,720
Total Active Vehicles	**102,627**	**74,937**	**177,564**

[1] Vehicles reported for the commuter rail mode, but not reported by commuter rail vehicle type.

[2] Vehicles reported for the motorbus mode, but not reported by vehicle type.

[3] Includes aerial tramway vehicles, Alaska railroad vehicles, automated guideway vehicles, automobiles, cable cars, ferryboats, inclined plane vehicles, monorail vehicles, taxicabs, and trolleybuses. Also includes jitney and público vehicles other than busses or vans.

[4] *Source: Section 5311 Status of Rural Public Transportation 2000, CTAA, April 2001.*

[5] *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.

Q&A

What are the characteristics of the rural service vehicles and the special service vehicles listed in Exhibit 2-17?

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.

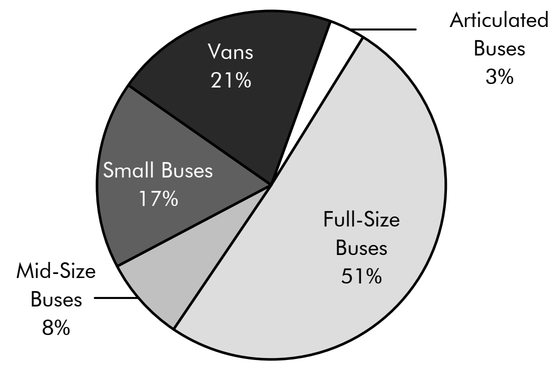
Special service vehicles are vehicles that are used to provide service to the elderly and disabled, and receive funding from FTA as directed by Title 49—United States Code, Section 5310. Special service vehicle funding is directed toward private nonprofit organizations, although in certain cases specified 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 first 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.

Exhibit 2-18 shows the composition of the Nation's urban transit road vehicle fleet in 2004. The most common type of vehicle is the full-size bus, comprising 51 percent of the fleet, followed by vans and small buses, comprising 21 percent and 17 percent of the fleet, respectively. Articulated buses account for about 3 percent of the total fleet. Overall, the Nation's urban transit road vehicle fleet has grown by 32 percent, which is just over 22,000 vehicles, since 1995. The largest component of growth in the Nation's urban transit road vehicle fleet between 1995 and 2004 has come from small-size buses, which have more than doubled in number since 1995. The number of full-size buses, by contrast, has remained nearly constant during that same time. For more information on the composition of the Nation's urban transit road vehicle fleet, please see Chapter 3.

Exhibit 2-18

Composition of Urban Transit Road Vehicle Fleet, 2004



Source: National Transit Database.

The Nation's urban transit rail fleet consists primarily of heavy rail vehicles, light rail vehicles, self-propelled commuter rail vehicles, commuter rail locomotives, and commuter rail passenger coaches. In 2004, heavy rail vehicles accounted for 57 percent of the Nation's urban transit rail fleet, commuter rail vehicles for 34 percent, and light rail vehicles for 9 percent.

Track, Stations, and Maintenance Facilities

In 2004, there were 793 maintenance facilities for all transit modes in urban areas, compared with 769 in 2002. The number of light rail maintenance facilities increased from 32 in 2002 to 38 in 2004 and the number of heavy rail increased from 53 to 55. Over this same period, the number of bus maintenance facilities was unchanged at 516, while the number of demand response vehicle maintenance facilities increased from 91 to 103 [*Exhibit 2-19*].

Exhibit 2-19

Maintenance Facilities for Directly Operated Services, 2004

	Areas Over 1 Million in Population	Areas Under 1 Million in Population	Total
Maintenance Facilities [1]			
Heavy Rail	55	0	55
Commuter Rail	61	0	61
Light Rail	32	6	38
Other Rail [2]	3	4	7
Motorbus	281	235	516
Demand Response	32	72	103
Ferryboat	6	0	6
Other Nonrail [3]	0	6	6
Total Urban Maintenance Facilities	**470**	**323**	**793**
Rural Transit [4]		510	510
Total Maintenance Facilities	**470**	**833**	**1,303**

[1] Includes owned and leased facilities, but for directly operated service only.

[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.

In 2004, transit providers operated 10,892 miles of track and served 2,961 stations, compared with 10,722 miles of track and 2,862 stations in 2002. The bulk of the increase in these transit track and station assets was for light rail service. Light rail track increased from 1,114 miles in 2002 to 1,321 miles in 2004, and the light rail stations increased from 640 to 723. The Nation's urban transit rail system infrastructure, however, continues to be dominated by commuter rail. In 2004, commuter rail systems accounted for 67 percent of transit track miles (7,284 miles) and 39 percent of transit rail stations (1,153). This reflects the longer distances generally covered by commuter rail. In 2004, heavy rail accounted for 20 percent (2,210 miles) of track miles and 35 percent of stations (1,023). Heavy rail typically operates in more densely developed areas than commuter rail, and thus has a higher ratio of stations to track miles *[Exhibit 2-20].*

Exhibit 2-20

Transit Rail Mileage and Stations, 2004

	Urbanized Areas Over 1 Million in Population	Urbanized Areas Under 1 Million in Population	Total
Track Mileage			
Heavy Rail	2,210	0	2,210
Commuter Rail	7,088	196	7,284
Light Rail	1,250	71	1,321
Other Rail and Tramway *	24	53	77
Total Urbanized Area Track Mileage	**10,572**	**320**	**10,892**
Stations			
Heavy Rail	1,023	0	1,023
Commuter Rail	1,135	18	1,153
Light Rail	673	50	723
Other Rail and Tramway *	40	22	62
Total Urbanized Area Transit Rail Stations	**2,871**	**90**	**2,961**

* 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 2004, 216,620 urban route miles were provided by nonrail and 9,782 urban route miles were provided by rail modes [*Exhibit 2-21*]. Bus modes, which cover a wider area than rail modes, accounted for 96 percent of urban route miles. Rail modes cover smaller areas, typically providing higher-frequency service on the same route and producing fewer directional route miles.

Exhibit 2-21

Transit Directional Route Miles, 1995–2004

	1995	1997	1999	2000	2002	2004	Average Annual Rate of Change 2004 / 1995	2004 / 2002
Rail	**8,211**	**8,602**	**9,170**	**9,222**	**9,484**	**9,782**	**2.0%**	**1.6%**
Heavy Rail	1,458	1,527	1,540	1,558	1,572	1,597	**1.0%**	**0.8%**
Commuter Rail	6,162	6,393	6,802	6,802	6,831	6,875	**1.2%**	**0.3%**
Light Rail	568	659	802	834	960	1,187	**8.5%**	**11.2%**
Other Rail [1]	24	24	27	29	122	123	**NA**	**0.3%**
Nonrail [2]	**187,757**	**185,164**	**195,985**	**196,858**	**225,820**	**216,620**	**1.6%**	**-2.1%**
Motorbus	186,856	184,248	195,022	195,884	224,838	215,571	**1.6%**	**-2.1%**
Ferryboat	490	496	533	505	513	623	**2.7%**	**10.2%**
Trolleybus	412	420	430	469	468	425	**0.4%**	**-4.7%**
Total	**195,968**	**193,766**	**205,154**	**206,080**	**235,303**	**226,402**	**1.6%**	**-1.9%**
Percent Nonrail	95.8%	95.6%	95.5%	95.5%	96.0%	95.7%		

[1] Includes automated gateway, inclined plane, and cable car. Includes monorail from 2000 onward, and includes the Alaska railroad, which was not reported to the NTD prior to 2001. Alaska railroad, with 92 Directional Route Miles, was included in commuter rail in the last C&P report.

[2] Includes aerial tramway in 2004, with 1.2 directional route miles. Excludes demand response, jitney, público, and vanpool.

Source: National Transit Database.

Total route miles increased at an average annual rate of 1.6 percent between 1995 and 2004, but decreased at an average annual rate of 1.9 percent between 2002 and 2004. This decline resulted from a drop in motorbus directional route miles, which account for the vast majority of total route miles. Reported motorbus miles reached a peak of 224,838 in 2002, declining to 215,571 in 2004. Rail route miles increased at an average annual rate of 2.0 between 1995 and 2004, and at a 1.6 percent average annual rate from 2002 to 2004. 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 8.5 percent between 1995 and 2004, accelerating to 11.2 percent from 2002 to 2004.

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 motorbus vehicles representing the baseline.

Exhibit 2-22 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 were constant between 1995 and 2004. Nonrail modes accounted for 73 percent and rail modes accounted for 27 percent of unadjusted VRMs in 2004. As subsequent paragraphs will show, however, the share of VRMs on rail modes, adjusted for capacity, is considerably higher than the share when unadjusted for capacity.

Exhibit 2-22

Vehicle Revenue Miles, 1995–2004

	1995	1997	1999	2000	2002	2004	Average Annual Rate of Change 2004/1995	2004/2002
	(Millions)							
Rail	**775**	**811**	**854**	**880**	**925**	**962**	**2.4%**	**2.0%**
Heavy Rail	522	540	561	578	603	625	**2.0%**	**1.7%**
Commuter Rail	218	230	243	248	259	269	**2.4%**	**1.8%**
Light Rail	34	40	47	51	60	67	**7.8%**	**5.4%**
Other Rail [1]	2	2	2	2	3	2	**NA**	**-9.6%**
Nonrail	**1,957**	**2,042**	**2,257**	**2,322**	**2,502**	**2,586**	**3.1%**	**1.7%**
Motorbus	1,591	1,606	1,719	1,764	1,864	1,885	**1.9%**	**0.6%**
Demand Response	297	350	418	452	525	561	**7.3%**	**3.4%**
Vanpool	22	40	60	62	71	78	**15.0%**	**5.3%**
Ferryboat	2	2	2	2	3	3	**4.9%**	**5.4%**
Trolleybus	13	13	14	14	13	13	**-0.1%**	**-1.1%**
Other Nonrail [2]	31	31	44	28	26	46	**4.2%**	**32.1%**
Total	**2,732**	**2,853**	**3,111**	**3,202**	**3,427**	**3,548**	**2.9%**	**1.8%**
Percent Rail	28.4%	28.4%	27.4%	27.5%	27.0%	27.1%		

[1] Alaska railroad, automated guideway, inclined plane, cable car, and monorail. Alaska railroad began reporting to the NTD in 2001; it accounted for 5 percent or less of "other rail" vehicle revenue miles in 2002 and 2004.

[2] Aerial tramway, jitney, and público; 99% or more of the "other nonrail" VRMs for each year are on público. Jitney was not reported in 2000. Aerial tramway began reporting to the NTD in 2003.

Source: National Transit Database.

The 2004 capacity-equivalent factors for each mode are shown in *Exhibit 2-23*. 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 motorbus vehicles in active service. For vehicles that prohibit standing, as is the case of some commuter rail systems, standing capacity is assumed to be 0. The capacity-equivalent factors used in this report differ slightly from those in the 2004 C&P report. In this report, capacity-equivalent VRMs have been 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 2-23

2004 Capacity-Equivalent Factors by Mode

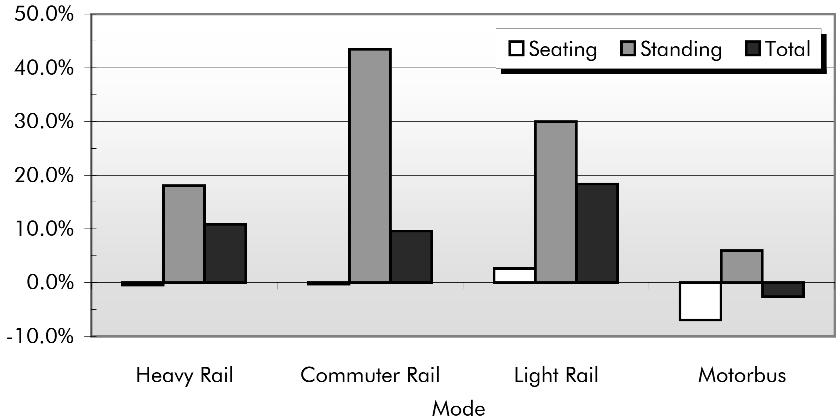
Base = Average Motorbus Vehicle Capacity			
Automated Guideway	1.4	Jitney	0.6
Alaska Railroad	0.3	Light Rail	2.7
Cable Car	0.8	**Motorbus**	**1.0**
Commuter Rail	2.5	Monorail	1.8
Demand Response	0.2	Público	0.3
Ferryboat	10.8	Trolleybus	1.5
Heavy Rail	2.5	Aerial Tramway	2.3
Inclined Plane	0.8	Vanpool	0.2

Source: National Transit Database.

Since 1995, the capacity-equivalent factors of the major rail modes have increased significantly, largely as a result of increased standing capacity. *Exhibit 2-24* shows the percentage change in seating, standing, and total capacity for the four largest transit modes since 1995. The average seating capacity for motorbus has declined in part through the addition of many more small buses to the motorbus 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.

Exhibit 2-24

Change in Vehicle Capacity, 2004 Versus 1995



Source: National Transit Database.

Total capacity-equivalent VRMs, are shown in *Exhibit 2-25*. Nonrail modes accounted for only 46 percent of capacity-equivalent VRMs, while rail modes accounted for 54 percent of capacity-equivalent VRMs. For all modes, capacity-equivalent VRMs increased at an average annual rate of 3.1 percent between 1995 and 2004, and 1.9 percent between 2002 and 2004. Rail capacity-equivalent VRMs increased at an average annual rate of 3.9 percent between 1995 and 2004 and 3.0 percent between 2002 and 2004. Among the

Exhibit 2-25

Capacity-Equivalent Vehicle Revenue Miles, 1995–2004

	(Millions)						Average Annual Rate of Change	
	1995	1997	1999	2000	2002	2004	2004/ 1995	2004/ 2002
Rail	**1,706**	**1,801**	**1,936**	**2,046**	**2,274**	**2,413**	**3.9%**	**3.0%**
Heavy Rail	1,135	1,183	1,247	1,321	1,469	1,546	**3.5%**	**2.6%**
Commuter Rail	493	522	572	595	652	685	**3.7%**	**2.5%**
Light Rail	75	92	114	127	150	179	**10.2%**	**9.4%**
Other Rail [1]	3	4	4	3	3	3	**-2.6%**	**-12.7%**
Nonrail	**1,689**	**1,720**	**1,862**	**1,908**	**2,037**	**2,064**	**2.3%**	**0.7%**
Motorbus	1,591	1,606	1,719	1,764	1,864	1,885	**1.9%**	**0.6%**
Demand Response	46	56	72	76	100	101	**9.1%**	**0.5%**
Vanpool	4	8	11	11	15	15	**14.4%**	**1.5%**
Ferryboat	23	24	30	30	32	32	**3.9%**	**0.1%**
Trolleybus	17	19	19	20	20	20	**1.7%**	**0.6%**
Other Nonrail [2]	8	8	11	7	7	12	**4.6%**	**31.3%**
Total	**3,395**	**3,521**	**3,799**	**3,954**	**4,311**	**4,478**	**3.1%**	**1.9%**
Percent Rail	50.3%	51.1%	51.0%	51.7%	52.8%	53.9%		

[1] Alaska railroad, automated guideway, inclined plane, cable car, and monorail. Alaska railroad was reported to the NTD for the first time from 2001 onward; it accounted for 1.4% or less of "other rail" capacity-equivalent VRMs in 2002 and 2004.

[2] Aerial tramway, jitney, and público; 99% or more of the "other nonrail" capacity-equivalent VRMs for each year are on público. Jitney was not reported in 2000. Aerial tramway was reported to the NTD for the first time in 2003 and 2004.

Source: National Transit Database.

rail modes, light rail capacity-equivalent VRMs have grown the most rapidly, increasing from 75 million capacity-equivalent VRMs in 1995 to 179 million capacity-equivalent VRMs in 2004, an average annual increase of 10.2 percent.

Capacity-equivalent VRMs for nonrail modes increased at an average annual rate of 2.3 percent between 1995 and 2004 and an average annual rate of 0.7 percent between 2002 and 2004. The most rapid expansion in capacity-equivalent VRMs has been for vanpools, growing from 4 million in 1995 to 15 million in 2004, at an average annual rate of 14 percent, for total growth of 235 percent.

The ADA spurred a rapid expansion of demand response capacity-equivalent VRMs, which increased at an average annual rate of 9 percent from 1995 to 2004, but slowed to an average increase of 0.5 percent from 2002 to 2004.

Ridership

There are two primary measures of transit ridership—unlinked passenger trips and passenger miles traveled (PMT). 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.

Q&A

What factors affect transit ridership?

Transit ridership is comprised 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.

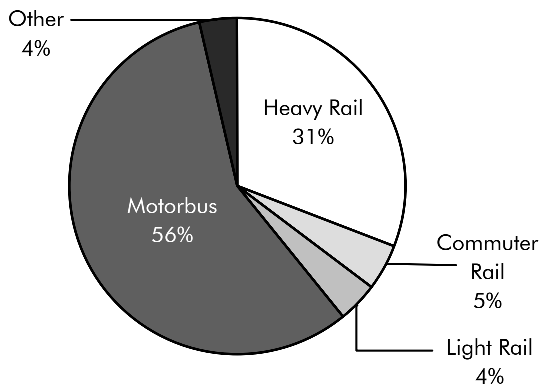
Transit ridership increases when transit provides a savings compared to a private vehicle in money, time, or both. Transit ridership will typically decrease after a fare increase, while transit ridership will often increase after an increase in gasoline prices or parking costs. Likewise, increasing congestion 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 2-26 and *Exhibit 2-27* show the distribution of unlinked passenger trips and PMT by mode. In 2004, there were 8.9 billion unlinked trips and 46.5 billion PMT. Fifty-six percent of unlinked trips were on motorbuses, 31 percent were on heavy rail, 5 percent were on commuter rail, and 4 percent each were on light rail and other. By comparison, 41 percent of PMT in 2004 were on motorbus, 31 percent were on heavy rail, 21 percent were on commuter rail, 3 percent were on light rail, and 4 percent were on other.

Exhibit 2-26

Modal Distribution of 8.9 Billion Unlinked Passenger Trips in 2004

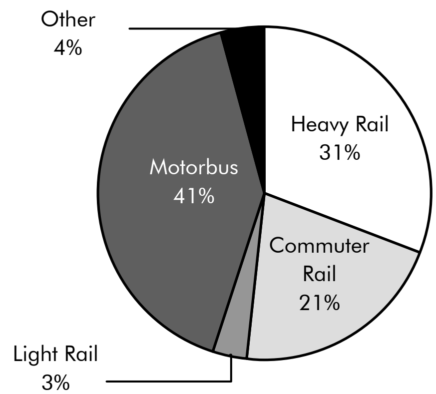


"Other" includes aerial tramway, Alaska railroad, automated guideway, cable car, demand response, ferryboat, inclined plane, jitney, monorail, público, and trolleybus.

Source: National Transit Database.

Exhibit 2-27

Modal Distribution of 46.5 Billion Passenger Miles Traveled in 2004



"Other" includes aerial tramway, Alaska railroad, automated guideway, cable car, demand response, ferryboat, inclined plane, jitney, monorail, público, and trolleybus.

Source: National Transit Database.

Exhibit 2-28 provides total PMT for selected years between 1995 and 2004. PMT increased at an average annual rate of 2.3 percent between 1995 and 2004, growing from 38 billion miles in 1995 to 46.5 billion miles in 2004. This rate of growth has slowed in recent years, averaging 0.7 percent between 2002 and 2004. PMT on all rail modes combined increased at an average annual rate of 3.0 percent between 1995 and 2004, twice the 1.5 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 percent in 1995 to 55 percent in 2004.

The fastest growth in PMT has been on modes with low levels of ridership in 1995 and which have experienced rapid growth in capacity since then. PMT on vanpools grew the most rapidly between 1995 and 2004, at an average annual rate of 10.6 percent, as transit agencies expanded their offerings of this service to commuters. PMT on light rail also grew briskly, at an average annual rate of 7.0 percent between 1995 and 2004, as new light rail systems and extensions were opened. This rate slowed slightly to an average annual rate of 4.9 percent between 2002 and 2004, but remained well above the rate for other rail modes. PMT on demand response systems has also grown rapidly, increasing at an average annual rate of 6.6 percent between 1995 and 2004.

Exhibit 2-28

Transit Urban Passenger Miles, 1995–2004

	(Millions)						Average Annual Rate of Change	
	1995	1997	1999	2000	2002	2004	2004/ 1995	2004/ 2002
Rail	**19,682**	**21,138**	**22,875**	**24,603**	**24,616**	**25,668**	**3.0%**	**2.1%**
Heavy Rail	10,559	12,056	12,902	13,844	13,663	14,354	**3.5%**	**2.5%**
Commuter Rail	8,244	8,037	8,764	9,400	9,500	9,715	**1.8%**	**1.1%**
Light Rail	859	1,024	1,190	1,340	1,432	1,576	**7.0%**	**4.9%**
Other Rail [1]	21	21	19	20	22	22	**0.7%**	**0.6%**
Nonrail	**18,288**	**19,042**	**20,404**	**20,498**	**21,328**	**20,878**	**1.5%**	**-1.1%**
Motorbus	17,024	17,509	18,684	18,807	19,527	18,921	**1.2%**	**-1.6%**
Demand Response	397	531	559	588	651	704	**6.6%**	**4.0%**
Vanpool	185	310	413	407	455	459	**10.6%**	**0.4%**
Ferryboat	243	254	295	298	301	357	**4.4%**	**8.8%**
Trolleybus	187	189	186	192	188	173	**-0.9%**	**-4.0%**
Other Nonrail [2]	252	249	267	205	206	265	**0.5%**	**13.4%**
Total	**37,971**	**40,180**	**43,279**	**45,101**	**45,944**	**46,546**	**2.3%**	**0.7%**
Percent Rail	51.8%	52.6%	52.9%	54.6%	53.6%	55.1%		

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail. Alaska railroad was first reported to the NTD from 2001 onward. Alaska railroad accounted for approximately 9% of PMTs in 2002 and 2004.

[2] Aerial tramway, jitney, and público. 99% or more of the PMT for each year are on público. Jitney was not reported in 2000. Aerial tramway was reported to the NTD for the first time in 2003 and 2004.

Source: National Transit Database.

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.

In 2000, there were 1,215 rural transit operators. While the number of rural transit providers had remained relatively constant since 1994, the year of the previous survey, fleet sizes expanded dramatically between 1994 and the most recent

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.

surveys undertaken in 1999 and 2000. The 150 providers that responded to a question on fleet size had an average fleet size of 17.5 vehicles, compared with an average fleet size of 11 vehicles in 1994, an increase of almost 50 percent. Correspondingly, the median fleet size in the most recent survey increased to 9 vehicles, compared with a median size of 6 vehicles in 1994. Total rural fleet size was estimated to have increased from 12,223 vehicles in 1994 to 19,185 vehicles in the most recent study.

The majority of rural transit operators' vehicles are vans (8 to 15 passengers) and small buses (16 to 24 passengers). According to the most recent survey, vans accounted for 54 percent of the rural fleet and small buses for 23 percent. Small vehicles (fewer than 8 passengers) accounted for 10 percent, medium buses (25 to 35 passengers) for 9 percent, and large buses (more than 35 passengers) for 4 percent.

Rural systems provide both traditional fixed-route and demand response services. About half of all rural transit providers offer various forms of route-deviation services. About 5 percent of rural systems also coordinate van and carpooling programs. Sixty percent of the rural fleet in the most recent survey was lift- or ramp-equipped, compared with 40 percent in 1994.

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 in 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. 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 2004, 79 percent of all the transit vehicles reported to the NTD were ADA-compliant. This percentage is the same as in 2002, and is above the 73 percent reported for 2000. The percentage of vehicles compliant with the ADA for each mode is shown in *Exhibit 2-29.*

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 Community Transportation Association of America (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.

Exhibit 2-29

Urban Transit Operators' ADA Vehicle Fleets by Mode, 2004

	Active Vehicles	ADA-Compliant Vehicles	ADA as a Percentage of Active Vehicles
Rail Modes			
Heavy Rail	10,965	10,418	95%
Commuter Rail	6,545	2,974	45%
Light Rail	1,671	1,260	75%
Alaska Railroad	97	30	31%
Automated Guideway	51	51	100%
Cable Car	40	-	0%
Inclined Plane	8	6	75%
Monorail	8	8	100%
Total Rail	**19,385**	**14,747**	**76%**
Nonrail Modes			
Motorbus	62,416	61,222	98%
Demand Response	27,919	18,409	66%
Vanpool	5,549	222	4%
Ferryboat	120	102	85%
Trolleybus	617	544	88%
Tramway	2	1	50%
Jitney	10	8	80%
Público	4,641	-	0%
Total Nonrail	**101,274**	**80,508**	**79%**
All Modes			
Total	**120,659**	**95,255**	**79%**

Source: National Transit Database.

In 2004, 70 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 2-30*].

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.

Exhibit 2-30

Urban Transit Operators' ADA Stations by Mode, 2004

	Total Stations	ADA-Compliant Stations	Percentage of Stations ADA Compliant
Rail Modes			
Heavy Rail	1,023	428	42%
Commuter Rail	1,153	666	58%
Light Rail	723	589	81%
Alaska Railroad	10	10	100%
Automated Guideway	42	41	98%
Inclined Plane	8	7	88%
Monorail	2	2	100%
Total Rail	**2,961**	**1,743**	**59%**
Nonrail Modes			
Motorbus	1,180	1,158	98%
Ferryboat	70	65	93%
Trolleybus	10	10	100%
Aerial Tramway	2	1	50%
Total Nonrail	**1,262**	**1,234**	**98%**
All Modes			
Total	**4,223**	**2,977**	**70%**

Source: National Transit Database.

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 2004, there were 687 key rail stations, of which 69 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.

Of the 618 identified key rail stations not under an FTA-approved time extension, 291 stations, or 47 percent, were ADA-compliant in 2004. As recently as 2000, only 52 key rail stations (about 8 percent) were ADA-compliant. In the 2002 edition of this report, 423 key rail stations were reported as being compliant, based upon self-certification of ADA compliance by the transit agencies themselves. The decrease in reported ADA compliance from 2002 to 2004 is a result of FTA efforts to verify the ADA compliance of these stations and, in some cases, to require additional modifications to the station in order to meet the requirements of the ADA.

CHAPTER 3

System Conditions

Summary

Exhibit 3-1 compares key highway and transit statistics discussed in this chapter with the values shown in the last report. The first data column contains the values reported in the 2004 C&P report, which were based on 2002 data. Where the 2002 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2004 data.

Exhibit 3-1

Comparison of System Conditions Statistics with Those in the 2004 C&P Report

		2002 Data		
Statistic	**Condition**	**2004 C&P Report**	**Revised**	**2004 Data**
Total VMT on Pavements with Ride Quality of:	Good	43.8%		44.2%
	Acceptable	85.3%		84.9%
Rural VMT on Pavements with Ride Quality of:	Good	58.0%		58.3%
	Acceptable	94.1%		94.5%
Small Urban VMT on Pavements with Ride Quality of:	Good	41.6%		41.2%
	Acceptable	84.4%		84.3%
Urbanized VMT on Pavements with Ride Quality of:	Good	34.1%		36.1%
	Acceptable	79.3%		79.2%
Deficient Bridges as a Percent of Total Bridges		27.5%		26.7%
Structurally Deficient Bridges as a Percent of Total		13.7%		13.1%
Functional Obsolete Bridges as a Percent of Total		13.8%		13.6%
Average Urban Bus Vehicle Condition *		3.19	3.07	3.08
Average Rail Vehicle Condition*		3.47		3.50
Urban Bus Maintenance Facilities	Excellent	7%		17%
	Good	6%		5%
	Adequate	55%		46%
Rail Maintenance Facilities	Excellent	3%		26%
	Good	41%		17%
	Adequate	43%		48%
Rail Maintenance Yards	Excellent	1%		0%
	Good	31%		48%
	Adequate	48%		52%
Rail Stations	Excellent	3%		7%
	Good	22%		28%
	Adequate	18%		14%
Rail Track	Excellent	40%		35%
	Good	34%		39%
	Adequate	12%		18%

* Average Condition. Conditions are rated on ranking of 1 (poor) to 5 (excellent).

Highway Conditions

The pavement conditions reported in this chapter reflect all functional classifications except rural minor collectors and local roads, for which data are not available. Pavement conditions are presented for three population groupings: rural (population less than 5,000), small urban (population 5,000 to 49,999), and urbanized (population equal to or greater than 50,000). Pavement is classified as being in one of two ride quality categories—"acceptable" or "not acceptable." The acceptable category contains a sub-category—"good," which represents a higher level of performance. These ratings are derived from one of two measures: International Roughness Index (IRI) or Present Serviceability Rating (PSR). The definitions for IRI and PSR, the relationship between them, and the ride quality ratings are discussed later in the chapter. This chapter focuses on ride quality on all roads for which data are available; Chapter 12 includes statistics on ride quality on the National Highway System (NHS).

Between 2002 and 2004, the percentage of vehicle miles traveled (VMT) on pavements with good ride quality has increased from 43.8 percent to 44.2 percent. For the same period, there has been a decrease in the percentage of VMT on pavements with acceptable ride quality from 85.3 percent to 84.9 percent. In rural areas, the percentage of VMT on pavements with good ride quality increased from 58.0 percent to 58.3 percent, percentage of VMT on pavements with acceptable ride quality increased from 94.1 percent to 94.5 percent. In contrast, the comparable good and acceptable percentages for small urban areas both declined over this period, from 41.6 percent to 41.2 percent for good and from 84.4 percent to 84.3 percent for acceptable. The situation was mixed for urbanized areas as the percentage of VMT on pavements with good ride quality rose from 34.1 percent in 2002 to 36.1 percent in 2004, while the percent of travel on acceptable pavements fell from 79.3 percent to 79.2 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 focuses on the physical conditions of all bridges; Chapter 12 examines bridge conditions on the NHS in more detail.

The total number of structurally deficient bridges in 2004 was 77,796, which accounted for 9.7 percent of the total deck area on all bridges. The number of functionally obsolete bridges in 2004 was 80,632, which accounted for approximately 17.4 percent of the total deck area. When combined, the total number of structurally deficient and functionally obsolete bridges for 2004 was 158,428 and accounted for 27.1 percent of the total deck area.

The percent of structurally deficient bridges declined from 13.7 percent in 2002 to 13.1 percent in 2004. The percent of functionally obsolete bridges also declined, from 13.8 percent to 13.6 percent, so that the combined percent of structurally deficient and functionally obsolete bridges fell from 27.5 percent to 26.7 percent.

Transit Conditions

The Federal Transit Administration (FTA) estimates conditions for transit vehicles, maintenance facilities, yards, stations, track, structures, and power systems using the Transit Economic Requirements Model (TERM), data collected through the National Transit Database (NTD) and special engineering surveys of transit assets. Since the 2004 C&P report, asset data for approximately 35 percent of the Nation's transit assets have been updated.

The estimated condition of transit vehicles improved between 2002 and 2004, and the average age of transit vehicles declined. On a scale of 1 (poor) to 5 (excellent), bus vehicles had an average condition of 3.08 in 2004 compared with 3.07 in 2002. The average age of the bus vehicle fleet was virtually unchanged, declining from 6.2 years in 2002 to 6.1 years in 2004. The average condition of the rail fleet increased from 3.47 in 2002 to 3.50 in 2004. The average age of rail vehicles declined from 20.4 years in 2002 to 19.7 years in 2004. Average rail vehicle age and condition are heavily influenced by the average age and condition of heavy rail vehicles, which account for 60 percent of the U.S. fleet.

The average condition of urban bus maintenance facilities (including facilities for vans and demand response vehicles) improved, increasing from 3.34 in 2002 to 3.41 in 2004. In 2004, 46 percent of urban bus maintenance facilities was in adequate condition, 5 percent was in good condition, and 17 percent was in excellent condition, for a combined total of 69 percent in adequate or better condition. The conditions of rail maintenance facilities increased from 3.56 in 2002 to 3.82 in 2004. This increase reflects updated inventory information collected since the last report from some of the Nation's younger and larger rail agencies. Ninety-two percent of all rail maintenance facilities are estimated to be in adequate or better condition and 8 percent in poor or substandard condition.

The condition of rail stations increased from 2.87 in 2002 to 3.37 in 2004 as a result of a revision in the decay curves and the fact that, on average, rail stations 22 years or older are in much better condition than previously estimated. Based on on-site surveys in 2004, subway stations were also found to be in better condition, on average, than elevated or at-grade stations. (In contrast, asset information collected for the 2004 report found stations to be in worse condition than previously estimated.) Nonrail stations are, on average, in better condition than rail stations. The condition of nonrail stations is estimated to have declined from 4.37 in 2002 to 4.23 in 2004. Surveys of nonrail stations have not been conducted.

Based on preliminary on-site engineering surveys in 2005, the condition of rail communications systems were found to be better than provided in the last report, the condition of train control systems slightly worse, and the condition of traction power systems about the same. These surveys are continuing in 2006; the final results will be discussed in the 2008 C&P report. The estimated conditions of structures, track, and yards have also been revised upwards and are in adequate to good condition.

Road Conditions

Pavement Terminology and Measurements

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. Delay occurs when vehicles slow for potholes or very rough pavement; in heavy traffic, such slowing can create significant queuing and subsequent delay. Inadequate road surfaces may reduce road friction, which affects the stopping ability and maneuverability of vehicles. This, and unexpected changes in surface conditions, may result in crashes.

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 3-2* 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 of any given pavement condition category may differ depending on the rating methodology. The historic pavement ride quality data in this report go back to 1995, while IRI data only began to be collected in 1993. Caution should be used when making

Q&A

How much of the pavement data reflected in this Chapter is based on IRI data, as opposed to PSR data?

The FHWA's *Highway Performance Monitoring System (HPMS) Field Manual* requires reporting of IRI data for all principal arterials and any other roadway that is part of the NHS. Reporting is required on a sample basis for rural minor arterials. Compliance with this requirement exceeded 99 percent in 2004 for rural Interstate, rural other principal arterials, rural minor arterials, urban Interstate and urban other freeways and expressways. However, IRI values were reported for only 95 percent of urban other principal arterials.

States may choose between reporting IRI or PSR data on a sample basis for rural major collectors, urban minor arterials, and urban collectors, although IRI reporting is recommended. States are gradually shifting over to reporting IRI data. For rural major collectors, the percentage of sample sections for which IRI data were reported rose from 63 percent in 2002 to 69 percent in 2004. In 2004, IRI data were reported for 61 percent of urban minor arterial sample sections.

comparisons with older data from earlier editions of this report and when attempting to make comparisons between PSR and IRI data in general.

The *Federal Highway Administration 1998 National Strategic Plan* introduced a new descriptive term for pavement condition on the National Highway System, "acceptable ride quality," which was defined as pavements having an IRI value less than or equal to 170 inches per mile. To place greater emphasis on the benefits of ride quality to highway users, this metric was subsequently revised and based on the percentage of vehicle miles traveled (VMT) on NHS pavements with acceptable ride quality. The U.S. Department of Transportation has subsequently adopted an even more exacting performance measure, the percentage of VMT on NHS with "good ride quality," defined as having an IRI value less than 95 inches per mile. While these descriptive terms were originally defined in terms of the NHS, in this chapter these IRI measures are applied to all functional classes. 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.

Exhibit 3-2

Pavement Condition Criteria

	All Functional Classifications	
Ride Quality Terms*	**IRI Rating**	**PSR Rating**
Good	< 95	≥ 3.5
Acceptable	≤ 170	≥ 2.5
Not 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."

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 VMT occurring on pavements with good and/or acceptable ride quality. The conditions of the roadways on the Interstate System and for the NHS are discussed in more detail in Chapters 11 and 12.

Overall Pavement Ride Quality

For those functional classes on which data are collected, the VMT on pavements with good ride quality has increased from 39.8 percent in 1995 to 44.2 percent in 2004. The VMT on pavements meeting the standard of acceptable (which includes the category of good) have shown a steady decrease from 86.6 percent in 1995 to 84.9 percent in 2004. [*Exhibit 3-3*]

Q&A

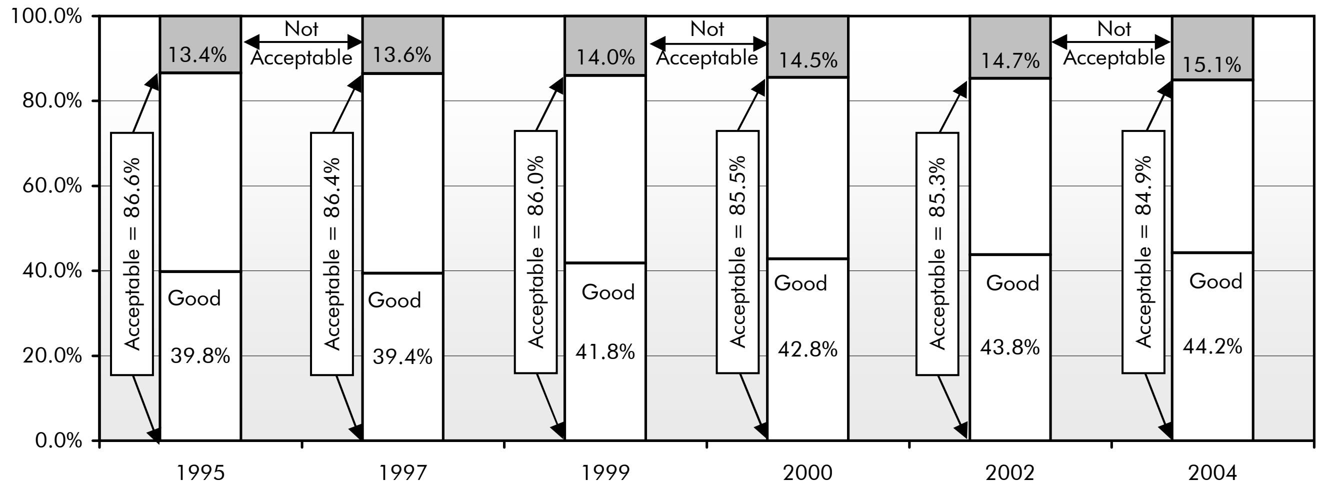
Do other measures of pavement condition exist?

Other principal measures of pavement condition or distress such as rutting, cracking, and faulting exist, but are not reported in HPMS. States vary in the inventories of these distress measures for their highway systems. To continue improving our pavement evaluation, FHWA is undertaking an effort to determine which measures are commonly collected by most states. Adding such measures to FHWA's database would enable the agency to account for pavement needs nationwide more accurately.

It is important to note that the pavement data presented in this chapter do not include rural minor collectors or the rural local and urban local functional classifications, since such data are not collected in the HPMS. These functional classifications account for almost 75.7 percent of the total mileage on the Nation's system and 72.3 percent of the total lane mileage. However, they carry only 14.8 percent of the total daily VMT on the Nation's roadway system, so this omission is less significant since this report has shifted its focus to VMT-based measures of ride quality rather than mileage-based measures.

Exhibit 3-3

Percent of VMT on Pavements With Good and Acceptable Ride Quality, 1995–2004



Note: Excludes Rural Minor Collectors and roads functionally classified as 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 75.1 percent of road miles, but only 35.9 percent of annual VMT. In other words, although rural areas have a larger percentage of road miles, the majority of travel is occurring in urban areas. According to 2004 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 3-4* shows that 58.3 percent of total VMT in rural areas is on pavement with good ride quality, compared with 41.2 percent of VMT in small urban areas and 36.1 percent of the VMT in urbanized areas.

Exhibit 3-4

Percent of VMT on Pavements With Good and Acceptable Ride Quality, by Population Area, 1995–2004

	1995	1997	1999	2000	2002	2004
Rural						
Good (IRI<95)	46.3%	47.9%	53.0%	55.2%	58.0%	58.3%
Acceptable (IRI ≤170)	91.5%	92.5%	93.5%	93.8%	94.1%	94.5%
Small Urban						
Good (IRI<95)	39.8%	39.3%	40.0%	41.2%	41.6%	41.2%
Acceptable (IRI ≤170)	83.9%	84.0%	83.9%	84.1%	84.4%	84.3%
Urbanized						
Good (IRI<95)	35.2%	33.5%	34.1%	34.3%	34.1%	36.1%
Acceptable (IRI ≤170)	83.5%	82.6%	81.0%	79.9%	79.3%	79.2%

Source: Highway Performance Monitoring System.

The percentage of VMT classified as occurring on pavements rated as having good ride quality in the rural areas has steadily increased from 46.3 percent in 1995 to 58.3 percent in 2004. The percentage of VMT on similar pavements in small urban and urbanized areas has fluctuated during the same period. In small urban areas, the percentage of VMT on good pavements increased from 39.8 percent in 1995 to a high of 41.6 percent in 2002 before declining to 41.2 percent in 2004. In urbanized areas, the range of fluctuation is smaller, as the percentage of VMT on good pavements decreased from 35.2 percent in 1995 to 33.5 percent in 1997 before rising to 36.1 percent in 2004.

The percentage of VMT on pavements with acceptable ride quality increased from 91.4 percent for 1995 to 94.5 percent for 2004 in rural areas; in small urban areas the comparable percentage rose from 83.9 percent to 84.3 percent over the same period of time. However, the percentage of VMT on pavements rated in acceptable condition has decreased from 83.5 percent to 79.2 percent in urbanized areas. The declines in urbanized areas more than offset the increases in rural and small urban areas, causing the overall decline shown earlier in Exhibit 3-3.

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.

The percentages of VMT on Interstate pavements rated as having acceptable ride quality (includes the higher standard of good) in 2004 were for rural Interstates—97.8 percent, small urban Interstates—95.0 percent, and urbanized Interstates—89.9 percent. When considering the VMT on Interstate pavements meeting the higher standard of good ride quality, 73.7 percent of the VMT on rural Interstates was on pavements rated as good; for small urban Interstates, 65.6 percent of the VMT was on good quality pavements; the comparable percentages for small urban and urbanized Interstates were 65.6 percent and 48.5 percent, respectively. For every functional classification, the same general pattern as shown for Interstates is followed for each combination of population area and pavement rating, as the percent of VMT on pavements with good ride quality is higher for rural roads than urban.

Exhibit 3-5 shows the percent of VMT on good and acceptable pavements for each functional class from 1995 to 2004. Since 1995, the percentage of total rural road VMT on pavements with acceptable ride quality has continued to increase in each of the four functional classes of rural roads for which data are available. For the five functional classifications of roadways in small urban areas, however, one has remained essentially constant—Interstate at 95.0 percent of VMT on pavements with acceptable ride quality, two have shown an increase—other freeways and expressways and other principal arterials, and the remaining two have shown a decrease. For the five functional classes of roads for the urbanized areas, one functional classification—Interstate— has seen an increase in the percentage of VMT on pavements rated as having acceptable ride quality, one functional classification—other freeways and expressways—has remained relatively constant, while the remaining three functional classes—other principal arterials, minor arterials, and collectors—have experienced declines.

The greatest increase in the percentage of VMT on pavements with good ride quality from 1995 to 2004 was on the Interstate System. In rural areas there was an increase from 53.3 percent in 1995 to 73.7 percent in 2004; for small urban areas the increase was from 51.4 percent to 65.6 percent; in urbanized areas the increase was from 39.1 percent to 48.5 percent.

For other functional classifications, in rural areas the percentage of VMT on pavements with good ride quality increased on other principal arterial and minor arterials but decreased on major collector routes. For small urban areas, the percentage of VMT on good ride quality pavements increased on other freeways and

Exhibit 3-5

Percent of VMT on Pavements With Good and Acceptable Ride Quality, by Functional System, 1995–2004

Functional System	1995	1997	1999	2000	2002	2004
Percent Acceptable						
Rural Interstate	94.5%	95.7%	97.4%	97.4%	97.3%	97.8%
Rural Principal Arterial	92.9%	93.8%	95.5%	96.0%	96.2%	96.1%
Rural Minor Arterial	91.2%	92.1%	93.2%	93.1%	93.8%	94.3%
Rural Major Collector	86.4%	87.3%	86.1%	86.9%	87.6%	88.5%
Small Urban Interstate	94.9%	96.1%	95.9%	95.3%	94.6%	95.0%
Small Urban Other Freeway & Expressway	91.1%	92.6%	93.0%	94.4%	95.3%	93.9%
Small Urban Other Principal Arterial	82.1%	80.6%	82.2%	83.3%	83.8%	84.2%
Small Urban Minor Arterial	82.4%	84.0%	81.8%	81.7%	82.1%	77.6%
Small Urban Collector	78.8%	78.7%	76.6%	74.3%	74.9%	66.5%
Urbanized Interstate	88.8%	88.1%	90.4%	91.0%	89.3%	89.9%
Urbanized Other Freeway & Expressway	87.8%	86.9%	87.6%	86.8%	87.4%	87.4%
Urbanized Other Principal Arterial	76.4%	73.3%	68.3%	68.8%	68.8%	70.7%
Urbanized Minor Arterial	83.4%	83.3%	80.2%	75.7%	75.4%	73.1%
Urbanized Collector	82.1%	84.4%	80.1%	76.4%	74.5%	72.4%
Percent Good						
Rural Interstate	53.3%	56.5%	66.8%	69.6%	72.2%	73.7%
Rural Principal Arterial	43.6%	47.0%	54.3%	56.8%	60.2%	61.0%
Rural Minor Arterial	42.8%	43.8%	47.2%	48.9%	51.0%	51.5%
Rural Major Collector	43.9%	41.9%	38.6%	39.9%	42.4%	40.3%
Small Urban Interstate	51.4%	52.9%	59.8%	62.5%	65.1%	65.6%
Small Urban Other Freeway & Expressway	42.9%	38.2%	39.8%	41.6%	48.1%	57.7%
Small Urban Other Principal Arterial	36.0%	32.9%	35.0%	38.0%	37.0%	37.6%
Small Urban Minor Arterial	41.1%	43.6%	39.2%	38.2%	38.5%	33.0%
Small Urban Collector	35.8%	36.6%	36.0%	34.1%	32.8%	30.7%
Urbanized Interstate	39.1%	35.4%	39.7%	42.5%	43.8%	48.5%
Urbanized Other Freeway & Expressway	34.1%	27.4%	31.3%	31.9%	32.8%	37.8%
Urbanized Other Principal Arterial	27.3%	26.1%	24.2%	25.0%	23.8%	24.8%
Urbanized Minor Arterial	39.9%	40.8%	37.8%	33.9%	33.4%	32.2%
Urbanized Collector	35.8%	39.8%	39.9%	38.5%	35.9%	36.4%

Source: Highway Performance Monitoring System.

expressways and other principal arterials. The percentage of VMT on good ride quality pavements decreased on small urban minor arterials and collector routes. In urbanized areas, other freeways and expressways had an increase in the percentage of VMT on good ride quality roads while other principal arterial, minor arterial and collector routes showed decreases in the percentage of VMT on good ride quality pavements.

Pavement Ride Quality by Mileage

Exhibit 3-6 shows the pavement ride quality by functional classification from 1995 to 2004 based on mileage, rather than on VMT. Comparing these figures with those in Exhibit 3-5 shows that rural pavement ride quality generally appears worse when measured as a percentage of miles with good or acceptable ride quality rather than as the percentage of VMT on such roads, although this is not true for all functional classes. For urbanized areas, the situation is reversed; the percentage of miles with acceptable ride quality is generally higher than the percentage of VMT on roads with acceptable ride quality.

Exhibit 3-6

Percent of Mileage With Good and Acceptable Ride Quality, by Functional System, 1995–2004

Functional System	1995	1997	1999	2000	2002	2004
Percent Acceptable						
Rural Interstate	94.5%	95.9%	97.6%	97.8%	97.8%	98.0%
Rural Other Principal Arterial	91.4%	93.7%	95.4%	96.0%	96.6%	95.8%
Rural Minor Arterial	85.1%	89.8%	92.0%	92.0%	93.8%	93.9%
Rural Major Collector	82.5%	84.0%	79.7%	82.1%	85.9%	85.8%
Small Urban Interstate	94.4%	95.8%	95.4%	95.7%	95.3%	95.0%
Small Urban Other Freeway & Expressway	90.2%	91.2%	92.8%	93.7%	94.8%	93.9%
Small Urban Other Principal Arterial	82.0%	80.5%	81.7%	82.9%	83.0%	84.2%
Small Urban Minor Arterial	82.5%	82.2%	78.1%	80.0%	81.3%	77.6%
Small Urban Collector	76.4%	75.9%	68.3%	68.9%	70.8%	66.5%
Urbanized Interstate	90.0%	90.0%	92.2%	93.0%	91.7%	92.2%
Urbanized Other Freeway & Expressway	87.5%	87.7%	88.8%	88.3%	88.8%	89.7%
Urbanized Other Principal Arterial	75.9%	73.2%	67.6%	67.7%	67.5%	69.3%
Urbanized Minor Arterial	82.1%	82.6%	78.5%	78.3%	75.9%	75.6%
Urbanized Collector	84.4%	86.4%	80.3%	77.4%	77.6%	75.5%
Percent Good						
Rural Interstate	51.8%	56.9%	65.4%	68.5%	71.9%	72.9%
Rural Other Principal Arterial	41.0%	47.5%	54.0%	57.4%	60.9%	60.1%
Rural Minor Arterial	40.7%	45.3%	46.9%	47.7%	50.2%	47.6%
Rural Major Collector	47.7%	40.1%	32.5%	36.2%	37.1%	36.3%
Small Urban Interstate	49.8%	51.4%	58.2%	61.6%	64.9%	66.0%
Small Urban Other Freeway & Expressway	41.2%	35.8%	41.3%	43.8%	49.7%	54.6%
Small Urban Other Principal Arterial	36.3%	32.6%	33.7%	36.6%	35.4%	36.0%
Small Urban Minor Arterial	46.8%	45.5%	37.2%	38.1%	42.1%	36.3%
Small Urban Collector	43.4%	44.4%	29.3%	29.8%	33.1%	28.5%
Urbanized Interstate	41.3%	39.3%	45.0%	48.2%	48.7%	53.2%
Urbanized Other Freeway & Expressway	36.8%	31.4%	35.5%	37.9%	39.6%	43.3%
Urbanized Other Principal Arterial	28.7%	26.6%	23.5%	23.9%	22.7%	23.4%
Urbanized Minor Arterial	44.8%	45.2%	37.2%	37.6%	37.7%	35.5%
Urbanized Collector	44.3%	46.6%	30.2%	31.4%	33.4%	32.0%

Source: Highway Performance Monitoring System.

Roadway Alignment

Alignment adequacy affects the level of service and safety of the highway system. There are two types of alignment: horizontal and vertical. Inadequate alignment may result in speed reductions and impaired sight distance. In particular, trucks are affected by inadequate roadway 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 normally not an issue in 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 alignment criteria, vertical and horizontal, and therefore, except under very extreme conditions, do not have alignment problems. [*Exhibit 3-7*]

Exhibit 3-7

Rural Alignment by Functional Class, 2004

	Code 1	Code 2	Code 3	Code 4
Horizontal				
Interstate	95.3%	1.3%	0.8%	2.6%
Other Pricipal Arterial	77.0%	9.0%	8.9%	5.1%
Minor Arterial	70.0%	5.7%	16.6%	7.7%
Major collector	57.5%	18.2%	15.9%	8.5%
Vertical				
Interstate	92.6%	6.3%	0.4%	0.7%
Other Pricipal Arterial	65.1%	24.7%	6.3%	3.9%
Minor Arterial	51.2%	28.5%	12.8%	7.5%
Major collector	51.6%	28.7%	13.0%	6.7%

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.

Lane Width

Lane width affects capacity and safety; narrow lanes prevent a road from operating at capacity. As with roadway alignment, lane width is more crucial on those functional classifications with higher travel volumes. Over 99 percent of rural Interstate highways had lane widths of 12 feet or greater in 2004. The comparable percentages for urban Interstate highways and urban other freeways and expressways were 98 percent and 94 percent, respectively.

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, a plurality (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. [*Exhibit 3-8*]

Exhibit 3-8

Lane Width by Functional Class, 2004

	> 12ft	11ft	10ft	9ft	<9ft
Rural					
Interstate	99.66%	0.32%	0.00%	0.00%	0.02%
Other Pricipal Arterial	89.27%	8.75%	1.72%	0.25%	0.02%
Minor Arterial	70.31%	18.60%	9.95%	0.98%	0.16%
Major collector	37.75%	25.88%	27.05%	7.05%	2.27%
Urban					
Interstate	98.31%	1.55%	0.10%	0.00%	0.03%
Other Freeway & Expressway	94.11%	4.93%	0.79%	0.16%	0.01%
Other Prinicpal Arterial	80.91%	12.86%	5.68%	0.38%	0.17%
Minor Arterial	66.51%	17.66%	13.65%	1.76%	0.42%
Collector	50.70%	19.49%	22.09%	5.97%	1.75%

Source: Highway Performance Monitoring System.

Bridge System Conditions

The National Bridge Inspection Standards (NBIS), in place since the early 1970s, requires biennial safety inspections for bridges in excess of 6.1 meters, approximately 20 feet, in total length located on public roads. Information is collected documenting the conditions and composition of the structures. Baseline composition information is collected describing the functional characteristics, descriptions and location information, geometric data, ownership and maintenance responsibilities, and other information. This information permits characterization of the system of bridges on a national level and permits analysis on the composition of the bridges. Safety, the primary purpose of the program, is ensured through periodic hands-on inspections and rating of the primary components of the bridge, such as the deck, superstructure, and substructure. This composition and condition information is maintained in the National Bridge Inventory (NBI) database maintained by FHWA. This database represents the most comprehensive source of information on bridges throughout the United States.

Q&A

How often are the bridges inspected?

Most bridges in the U.S. Highway Bridge inventory are inspected once every 2 years. These inspections are performed by qualified inspectors. Structures with advanced deterioration or other conditions warranting closer monitoring can be inspected more frequently. Certain types of structures in very good condition may receive an exemption from the 2-year inspection cycle. These structures can be inspected once every 4 years. Qualification for this extended inspection cycle is reevaluated depending on the conditions of the bridge. Approximately 83 percent are inspected once every 2 years, 12 percent are inspected annually, and 5 percent are inspected on a 4-year cycle.

See Chapter 15 in the 2004 C&P report for more details on the National Bridge Inspection Program and the Highway Bridge Replacement and Rehabilitation Program.

Explanation of Bridge Deficiencies

From the information collected through the inspection process, assessments are performed to determine the adequacy of the structure to service the current demands for structural and functional purposes. Factors considered include the load-carrying capacity, 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 to current standards and demands. Disparities between the actual and desired 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 suffering from a structural deficiency and functional obsolescence would be classified as structurally deficient.

Condition Rating Structural Deficiencies

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 is the primary surface used for transportation. The deck is supported by the superstructure. This transfers the load of the deck and the traffic carried to the supports.

Condition ratings are used to describe the existing, in-place status of a component and not its as-built state. Rather, the existing condition is compared with an as-new condition. Bridge inspectors assign condition ratings by evaluating the severity of the deterioration or disrepair and the extent it has spread through the component being rated. They provide an overall characterization of the general condition of the entire component being rated and not an indication of localized conditions. *Exhibit 3-9* describes the bridge condition ratings in more detail.

Exhibit 3-9

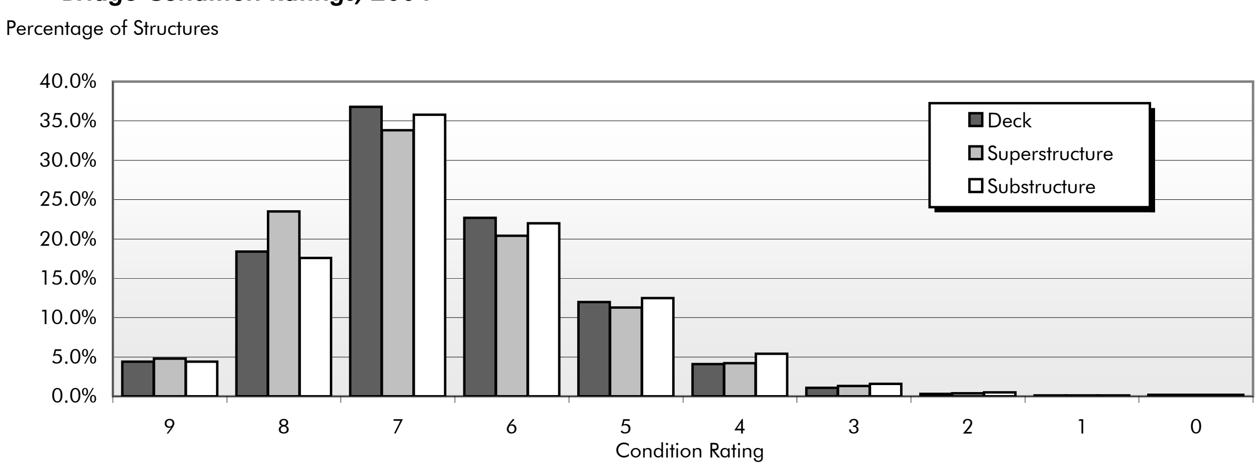
Bridge Condition Rating Categories

Rating	Condition Category	Description
9	Excellent	
8	Very Good	
7	Good	No problems noted.
6	Satisfactory	Some minor problems.
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 the 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 be 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 back in light service.
0	Failed	Out of service; beyond corrective action.

Condition rating distributions are shown in *Exhibit 3-10* for the deck, superstructure, and substructure. Condition ratings of 4 and below indicate poor or worse conditions and result in structural deficiencies. Approximately 5.8 percent of all bridge decks are deficient based on condition rating, and 6.2 percent of all superstructures and 7.8 percent of all substructures are deficient. These classifications are not mutually exclusive, and an individual structure may have one or more than one deficient component.

Exhibit 3-10

Bridge Condition Ratings, 2004



Source: National Bridge Inventory.

Appraisal Rating Structural Deficiencies

Condition ratings are the primary criteria used in the classification of structural deficiencies; 80 percent of all structurally deficient bridges have condition rating deficiencies in their decks, superstructures, substructures, or culvert ratings. The remaining 20 percent of structural deficiencies are classified based on inadequate structural appraisal ratings and/or inadequate waterway adequacy ratings. These appraisal ratings evaluate a bridge in relation to the level of service it provides on the highway system on which it is located**. The appraisal ratings compare the existing conditions with the current standards used for highway bridge design.** *Exhibit 3-11* describes appraisal rating codes in more detail.

Load-carrying capacity does not influence the assignment of the condition ratings, but it does factor into the structural evaluation appraisal rating. This is calculated according to the capacity ratings for various categories of traffic in terms of average daily traffic (ADT). A rating of 2 or less indicates the carrying capacity is too low and the structure should be replaced. In this case, the bridge is classified as structurally deficient.

Q&A

What makes a bridge structurally deficient, and are structurally deficient bridges 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. The fact that a bridge is "deficient" does not immediately imply that it is likely to collapse or that it is unsafe. With hands-on inspection, unsafe conditions may be identified and, 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 are often posted with weight limits to restrict the gross weight of vehicles using the bridges to less than the maximum weight typically allowed by statute.

Exhibit 3-11

Bridge Appraisal Rating Categories

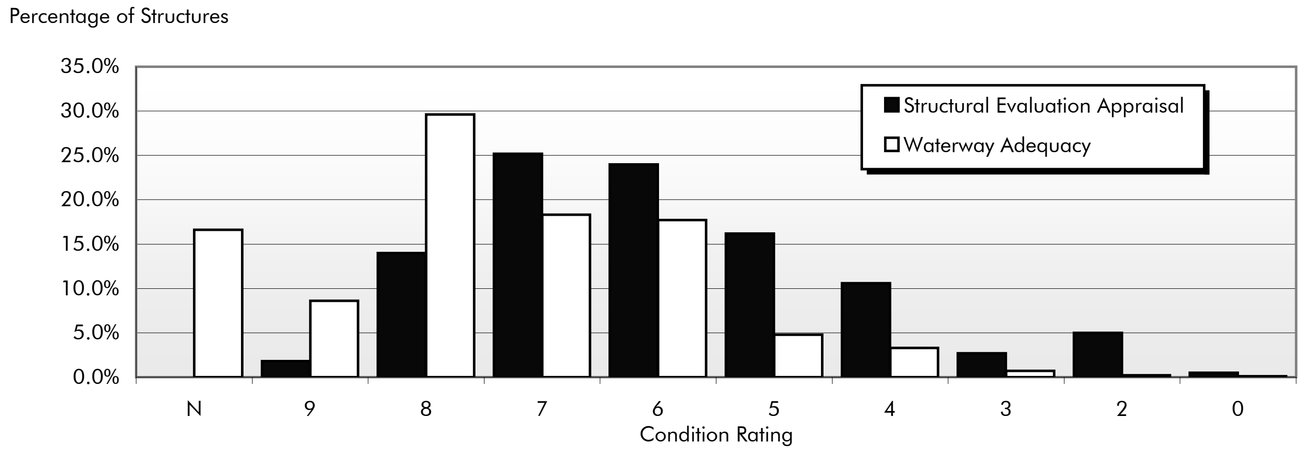
Rating	Description
N	Not applicable.
9	Superior to present desirable criteria.
8	Equal to present desirable criteria.
7	Better than present minimum criteria.
6	Equal to present minimum criteria.
5	Somewhat better than minimum adequacy to tolerate being left in place as is.
4	Meets minimum tolerable limits 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.

The waterway adequacy appraisal rating assesses the opening of the structure with respect to the passage of flow through the bridge. This factor, which considers the potential for overtopping of the structure during a flood event and the potential inconvenience to the traveling public, is assigned based on criteria assigned by functional classification. Waterway adequacy appraisal ratings of 2 or less categorize a bridge as structurally deficient.

The distribution of structural evaluation appraisal and waterway adequacy ratings is shown in *Exhibit 3-12.* Roughly 5.5 percent of bridges are structurally deficient based on inadequate structural evaluation appraisal ratings, indicating the existing deficiencies require replacement of the structure. Waterway adequacy impacts a much smaller percentage of structures, with 0.3 percent of the bridges in the network classified as structurally deficient resulting from ratings of 2 or below.

Exhibit 3-12

Structural Evaluation/Waterway Adequacy Ratings, 2004



Source: National Bridge Inventory.

The structural evaluation appraisal ratings, as mentioned, are used as a factor for determining whether a bridge has a structural deficiency. Descriptions of the ratings are given in Exhibit 3-11. A rating of 3 indicates the load-carrying capacity is too low; however, the situation can be mitigated through corrective action. In this case, the bridge is classified as functionally obsolete. Likewise, waterway adequacy appraisal ratings of 3 result in functional obsolescence. Ratings of 2 or below for either the structural evaluation or waterway adequacy appraisals result in a bridge being classified as structurally deficient as these ratings typically are not correctable without replacement.

Q&A

How does a bridge become functionally obsolete?

Functional obsolescence is a function of the geometrics 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 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. However, the design standards have changed since the 1930s. Therefore, 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 the existing conditions cause the bridge to be classified as functionally obsolete.

Appraisal Rating Functional Obsolescence

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

Deck geometry ratings consider the width of the bridge, the ADT, the number of lanes carried by the structure, whether two-way or one-way traffic is serviced, and functional classifications. The minimum desired width for the roadways is compared with the actual widths and used as a basis for appraisal rating assignment. Minimum vertical clearances are also considered by functional classification. Underclearance appraisals consider both the vertical and horizontal underclearances as measured from the through roadway to the nearest bridge component. 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 rating philosophy. Instead of comparing the approach alignment with current standards, the alignment of the approach roadway is compared with the alignment of the bridge spans. Deficiencies are identified where the bridge route does not function adequately because of alignment disparities.

The distribution of structural evaluation appraisal and waterway adequacy ratings is shown in Exhibit 3-12. Approximately 5.5 percent of bridges are classified as functionally obsolete based on structural evaluation appraisal ratings. Waterway adequacy impacts a much smaller percentage of structures, with 0.7 percent of bridges classified as functionally obsolete resulting from a rating of 3, indicating corrective actions are required to mitigate the inadequate waterway capacities.

Functional obsolescence occurs primarily because of the deck geometry, underclearance, and approach alignment appraisals. Distributions of the number of structures classified as functionally obsolete by appraisal ratings are given for these factors in *Exhibit 3-13.*

Overall Bridge Condition

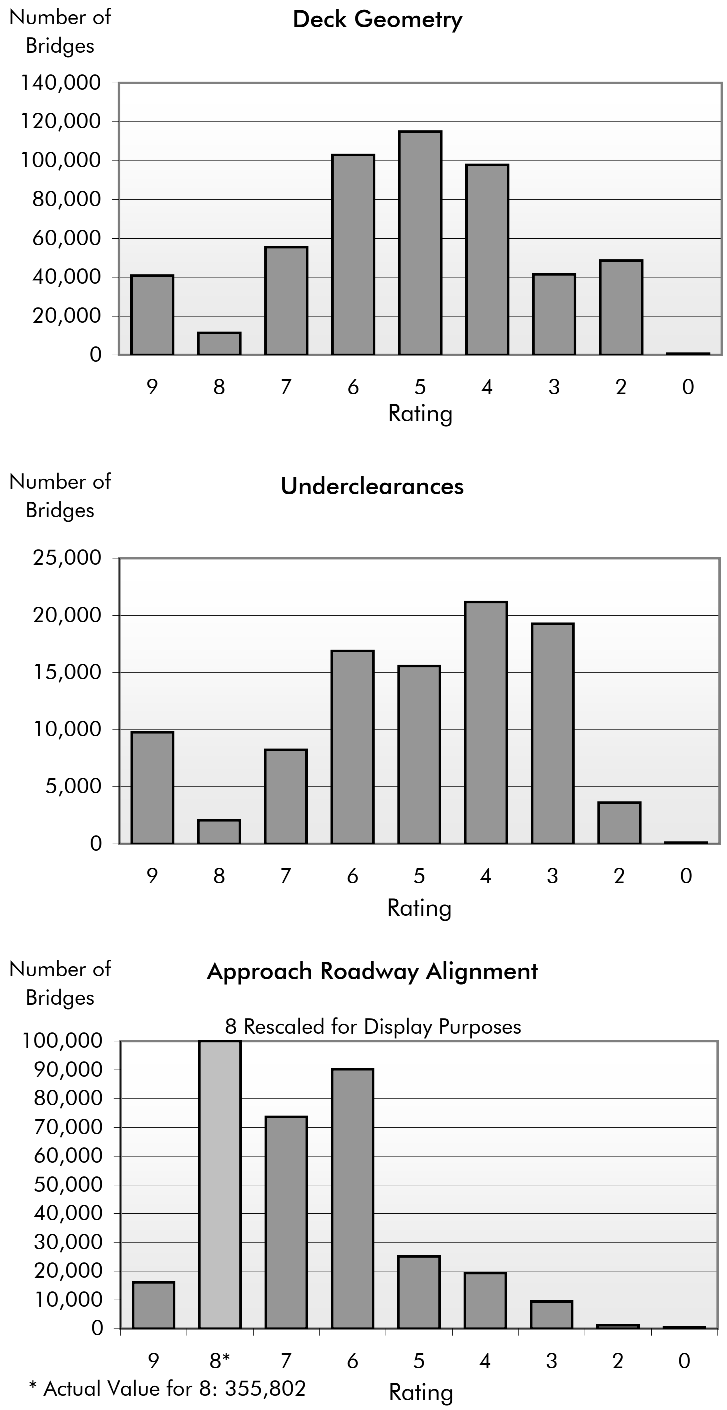
Structural deficiencies and functional obsolescence are not mutually exclusive, and a bridge may have both types of deficiencies. When deficiency percentages are presented, however, bridges are indicated as being in one of three categories—structurally deficient, functionally obsolete, or non-deficient. As structural deficiencies may imply safety problems, they are considered more critical; thus, **a bridge that is both structurally deficient and functionally obsolete is identified only as structurally deficient**. Approximately 50 percent of the structurally deficient population also will have functional issues to be corrected. Bridges indicated as functionally obsolete do not have structural deficiencies.

Number of Deficient Bridges

One commonly cited indicator of bridge condition is the number of deficient bridges. Of the 594,101 bridges listed in the inventory in 2004, 158,428, or slightly less than 26.7 percent, are classified as deficient for either structural or functional reasons. Of these, 77,796 are classified as structurally deficient and 80,632 are classified as functionally obsolete. Thus, roughly half of the deficiencies are structural and half are functional.

Exhibit 3-13

Functional Obsolescence: Deck Geometry, Underclearance, and Approach Alignment Ratings, 2004



Source: National Bridge Inventory.

Exhibit 3-14 shows the trend of deficiency percentages from 1994 through 2004. 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 structurally deficient bridges have no functional obsolescence issues and are deficient solely on the basis of structural safety and deteriorated bridge component conditions. The remaining structurally deficient bridges also have some type of functional obsolescence.

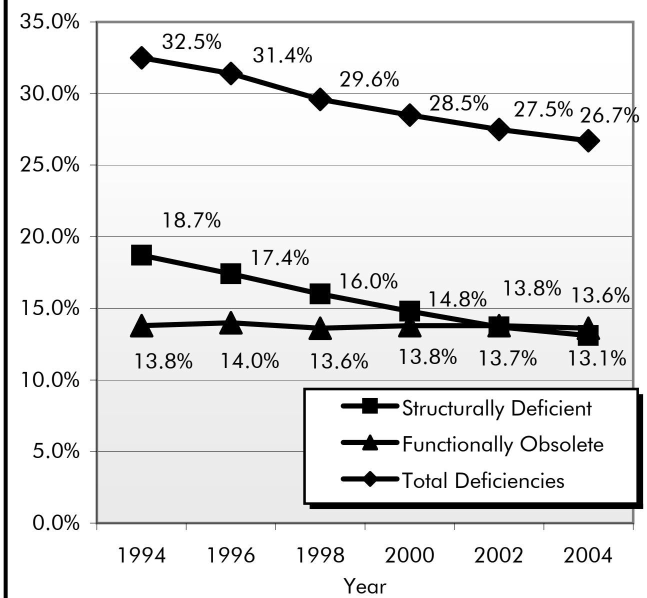
Deficient Bridges by Deck Area and Traffic Carried

The FHWA has adopted the percent of deficient deck area on bridges on the NHS and the percent of deficient deck area on non-NHS bridges as primary performance measures for bridge condition. See Chapter 12 for additional information on NHS bridge conditions.

The 77,796 bridges identified as structurally deficient in 2004 comprised 9.7 percent of the total deck area of all bridges on and off the NHS. The 80,632 functionally obsolete bridges in 2004 accounted for approximately 17.4 percent of the total deck area on all bridges. Taken together, the 158,428 bridges classified as structurally deficient or functionally obsolete bridges in 2004 accounted for 27.1 percent of the total deck area on all bridges. [*Exhibit 3-15*]

Exhibit 3-14

Bridge Deficiency Percentages, 1994–2004



Source: National Bridge Inventory.

The 158,428 deficient bridges in 2004 represent approximately 26.7 percent of the total inventory of highway bridges when bridges are weighted equally. When weighted by traffic carried, this percentage is slightly lower, as 26.6 percent of daily bridge traffic is carried by bridges that are classified as either structurally deficient or functionally obsolete.

Deficient Bridges by Owner

Bridge deficiencies by ownership are examined in *Exhibit 3-16.* For Federally owned bridges, the number of bridges classified as functionally obsolete outweighs the number classified as structurally deficient by almost a 2 to 1 ratio. Similar percentages are seen for State-owned bridges. These bridges constitute a much more significant proportion of the overall inventory of structures, since State agencies own approximately 48 percent of all bridges. Locally owned and private bridges have opposite trends, with the number of structurally deficient bridges outweighing the number of functionally obsolete bridges.

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 [Exhibit 3-16]. The percentages are dominated by State and local ownership, with only small percentages of the total population of all structures attributable to Federal, private, and other owners. However, it should be noted that 45 percent of privately owned bridges are deficient: 24 percent are structurally deficient and 21 percent are functionally obsolete.

Exhibit 3-15

Bridge Deficiencies by Number, Percent of Deck Area on Deficient Bridges, and Percent of ADT Carried on Deficient Bridges, 2004

	Total
Total Number of Bridges	**593,416**
Number of Structurally Deficient Bridges	77,720
Percent of Structurally Deficient Bridges	13.1%
Percent of Deck Area of Structurally Deficient Bridges	9.7%
Percent of ADT on Structurally Deficient Bridges	7.2%
Number of Functionally Obsolete Bridges	80,462
Percent of Functional Obsolete Bridges	13.6%
Percent of Deck Area of Functionally Obsolete Bridges	17.4%
Percent of ADT on Functionally Obsolete Bridges	19.3%
Total Number of Deficient Bridges	158,182
Total Percent of Deficient Bridges	26.7%
Total Percent of Deck Area on Deficient Bridges	27.1%
Total Percent of ADT on Deficient Bridges	26.5%

Note: Differences in total values are due to coding omissions or submission obmission.

Source: National Bridge Inventory

Exhibit 3-16

Bridge Deficiencies by Owner, 2004

	Federal	State	Local	Private/Other	Total
Numbers					
Total Bridges	8,425	282,552	300,444	2,680	594,082
Total Deficient	2,085	67,702	87,447	1,194	158,423
Structurally Deficient	708	24,061	52,390	637	77,793
Functionally Obsolete	1,377	43,641	35,057	557	80,630
Percentages					
% of Total Inventory for Owner	1%	48%	51%	0%	100.0%
% Deficient	25%	24%	29%	45%	26.7%
% Structurally Deficient	8%	9%	17%	24%	13.1%
% Functionally Obsolete	16%	15%	12%	21%	13.6%

Note: Differences in total values are due to coding omissions or submission obmission.

Source: National Bridge Inventory

Rural and Urban Deficient Bridges by Functional Classification

As noted in Chapter 2 and as shown in *Exhibit 3-17*, the majority of bridges in terms of numbers are located in rural environments. With rural bridges, the number of structural deficiencies (65,577) outweighs the number of bridges classified as functionally obsolete (50,276). Urban roadways carry significantly higher volumes of traffic, as noted in Chapter 2. With urban bridges, the number of structurally deficient bridges (12,176) is significantly lower than the number of functionally obsolete bridges (29,675). 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

Exhibit 3-17

Bridge Deficiencies by Functional System, 2004

Functional Class	Total Number of Structures	Structurally Deficient	Functionally Obsolete	Total Deficiencies
Rural Interstate	27,648	1,163	3,224	4,387
Rural Other Principal Arterial	36,259	1,934	3,238	5,172
Rural Minor Arterial	40,197	3,317	4,354	7,671
Rural Major Collector	94,079	10,825	9,826	20,651
Rural Minor Collector	49,391	6,560	5,470	12,030
Rural Local	208,641	41,778	24,164	65,942
Total Rural	456,215	65,577	50,276	115,853
Urban Interstate	27,667	1,667	5,617	7,331
Urban Other Freeways of Expressway	17,112	985	3,431	4,419
Urban Other Principal Arterial	24,529	2,194	5,428	7,659
Urban Minor Arterial	24,802	2,508	6,402	8,965
Urban Collector	15,548	1,685	3,783	5,590
Urban Local	27,940	3,137	5,014	8,520
Total Urban	137,598	12,176	29,675	42,484
Total Identified by Functional Class	593,813	77,753	79,951	158,337
Unknown	288	21	9	30
Total, Including Unknown	**594,101**	**77,774**	**79,960**	**158,367**

Source: National Bridge Inventory.

population and hence the number of deficiencies is larger. Structural deficiencies are more prevalent, in terms of percentages, in rural environments.

Bridge conditions in rural and urban areas have steadily improved over the past decade. As seen in *Exhibit 3-18,* overall deficiencies and structural deficiencies have both decreased. Functional obsolescence percentages, however, have not decreased and have remained relatively static in both rural and urban environments.

Exhibit 3-18

Percent Deficient Bridges by Functional Class and Area, 1994-2004

Year		1994	1996	1998	2000	2002	2004
Interstate							
Rural	Deficient Bridges	18.5%	19.1%	16.4%	16.0%	15.8%	15.9%
	Structurally Deficient	4.0%	4.4%	4.1%	3.9%	4.0%	4.2%
	Functionally Obsolete	14.5%	14.7%	12.2%	12.2%	11.8%	11.7%
Urban	Deficient Bridges	30.6%	30.8%	26.8%	27.0%	26.3%	26.5%
	Structurally Deficient	8.3%	7.8%	6.7%	6.5%	6.1%	6.0%
	Functionally Obsolete	22.3%	23.0%	20.1%	20.5%	20.1%	20.5%
All Bridges on	Deficient Bridges	24.2%	24.7%	21.6%	21.5%	21.1%	21.2%
Interstates	Structurally Deficient	6.0%	6.0%	5.4%	5.2%	5.1%	5.1%
	Functionally Obsolete	18.2%	18.7%	16.2%	16.4%	16.0%	16.1%
Other Arterials							
Rural	Deficient Bridges	21.7%	21.5%	19.4%	18.2%	17.5%	16.8%
	Structurally Deficient	9.5%	9.1%	8.3%	7.3%	7.1%	6.9%
	Functionally Obsolete	12.1%	12.4%	11.1%	11.0%	10.4%	9.9%
Urban	Deficient Bridges	36.0%	35.1%	33.6%	32.9%	32.2%	31.7%
	Structurally Deficient	12.7%	11.7%	10.6%	9.5%	9.0%	8.6%
	Functionally Obsolete	23.3%	23.4%	22.9%	23.4%	23.2%	23.0%
All Bridges on	Deficient Bridges	28.0%	27.6%	25.8%	24.9%	24.4%	23.7%
Other Arterials	Structurally Deficient	10.9%	10.2%	9.3%	8.3%	8.0%	7.7%
	Functionally Obsolete	17.0%	17.3%	16.5%	16.6%	16.4%	16.0%
Collectors							
Rural	Deficient Bridges	26.7%	25.8%	24.7%	24.3%	23.6%	22.8%
	Structurally Deficient	16.0%	14.8%	13.9%	13.2%	12.6%	12.1%
	Functionally Obsolete	10.7%	10.9%	10.8%	11.0%	11.0%	10.7%
Urban	Deficient Bridges	40.3%	40.2%	38.2%	37.3%	36.4%	36.0%
	Structurally Deficient	16.4%	15.7%	14.4%	12.7%	11.5%	10.8%
	Functionally Obsolete	23.9%	24.5%	23.8%	24.7%	24.9%	24.3%
All Bridges on	Deficient Bridges	27.9%	27.1%	26.0%	25.5%	24.8%	24.1%
Collectors	Structurally Deficient	16.1%	14.9%	14.0%	13.2%	12.5%	12.0%
	Functionally Obsolete	11.9%	12.2%	12.0%	12.3%	12.3%	12.0%
Locals							
Rural	Deficient Bridges	40.9%	38.5%	36.5%	34.7%	33.0%	31.6%
	Structurally Deficient	29.2%	27.1%	24.6%	23.0%	21.1%	20.0%
	Functionally Obsolete	11.7%	11.4%	11.8%	11.7%	11.9%	11.6%
Urban Bridges	Deficient Bridges	35.5%	34.0%	32.6%	31.6%	30.7%	30.5%
	Structurally Deficient	16.5%	15.5%	14.4%	13.0%	11.8%	11.2%
	Functionally Obsolete	19.0%	18.5%	18.2%	18.5%	18.8%	17.9%
All Bridges on	Deficient Bridges	40.3%	38.0%	36.1%	34.3%	32.7%	31.5%
Local Functional	Structurally Deficient	27.9%	25.9%	23.5%	21.9%	20.0%	19.0%
Classes	Functionally Obsolete	12.4%	12.1%	12.5%	12.5%	12.7%	12.3%

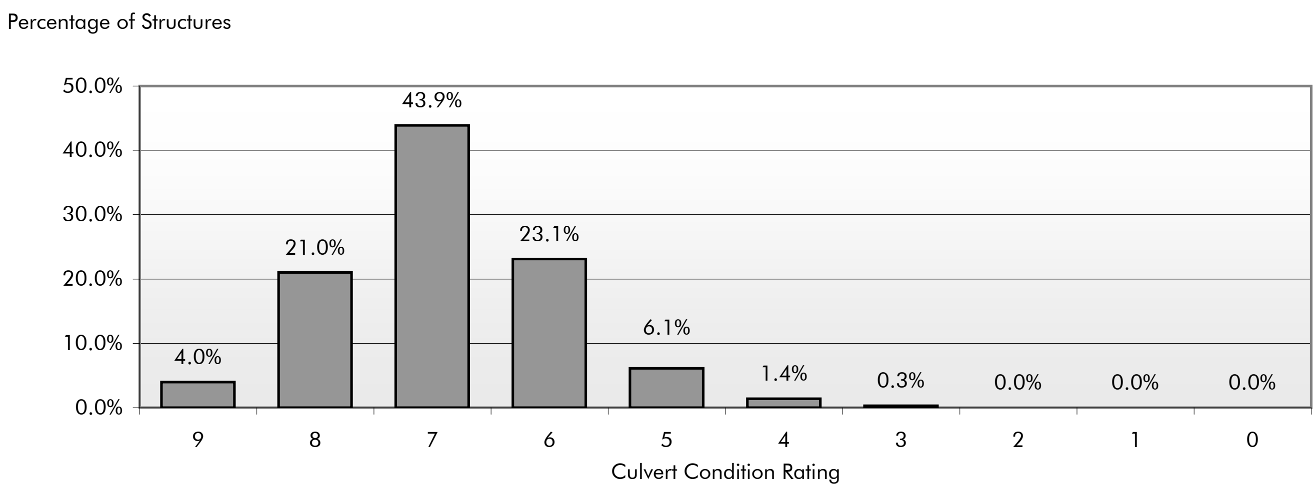
Source: National Bridge Inventory.

Culvert Deficiencies

There are 121,668 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 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 is shown in *Exhibit 3-19.* Of all 121,668 culverts in the inventory, approximately 1.7 percent are classified as structurally deficient based on condition ratings less than or equal to 4 (poor conditions).

Exhibit 3-19

Culvert Condition Ratings, 2004



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 such as bridges and tunnels.

The Federal Transit Administration (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 Federal Highway Administration to evaluate pavement conditions. A rating of 5, or "excellent," is synonymous with no visible defects or nearly new condition. At the other end of the scale, a rating of 1 indicates that the asset needs immediate repair and may have a seriously damaged component or components [*Exhibit 3-20*].

Exhibit 3-20

Definitions of Transit Asset Conditions

Rating	Condition	Description
Excellent	5	No visible defects, near new condition.
Good	4	Some slightly defective or deteriorated components.
Fair	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 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 capital nonreplacement 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 addition to age. [*See Appendix C.*]

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 2004. 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 nonreplacement capital expenditures by vehicle are also available on an agency and modal basis. For this reason, for the purpose of calculating conditions, average agency maintenance and nonreplacement capital 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 2004 C&P report, asset data for approximately 35 percent of the Nation's transit assets have been updated. Vehicle data from the NTD were used to update 21 percent of the TERM data. An additional 14 percent of TERM data were updated with inventory data provided by 25 of the nation's larger rail transit 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 1995 to 2004 in *Exhibit 3-21.*

Exhibit 3-21

Urban Transit Bus Fleet Count, Age, and Condition, 1995 –2004

						<-Revised Basis->	
YEAR	**1995**	**1997**	**1999**	**2000**	**2002**	**2002**	**2004**
Articulated Buses *							
Total Fleet	1,716	1,523	1,967	2,078	2,307	2,765	3,060
Percent Overage Vehicles**	33%	61%	46%	29%	15%	17%	7%
Average Age	10.7	11.8	8.7	6.9	6.7	7.1	4.9
Average Condition	2.55	2.49	3.10	3.33	3.17	3.11	3.38
Full-Size Buses							
Total Fleet	46,335	47,149	49,195	49,721	50,294	46,685	46,090
Percent Overage Vehicles**	23%	25%	26%	25%	22%	19%	18%
Average Age	8.6	8.2	8.7	8.5	7.7	7.5	7.3
Average Condition	2.83	2.86	2.90	2.93	2.99	3.02	3.00
Mid-Size Buses							
Total Fleet	3,879	5,328	6,807	7,643	8,914	7,304	7,114
Percent Overage Vehicles**	23%	18%	14%	15%	21%	34%	23%
Average Age	6.8	5.6	5.7	5.7	5.6	8.1	8.1
Average Condition	3.08	3.30	3.30	3.30	3.30	2.93	2.93
Small Buses							
Total Fleet	5,447	7,081	8,461	9,039	10,096	14,857	15,981
Percent Overage Vehicles**	13%	13%	13%	12%	14%	18%	13%
Average Age	4.0	3.7	4.0	4.2	4.1	4.5	4.8
Average Condition	3.55	3.56	3.51	3.47	3.53	3.39	3.37
Vans							
Total Fleet	11,969	13,796	14,539	16,234	17,300	17,300	19,164
Percent Overage Vehicles**	21%	22%	5%	6%	11%	11%	7%
Average Age	3.2	2.3	3.2	3.2	3.2	3.2	3.5
Average Condition	3.71	3.75	3.71	3.71	3.62	3.62	3.61
Total Fleet	69,346	74,877	80,969	84,715	88,911	88,911	91,409
Percent Overage Vehicles**	22%	24%	20%	19%	19%	19%	15%
Weighted Average Age	7.3	6.6	7.0	6.8	6.2	6.2	6.1
Weighted Average Condition	2.88	2.94	3.01	3.05	3.09	3.07	3.08

*An articulated bus has two passenger-carrying sections connected by a flexible section that allows the vehicle to bend and passengers to move from one section to the other.

**Percent over FTA minimum required replacement age.

Source: Transit Economic Requirements Model and National Transit Database.

Conditions have gradually improved for all bus vehicle types from 1995 to 2002 and declined slightly between 2002 and 2004. In 2004, the estimated average condition of the urban bus fleet was 3.08 compared with 3.09 in 2002 and 2.88 in 1995. [Note that all condition estimates prior to 2002 are based on a different bus vehicle classification system. The reclassification of vehicles had only a very marginal impact on the condition estimates for the total bus fleet.] The improvement in conditions between 1995 and 2004 reflects a decrease in the average age of the bus vehicle fleet from 7.3 to 6.1 years. Since 1995, larger vehicles *(articulated, full-size, and mid-size buses)* have tended to have, on average, slightly lower-rated conditions than smaller vehicles (small buses, vans). Vans, paratransit vehicles, and small buses, in general, decay more rapidly than full-size buses. Vans typically reach a condition of 2.5 in 7 years, compared with 14 years, on average, for a 40-foot bus. Average bus fleet conditions vary considerably from agency to agency. Average bus fleet conditions ranged from 2.30 to 4.40 for the 31 agencies that participated in the most recent FTA bus vehicle conditions assessment.

> **Q&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 3-21*. The first column reports average conditions based on bus categories determined by seating capacity only (old classification system), and the second column reports conditions based on bus categories determined first by length, and when length was not available, by seating capacity (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. All buses 45 feet or longer must be articulated for structural reasons. Four hundred and fifty-eight vehicles were shifted 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-sizes 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.

Articulated buses experienced the largest fluctuations in conditions between 1995 and 2004, ranging from 2.49 in 1997 to 3.38 in 2004. The fluctuations in articulated bus conditions are most likely the result of a 12-year industry replacement policy and the fact that the bulk of articulated buses was purchased between 1983 and 1984. [Note that vehicle age frequently exceeds the recommended replacement age, so that the gradual replacement of articulated buses starting around 1997 would be consistent with the 12-year replacement policy.] This replacement cycle is evidenced by a peak in the percentage of articulated buses that were overage at 61 percent in 1997 and the subsequent decline in this percentage to 7 percent in 2004. Mid-size buses had maintained an average condition above 3.0 in all years based on the old bus classification systems. However, based on the new classification system, their average condition fell from 3.30 in 2000 to 2.93 in both 2002 and 2004 as a considerable number of these vehicles in better-than-average condition for this category were reclassified as small buses. Both small buses and vans have consistently maintained an average condition of close to 3.5 or higher. However, vehicles reclassified from the full- and mid-size bus categories to the small bus category lowered the average conditions of small buses to 3.39 in 2002 and 3.37 in 2004. Full-size buses, which were on average consistently just below "adequate" condition between 1995 and 2000, reached an "adequate" average condition of 3.02 in 2002, under the new classification system, which was maintained at a condition of 3.00 in 2004.

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 declined from 1,219 in 2002 to 1,207 in 2004. *Exhibit 3-22* provides the estimated age distribution of these maintenance facilities in 2004. 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 2004 as reported in the NTD. In 2004, 10 percent of bus maintenance facilities were less than 10 years old (compared with 12 percent in 2002), 42 percent were 11 to 20 years old (compared with 33 percent in 2002), 24 percent were 21 to 30 years of age (compared with 31 percent in 2002), and 24 percent were 31 years or older (the same as in 2002). Individual facility ages may not relate well to condition, since substantive renovations are made to facilities at varying intervals. However, the increase in the percentage of maintenance facilities aged 20 years or less between 2002 and 2004 contributed to an increase in bus maintenance facility conditions during this period.

Exhibit 3-22

Urban Bus Maintenance Facility Ages, 2004 *

Age (Years)	Number	Percent
0–10	126	10%
11–20	505	42%
21–30	285	24%
31+	291	24%
Total	**1,207**	100%

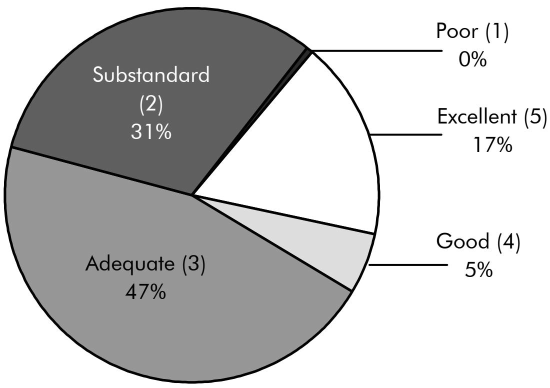
* Includes motorbus, demand response, Publico, trolleybus, and vanpool.

Source: TERM, National Transit Database.

The average condition of bus maintenance facilities, including those used for vans and demand response vehicles, improved from 3.34 in 2002 to 3.41 in 2004. In 2004, 17 percent of all urban bus maintenance facilities were in excellent condition (compared with 7 percent in 2002), 5 percent in good condition (compared with 6 percent in 2002), and 47 percent in adequate condition (compared with 55 percent in 2002). Combined, 69 percent of all urban bus maintenance facilities were in adequate or better condition in 2004 and 31 percent in unacceptable condition in 2004, compared with 67 percent in adequate or better condition and 33 percent in unacceptable condition in 2002 *[Exhibit 3-23].*

Exhibit 3-23

Conditions of Urban Bus Maintenance Facilities, 2004*



*Includes motorbus, demand response, Publico, trolleybus, and vanpool.

Source: Transit Economic Requirements Model.

	2004	
CONDITION	NUMBER	PERCENT
Excellent (5)	208	17%
Good (4)	62	5%
Adequate (3)	551	46%
Substandard (2)	379	31%
Poor (1)	6	0%
Total	1,207	100%

Rail Vehicles

The average rail vehicle condition increased from 3.47 in 2002 to 3.50 in 2004, reflecting a decline in the average age from 20.4 years in 2002 to 19.7 years in 2004. By comparison, in 1995 the average rail vehicle condition was 3.48 with an average age of 19.1 years *[Exhibit 3-24]*. Average rail vehicle age and condition are heavily influenced by the average age and condition of heavy rail vehicles, which in 2004 accounted for 56 percent of the total U.S. rail fleet. All rail vehicles combined have been, on average, in slightly better condition than all bus and bus-type vehicles over the 1995 to 2004 period.

Exhibit 3-24

Urban Transit Rail Fleet Count, Age, and Condition, 1995–2004

Year	1995	1997	1999	2000	2002	2004
Commuter Rail Locomotives						
Total Fleet	570	586	644	591	709	772
Percent Overage Vehicles**	21%	22%	17%	19%	23%	22%
Average Age	15.6	16.5	16.1	15.8	16.9	18.0
Average Condition	3.77	3.70	3.82	3.77	3.72	3.72
Commuter Rail Passenger Coaches						
Total Fleet	2,402	2,470	2,886	2,793	2,985	3,549
Percent Overage Vehicles**	36%	33%	32%	29%	34%	32%
Average Age	20.1	19.8	18.5	17.7	19.0	17.8
Average Condition	3.63	3.68	3.74	3.76	3.68	3.78
Commuter Rail Self-Propelled Passenger Coaches						
Total Fleet	2,645	2,681	2,455	2,472	2,389	2,447
Percent Overage Vehicles**	24%	25%	60%	61%	68%	62%
Average Age	19.7	22.0	24.3	25.2	27.1	23.6
Average Condition	3.68	3.62	3.57	3.55	3.50	3.69
Heavy Rail						
Total Fleet	10,157	10,173	10,366	10,375	11,093	11,046
Percent Overage Vehicles**	37%	36%	40%	40%	36%	33%
Average Age	19.3	21.0	22.5	23.0	20.0	19.8
Average Condition	3.39	3.31	3.26	3.25	3.41	3.35
Light Rail						
Total Fleet	955	1,132	1,400	1,524	1,637	1,884
Percent Overage Vehicles**	12%	10%	15%	13%	14%	13%
Average Age	14.8	14.6	18.9	18.4	16.1	16.5
Average Condition	3.55	3.63	3.62	3.63	3.61	3.60
Total Rail						
Total Fleet	16,729	17,042	17,751	17,755	18,813	19,698
Percent Overage Vehicles**	33%	32%	39%	38%	37%	34%
Weighted Average Age	19.1	20.4	21.6	21.8	20.4	19.7
Weighted Average Condition	3.48	3.42	3.40	3.38	3.47	3.50

**Percent over FTA minimum required replacement age.

Sources: Transit Economic Requirements Model and National Transit Database.

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. It is interesting to note that, although 62 percent of commuter rail self-propelled passenger coaches were overage in 2004, their average condition was 3.69.

Rail Maintenance Facilities

In 2004, 51 percent of all rail facilities were estimated to be 10 years old or less (compared with 30 percent in 2002), and 13 percent were estimated to be more than 31 years old (compared with 33 percent in 2002.). The percentage estimated to be 11 to 30 years old was virtually the same [*Exhibit 3-25*]. These revisions reflect updated inventory information collected since the last report from some of the Nation's younger rail agencies and several of the larger agencies including MARTA, DART, Fort Worth (The "T"), Metro North, Long Island Railroad, New Jersey Transit, and Seattle/King County Metro, which have younger maintenance facilities than previously estimated.

Exhibit 3-25

Rail Maintenance Facility Ages, 2004 *

Age (Years)	Number	Percent
0–10	77	51%
11–20	37	24%
21–30	19	13%
31+	19	13%
Total	**152**	100%

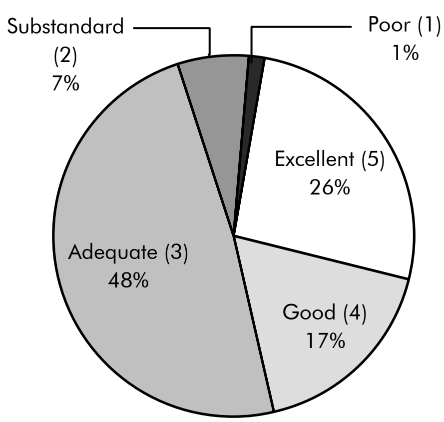
* Includes Alaska rail and inclined plane.

Source: National Rail Assessment.

Based on this new information that shifted the age distribution of rail facilities toward the "younger" 0 to 10 age group, the condition of these facilities increased from 3.56 in 2002 to 3.82 in 2004. In 2004, 26 percent were estimated to be in excellent condition (compared with 18 percent in 2002), 17 percent were estimated to be good condition (compared with 12 percent in 2002), and only 7 percent were estimated to be in substandard condition (compared with 18 percent in 2002) *[Exhibit 3-26].*

Exhibit 3-26

Conditions of Urban Rail Maintenance Facilities, 2004



	2004	
Condition	Number	Percent
Excellent (5)	40	26%
Good (4)	26	17%
Adequate (3)	74	48%
Substandard (2)	10	7%
Poor (1)	2	1%
Total	**152**	**100%**

Source: Transit Economic Requirements Model.

Rail Stations

The condition of *rail stations* increased from 2.87 in 2002 to 3.37 in 2004 *[Exhibit 3-27].* Forty-nine percent were in adequate or better condition (compared with 44 percent in 2002) and 51 percent in substandard or worse condition (compared with 56 percent in 2002). The increase in the average condition of rail stations has resulted from a revision in the rail station deterioration schedules based on data collected by FTA on-site surveys in 2004 and updated

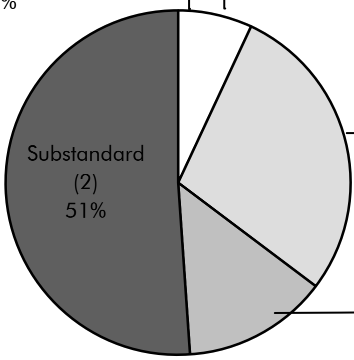
Q&A

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

Nonrail stations are in better condition than rail stations. The condition of nonrail stations is estimated to have declined from 4.37 in 2002 to 4.23 in 2004. Surveys of nonrail stations have not been conducted. Nonrail stations are assumed to have the same deterioration schedules as light rail. The condition of stations for all modes combined increased from 2.99 in 2002 to 3.43 in 2004. Rail stations dominate this average.

Exhibit 3-27

Conditions of Urban Rail Passenger Stations, 2004



Condition	2004 Number	2004 Percent
Excellent (5)	207	7%
Good (4)	834	28%
Adequate (3)	407	14%
Substandard (2)	1,510	51%
Poor (1)	3	0%
Total*	**2,961**	**100%**

**Excludes Alaska rail.*

Source: Transit Economic Requirements Model.

information on station assets collected directly from transit agencies. These surveys found that, after 10 years of age, light rail stations are, on average, in better condition than heavy rail stations; subway stations are, on average, in better condition than elevated rail stations, which are, on average, in better condition than at-grade stations. Based on these new decay curves, rail stations 22 years or older are in much better condition than previously estimated. This, combined with the finding that subway stations are, on average, in better condition than elevated or at-grade stations and account for roughly 78 percent of the value of the rail station assets, led to the large increase in condition between 2002 and 2004.

Rail Systems

Exhibit 3-28 provides estimates of the current conditions of rail systems. System data are based on the dollar amounts spent on different asset types (in constant dollars) rather than a numeric count of the assets. For this reason, condition results for these assets are displayed as percentages across condition levels. The system asset categories presented in this table differ from earlier reports. Conditions are reported for four categories—communications, train control, traction power, and revenue collection systems—assets that have been considered by TERM, but have not been reported in earlier editions of this report. The traction power category combines estimates for substations, overhead wire, and third rail, reported separately in earlier reports. This recategorization of systems in this report reflects FTA on-site engineering inspections

Exhibit 3-28

Conditions of U.S. Transit Rail Systems — Selected Years, 1997–2004

	Condition																			
	1 Poor				2 Substandard				3 Adequate				4 Good				5 Excellent			
	1997	2000	2002	2004	1997	2000	2002	2004	1997	2000	2002	2004	1997	2000	2002	2004	1997	2000	2002	2004
Communication	10%	12%	8%	0%	12%	14%	6%	0%	16%	12%	10%	25%	61%	62%	69%	63%	0%	0%	7%	12%
Train Control	13%	10%	8%	12%	11%	10%	10%	14%	16%	17%	11%	29%	52%	56%	66%	45%	9%	7%	6%	0%
Traction Power	14%	7%	4%	0%	7%	7%	3%	1%	10%	11%	11%	45%	44%	55%	45%	47%	25%	21%	37%	8%
Revenue Collect	12%	4%	1%	3%	10%	18%	7%	8%	18%	18%	2%	10%	33%	31%	56%	54%	27%	30%	34%	26%

Source: Transit Economic Requirements Model.

of systems conducted at seven agencies in 2005. [These surveys achieved a 75 percent level of statistical accuracy. Surveys are continuing in 2006. The 2008 C&P report will provide average condition estimates for each system asset based on a larger and more statistically significant sample of system assets.]

Based on the preliminary 2005 surveys, the condition of communications systems was better than indicated in the 2004 C&P report, the condition of train control systems slightly worse, and the condition of traction power systems about the same. The percentage of communications systems estimated to be in adequate or better condition increased from 86 percent in 2002 to 100 percent in 2004, and the percentage of train control systems estimated to be in adequate or better condition decreased from 83 percent in 2002 to 74 percent in 2004. Ninety-nine percent of traction power systems were estimated to be in adequate or better condition in 2004 compared with 93 percent in 2002; however, the percentage in excellent condition decreased and the percentage in adequate condition increased. Surveys were not undertaken of revenue collection systems. Changes in conditions of revenue collection systems reflect updated inventory information. Ninety percent of the revenue collection systems were estimated to be in adequate or better condition in 2004, compared with 92 percent in 2002.

Other Rail Infrastructure

Exhibit 3-29 provides conditions for other rail infrastructure. As for rail systems, 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, therefore, only provided condition results for these assets displayed as percentages across condition levels. This information is believed to be more accurate than average condition estimates. Bearing this in mind, however, this report also provides estimates of average condition by asset type.

The estimated conditions of *structures* improved. The average condition of *elevated structures* increased from 4.27 in 2002 to 4.31 in 2004. The percentage of elevated structures in adequate or better condition decreased from 91 percent in 2002 to 84 percent in 2004, and the percentage in substandard or worse condition increased from 9 to 16 percent. The average condition of *underground tunnels* increased from 4.09 in 2002 to 4.23 in 2004. The percentage of underground tunnels in adequate or better condition increased from 84 percent in 2002 to 86 percent in 2004. The percentage of underground tunnels in substandard and poor condition decreased from 17 percent in 2002 to 13 percent in 2004.

Exhibit 3-29

Conditions of U.S. Transit Rail Infrastructure—Selected Years, 1997–2004

				Condition																			
				1				**2**				**3**				**4**				**5**			
Condition Estimates				**Poor**				**Substandard**				**Adequate**				**Good**				**Excellent**			
	'00	**'02**	**'04**	**'97**	**'00**	**'02**	**'04**	**'97**	**'00**	**'02**	**'04**	**'97**	**'00**	**'02**	**'04**	**'97**	**'00**	**'02**	**'04**	**'97**	**'00**	**'02**	**'04**
Structures																							
Elevated Structures	4.02	4.27	4.31	1%	2%	2%	2%	29%	22%	7%	14%	12%	16%	3%	4%	59%	59%	83%	77%	0%	2%	5%	3%
Underground Tunnels	3.75	4.09	4.23	9%	12%	8%	7%	19%	11%	9%	6%	18%	19%	13%	12%	47%	46%	37%	48%	7%	12%	34%	26%
Track	4.06	4.17	4.27	7%	7%	6%	4%	10%	10%	9%	4%	10%	12%	12%	18%	49%	45%	34%	39%	24%	26%	40%	35%
Yards	4.00	3.64	3.80	0%	0%	0%	0%	0%	0%	20%	0%	37%	50%	48%	52%	63%	50%	31%	48%	0%	0%	1%	0%

Source: Transit Economic Requirements Model.

Track conditions are estimated to have improved from an average condition of 4.17 in 2002 to 4.27 in 2004, principally on the basis of updated asset information. The percentage of track in excellent or good condition was unchanged at 74 percent, the percentage in adequate condition increased from 12 to 18 percent, and the percentage in substandard or poor condition declined from 15 to 8 percent.

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 helped to set the groundwork for this report.

Q&A

Why did the average condition of structures increase while the percentage in adequate or better condition declined?

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

The condition of *yards* (vehicle storage yards) increased from 3.64 in 2002 to 3.80 in 2004. In 2004, 100 percent of all yards were in adequate or good condition, compared with 79 percent in 2002. The percentage in substandard condition decreased from 20 percent in 2002 to 0 percent in 2004. No yards were reported as being in poor condition in either 2002 or 2004.

The Value of U.S. Transit Assets

The value of the transit infrastructure in the United States is estimated to be $402.7 billion in 2004, compared with $347.7 billion in 2002 *[Exhibit 3-30]*. These estimates in current dollars are based on the information contained in TERM and on data collected through the NTD and the other data collection efforts discussed in this chapter. They exclude the value of assets that belong to rural and special service operators that do not report to the NTD. Sixty-four percent of the increase since the last report is a result of updated asset inventory information collected directly from transit agencies, 7 percent is a result of new vehicle count numbers from the NTD and updated vehicle costs, and 29 percent is a result of revisions to generated assets. FTA developed new algorithms to estimate generated assets, which led to the increase.

Rail assets are estimated to be $315 billion in 2004 (compared with $265 billion in 2002) and nonrail $79.5 billion in 2004 (compared with $66.7 billion in 2002). Joint assets are estimated to be $7.9 billion, compared with $16.4 billion in 2002. 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. Joint assets include administrative facilities, the external structure and furniture and equipment within, intermodal transfer centers, agency communications systems (such as PBX, radios, and computer networks), and vehicles used by agency management (such as vans and autos).

Q&A

What revisions were made to the generated assets component of TERM?

A comprehensive review was undertaken of TERM's capacity to generate assets for nonvehicle data. TERM has consistently generated assets for new agencies, but did not have a standardized mechanism 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.

Exhibit 3-30

Estimated Valuation of the Nation's Transit Assets, 2004

(Billions of current dollars)	Nonrail	Rail	Joint Assets	Total
Maintenance Facilities	$41.3	$16.1	$3.3	$60.8
Guideway Elements	$7.1	$136.0	$0.7	$143.7
Stations	$2.2	$52.3	$1.4	$55.9
Systems	$1.6	$51.6	$1.3	$54.5
Vehicles	$27.2	$59.4	$1.2	$87.7
Grand Total	**$79.5**	**$315.3**	**$7.9**	**$402.7**

Source: Transit Economic Requirements Model.

Rural Transit Vehicles and Facilities

All rural transit vehicles are buses. (Rail transit does not serve rural areas.) Data on the conditions of rural vehicles and 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 found that more than 50 percent of the rural transit fleet was overage. Forty-one percent of small buses, 34 percent of medium-size buses, 27 percent of full-size buses, and 60 percent of vans and other vehicles were found to be overage [*Exhibit 3-31*]. Small buses more than 7 years old, medium buses more than 10 years old, large buses more than 12 years old, and vans more than 5 years old were categorized as overage.

These surveys also found that 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.

Exhibit 3-31

Average Vehicle Age and Percent of Overage Vehicles in Rural Transit

1997–1999	Total Fleet	Average Age	Percent Overage
Full-Size Buses	767	7.8	27%
Medium-Size Buses	1,727	7.6	34%
Small Buses	4,413	5.7	41%
Vans and Other	11,991	7.0	60%
Total	**18,898**	**6.8**	**52%**

Source: Community Transportation Association of America.

Special Service Vehicles

No information is available on the age and condition of special service vehicles. FTA estimated that in 2002 nearly 60 percent of special service vehicles were more than 5 years old.

CHAPTER 4

Operational Performance

Summary

Exhibit 4-1 compares the key highway and transit statistics discussed in this chapter with the values shown in the last report. The first data column contains the values reported in the 2004 C&P report, which were based on 2002 data. Where the 2002 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2004 data.

Exhibit 4-1

Comparison of Highway and Transit Operational Performance Statistics with Those in the 2004 C&P Report

Statistic	2002 Data		2004 Data
	2004 C&P Report	Revised	
Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions [1]	30.5%	30.7%	31.6%
Average Length of Congested Conditions (Hours) [2]	6.6		6.6
Travel Time Index [3]	37%	1.37	1.38
Annual Delay per Peak Period Traveler (Hours) [4]	NA	45.4	45.7
Annual Delay per Capita (Hours) [5]	23.8		24.4
Passenger-mile Weighted Average Operating Speed (miles per hour)			
Total	19.9		20.1
Rail	25.3		25.0
Nonrail	13.7		14.0
Annual Passenger Miles per Capacity-equivalent Vehicle (thousands) [6]			
Motorbus	390	389	373
Heavy Rail	675	655	652
Commuter Rail	831	769	755
Light Rail	528	533	468
Demand Response	178	168	181

[1] Equivalent to Percent Travel under Congested Conditions in 2004 C&P report.

[2] Equivalent to Average Congested Travel Period in 2004 report.

[3] Equivalent to Percent of Additional Travel Time in 2004 report, but stated in different units. (37% equates to 1.37)

[4] New metric.

[5] Equivalent to Annual Hours of Traveler Delay in 2004 report.

[6] Revised due to a new methodology for calculating capacity factors. See Chapter 2 for details.

Highways

The Texas Transportation Institute (TTI) collects data related to congestion from approximately 400 communities across the Nation on a yearly basis. This information is used in the development and calculation of performance measures used by the Federal Highway Administration (FHWA). To examine highway operational performance, this chapter looks at five metrics developed at TTI to measure congestion on the Nation's highways. These are the Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions, Average Length of Congested Conditions, Travel Time Index, Annual Delay per Peak Period Traveler, and Annual Delay per Capita. Several of these measures were included in previous reports, but have been renamed to line up with the terminology used in TTI's annual Urban Mobility Study. It is important to recognize that, while these same metrics are used in that study, TTI's study is based on a smaller set of urbanized areas and are computed based on more detailed data not available for all areas. The urbanized areas reflected in that study tend to be larger than average and experience more congestion than the average urbanized area reflected in this report. Therefore, the values shown in TTI's study for these same metrics would tend to show higher levels of congestion.

The "Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions" is defined as the portion of the total VMT in an urbanized area occurring during periods of less than free-flow conditions. This metric has increased from 30.7 percent in 2002 to 31.6 percent in 2004. [Note that this measure was called the Percent of Travel Under Congested Conditions in the 2004 C&P report.]

The "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 6.6 hours between 2002 and 2004.

The "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 from 1.37 to 1.38 since 2002. In 2004, an average peak period trip required 38 percent longer than the same trip under nonpeak, noncongested conditions. For example, a trip that takes 20 minutes on average during non-congested periods would require 27.6 minutes during congested periods in 2004. [Note that this measure was described as the Percent of Additional Travel Time in the 2004 C&P report and stated as a percentage rather than a ratio.]

The "Annual Delay per Peak Period Traveler," defined as the total delay experienced by an average traveler under congested conditions during peak travel times, increased from 45.4 hours in 2002 to 45.7 hours. This is a new metric that measures the annual lost time per traveler during the congested period.

The "Annual Delay per Capita" relates the average hours of travel delay experienced by a resident of an urbanized area because of recurring congestion and incidents, such as vehicle breakdowns and crashes. Approximately 24.4 hours per capita were lost in 2004 because of congestion. This is an increase of 0.6 hour over the amount of annual delay in 2002, or an increase of approximately 2.5 percent.

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 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 motorbus fleet. As shown in Exhibit 4-1, 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 the three primary rail modes have all decreased from 2002 to 2004. Motorbus and trolleybus utilization rates were lower in 2004 than in 2002; while demand response, vanpool, and ferryboat utilization rates were higher. Utilization in all modes peaked in either 2000 or 2001 and remained below peak levels in 2004.

Average transit operating speeds remained relatively constant between 1995 and 2004 and were slightly higher in 2004 than in 2002. 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 2004, the average speed was 20.1 miles per hour, up from 19.9 miles per hour in 2002, and equal to the 10-year average of 20.1 miles per hour. The average operating speed as experienced by passengers on rail modes was 25.0 miles per hour in 2004, compared with 25.3 miles per hour in 2002, and a 10-year average of 25.6 miles per hour. The average operating speed of nonrail vehicles, which is affected by traffic, road, and safety conditions, was 14.0 miles per hour in 2004, up from 13.7 in 2002, and above the 10-year average of 13.8.

Most transit passengers do not experience unacceptably long waiting times. The 2001 National Household Travel Survey (NHTS) conducted by the FHWA, the most recent nationwide survey of passenger travel, found that 49 percent of all passengers who ride transit wait 5 minutes or less and 75 percent wait 10 minutes or less. Wait times are 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.

Highway Operational Performance

From the perspective of highway users, the ideal transportation system would move people and goods where they need to go when they need to get there, without damage to life and property, and with minimal costs to the user. Highway operational performance can be defined as how well the highway and street systems accommodate travel demand. Trends in congestion, speed, delay, and reliability are all potential metrics for measuring changes in operational performance over time.

This chapter focuses primarily on measuring operational performance trends from a broad perspective. Chapter 14 addresses operational issues that relate specifically to freight transportation, while Chapter 15 discusses operations strategies more broadly. Safety performance measures are discussed separately in Chapter 5. Issues relating to improving the measurement of operational performance are discussed in more depth in the Part IV "Afterword" section.

Highway congestion results when traffic demand approaches or exceeds the available capacity of the highway system. While this concept is straightforward, quantifying congestion is complicated by the fact that both travel demand and available capacity are variable rather than constant. It is clear that traffic demands vary significantly by time of day, day of week, 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. 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. The other half is due to nonrecurring congestion caused by temporary disruptions in traffic demand or in available capacity.

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 by many measures it is. 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 people, based on varying history and 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.

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.

The purpose of this chapter is to measure operational performance, rather than to list strategies for combating congestion problems. The Department of Transportation's ***National Strategy to Reduce Congestion on America's Transportation Network***, released in May 2006, provides a blueprint for Federal, State and local officials to follow in addressing critical operational performance issues. Several of the topics identified in the plan are also discussed in this report. Chapter 15 identifies a number of potential operations strategies to combat congestion, while Chapter 10 projects the potential impact that a more aggressive deployment of certain intelligent transportation systems (ITS) and operations strategies could have on future operational performance. Chapter 10 also includes some preliminary quantification of the possible impacts of **congestion pricing**, a potentially highly effective strategy for reducing peak period congestion. Congestion pricing is discussed in more depth in the "Introduction" to Part II of this report and is referenced in several other locations as well. Chapter 13 identifies various ongoing initiatives to reduce or remove barriers to private sector investment in the construction, ownership and operation of transportation infrastructure, and to encourage formation of **public-private partnerships**.

Operational Performance Measures

Daily vehicle miles traveled (DVMT) per lane mile is the most basic measure of the relationship between highway travel and highway capacity, since it is directly based on actual counts of traffic rather than estimated from other data. An increase in this measure over time indicates that the density of traffic is increasing, but does not indicate how this affects speed, delay, or user cost. The traditional congestion measure in this report has been the ratio of volume to service flow (V/SF), the ratio of the volume (V) of traffic using a road in the peak travel hour to the theoretical capacity or service flow (SF). V/SF is limited because it addresses only the severity and not the duration or extent of congestion. In many communities, the major operational performance issue is not that peak congestion is getting worse; it is that the peak period is spreading to occupy an increasing part of the travel day. Focusing on the V/SF measure alone can lead to erroneous conclusions about highway operational performance.

In order to overcome the shortcomings of DVMT and V/SF as measures of congestion, the FHWA has worked in conjunction with the Texas Transportation Institute (TTI) to determine a group of metrics that provides a better indication of the level of congestion on the Nation's highways. These measures are still a work in progress; but taken together, they provide a broader view of operational performance than our traditional measures can provide.

In computing these metrics for the FHWA, the TTI includes approximately 400 communities across the Nation on a yearly basis. Information was collected for 428 communities in 2004. TTI divides these

Q&A

Which metrics computed for the FHWA by the TTI are presented in this report?

This report presents five main performance measures computed by TTI for the FHWA. In describing these measures, this report will use the names TTI has designated for them in its most recent annual Urban Mobility Study, which are different than those used in the 2004 C&P report. These names are longer, but more precise, and have been adopted to reduce confusion as to exactly what the measures mean.

The "Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions" is defined as the portion of the total VMT in an urbanized area occurring during periods of less than free-flow conditions. (This measure was identified as the "Percent Congested Travel" in the 2004 C&P report.)

The "Travel Time Index" is 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. (This measure was identified as the "Percent of Additional Time" in the 2004 C&P report.)

The "Average Length of Congested Conditions" is the number of hours during a 24-hour period where travel at less than free-flow speeds occurs on a portion of the road system of an urbanized area. (This measure was described as the "Average Congested Travel Period" in the 2004 C&P report.)

The "Annual Delay per Peak Period Traveler" is defined as the total delay experienced by an average traveler under congested conditions over the course of a year. (This measure was not included in the 2004 C&P report.)

The "Annual Delay per Capita" relates the average hours of travel delay experienced by a resident of an urbanized area over the course of a year. (This measure was identified as the "Annual Hours of Travel Delay" in the 2004 C&P report.)

communities into four groups, based on population size: the 357 urbanized areas with less than 500,000 population are classified as "Small," the 31 areas with population from 500,000 to 999,999 are classified as "Medium," the 27 areas with population of 1 million to 3 million are classified as "Large," and the 13 with population 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."

Q&A

How do the values of the metrics shown in this report compare to those reported by the TTI in its annual Urban Mobility Study?

The values shown in this report are calculated by TTI on behalf of the FHWA for performance planning purposes, using data from the Highway Performance Monitoring System (HPMS) for more cities/urbanized areas ranging in population from less than 500,000 to over 3 million.

In contrast, the Urban Mobility Study concentrates on a smaller number of areas (85 in the 2005 edition) and could be considered a subset of the cities used in the work for the Performance Plan Congestion/Mobility Measures. TTI's analysis of these cities incorporates additional data sources beyond those in HPMS, which allows for a more detailed analysis. The urbanized areas in the survey do not represent a random sample of all urbanized areas, and instead include most of the largest areas, which tend to have more severe congestion problems than smaller areas.

Consequently, one should not expect the values for these metrics in the Urban Mobility Study to equal the values computed based on the larger set of urbanized areas for the FHWA.

Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions (Percent Congested Travel)

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. *Exhibit 4-2* shows that this measure of the **extent** and **duration** of congestion has increased from 25.9 percent in 1995 to 31.6 percent in 2004 for all urbanized areas combined, an increase of 5.7 percentage points or approximately 0.633 percentage points annually. However, from 2002 to 2004, this percentage increased by only 0.45 percentage points per year (from 30.7 percent to 31.6 percent), suggesting that the extent of congestion may be growing more slowly over time.

Exhibit 4-2

Average Daily Percent of VMT Under Congested Conditions, by Urbanized Area Size, 1995–2004

Urbanized Area Population	Year					
	1995	1997	1999	2000	2002	2004
Less Than 500,000	11.0	12.6	13.7	14.2	15.4	16.6
500,000 to 999,999	19.0	20.6	22.4	22.6	23.8	24.8
1,000,000 to 3,000,000	26.0	27.5	29.8	30.5	31.2	31.7
Over 3,000,000	34.4	36.7	38.2	38.5	39.6	40.7
All Urbanized Areas	**25.9**	**27.5**	**29.1**	**29.6**	**30.7**	**31.6**

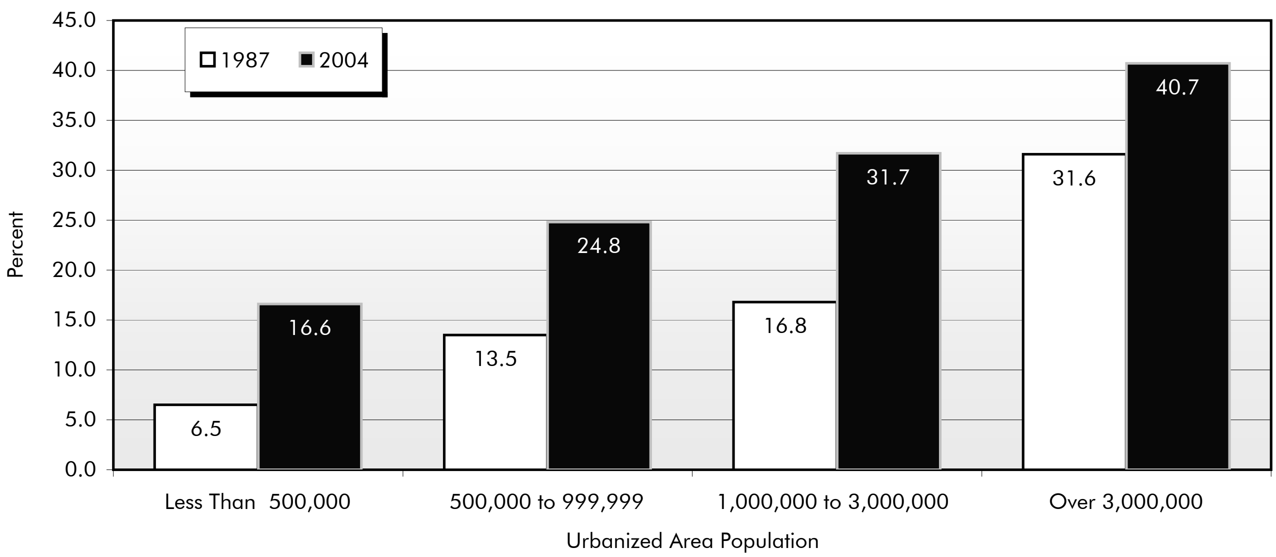
Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures

In absolute terms, this metric increased by about the same amount from 1995 through 2004 in each of the four population groups identified in Exhibit 4-2, with increases ranging from 5.6 percentage points to 6.3 percentage points. However, in relative terms, this was much more significant in the Small (population <500,000) category, since its starting point in 1995 was much lower; its increase from 11.0 percent in 1995 to 16.6 percent in 2004 exceeds 50 percent in relative terms. As was the case for urbanized areas overall, the increase for the Small (population <500,000) category for the period of 1995 to 2004 of 0.62 percentage points per year (5.6 percentage points over 9 years) was higher than the increase from 2002 to 2004 of 0.6 percentage points per year (1.2 percentage points over 2 years).

Exhibit 4-3 compares the Average Daily Percent Vehicle Miles Traveled Under Congested Conditions for each of the population groups for the years 1987 and 2004. (The year 1987 was used as a point of comparison in recent C&P reports and has been retained in this edition for consistency). A comparison between the 2 years shows communities in the Small (population <500,000) category are confronting approximately the same level of problem in 2004 as communities in the Large (population 1 million to 3 million) category were dealing with in 1987. In addition, communities in the Medium (population 500,000 to 999,999) category in 2004 are faced with a problem (24.8 percent congested travel) almost half again as great as that faced by communities in the Large category in 1987 (16.8 percent congested travel). These trends highlight that the problem of congestion does not just affect the largest cities; it is increasing in communities of all sizes across the entire Nation.

Exhibit 4-3

Average Daily Percent Vehicle Miles Traveled Under Congested Conditions, by Urbanized Area Size, 1987 vs. 2004

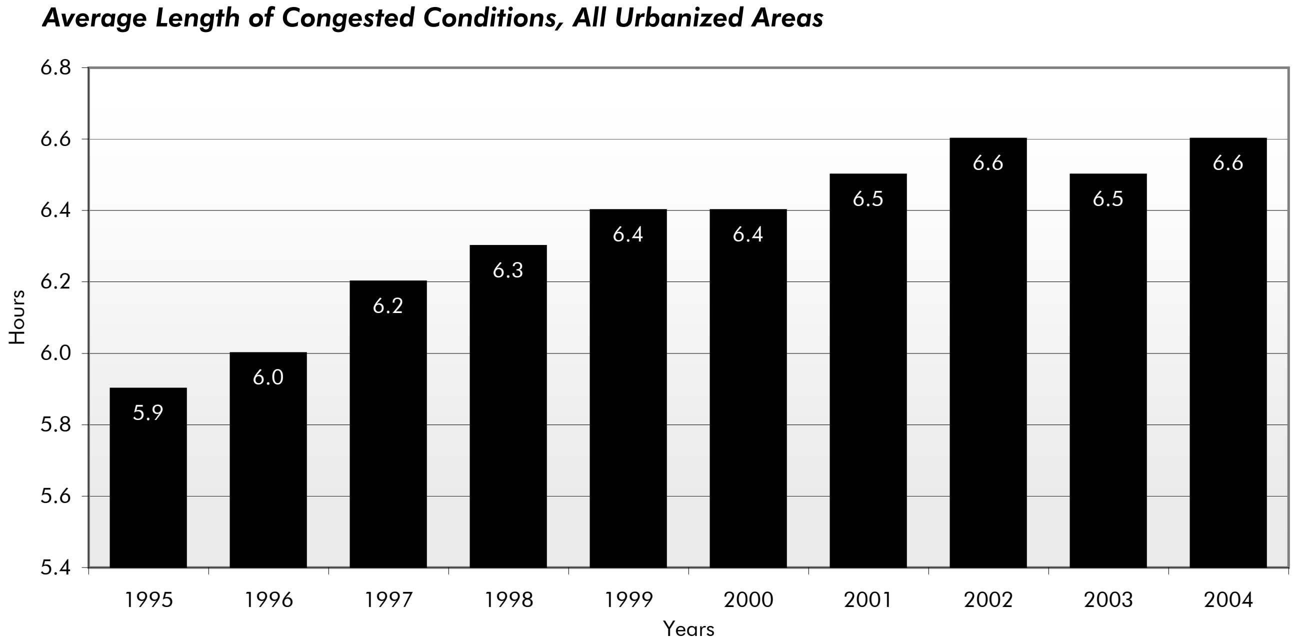


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Average Length of Congested Conditions

The Average Length of Congested Conditions is a measure of the **duration** of congestion. As shown in *Exhibit 4-4*, the average congested travel period for all urbanized areas combined has increased from 5.9 hours in 1995 to 6.6 hours in 2004—an increase in length of 42 minutes, or almost 12 percent, over a period of 9 years. The rate of increase has stabilized in recent years, as this metric has fluctuated between 6.5 hours and 6.6 hours per 24-hour period since 2001.

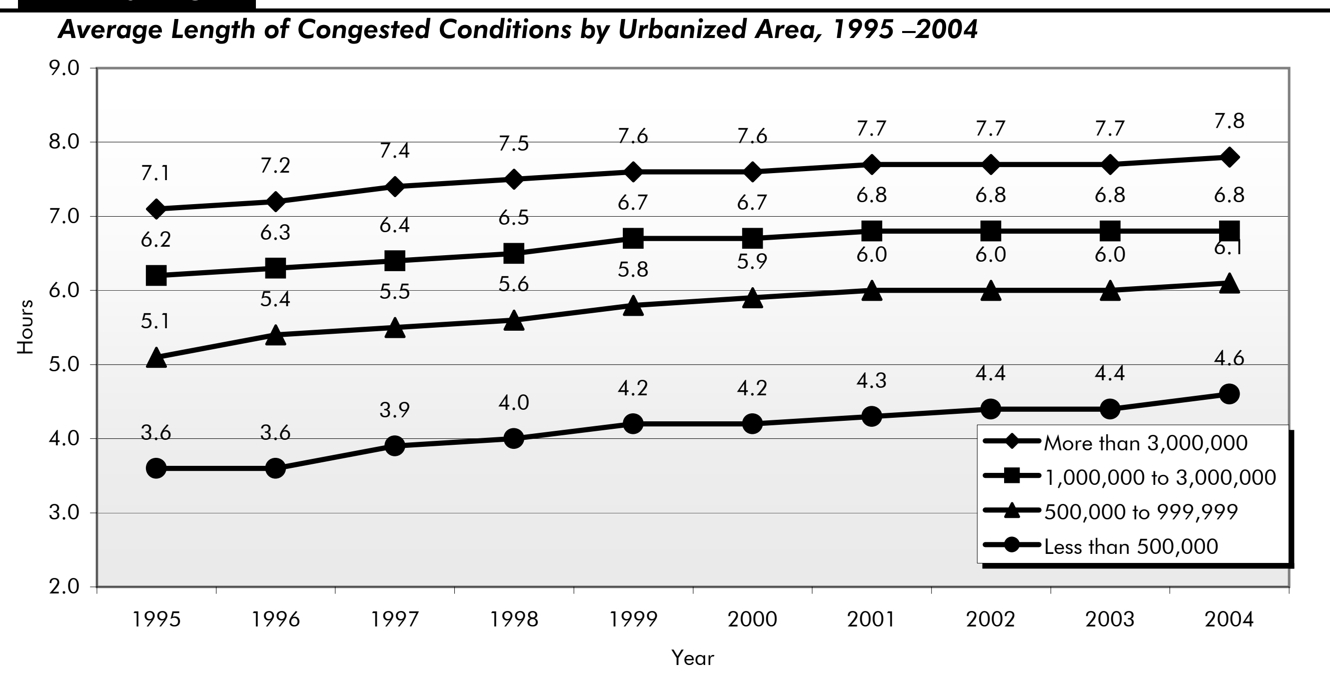
Exhibit 4-4



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

The pattern observed in the Average Length of Congested Conditions in each of the four urbanized area population categories, broken down in *Exhibit 4-5*, is similar to the overall averages shown in Exhibit 4-4; the average congested travel period has increased since 1995, but has grown more slowly in recent years. However, from 2003 to 2004, there was an increase of 0.2 hours or 12 minutes, in the average congested travel period for the 357 communities in the Small (population <500,000) category, or for 357 urbanized areas.

Exhibit 4-5



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

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) categories is a major problem. The length of the congested period in these communities is such that it is extending to a major portion of a normal workday. Recurring congestion is now no longer restricted to the traditional peak commuting periods but extends throughout the workday, resulting in continuous travel delays for highway users. 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 7.8 average hours of congested conditions identified in Exhibit 4-5 for Very Large (population > 3 million) communities could translate into congestion buildup during the morning period extending from 6:00 a.m. to 9:48 a.m. or 3.8 hours. Buildup during the afternoon period could begin at 3:30 p.m. and extend to approximately 7:30 p.m. (4 hours). 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 lateral or circumferential routes in the most congested metropolitan areas.

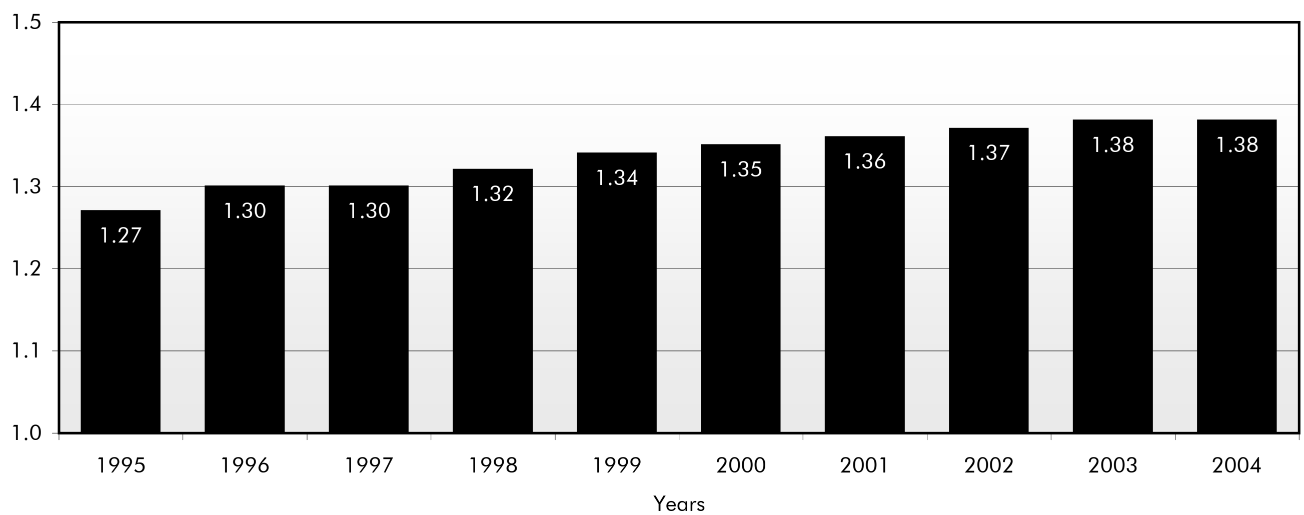
Travel Time Index

The Travel Time Index is an indicator of the **severity, duration, and extent** of congestion, measuring the additional time required to make a trip during the congested peak travel period rather than at other times of the day. 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. It is expressed as the percent of additional time required to a make a trip during the congested period of travel.

Exhibit 4-6 shows the growth of the national average of the Travel Time Index since 1995. In 1995, a trip that would take 20 minutes during off-peak noncongested periods would take 27 percent (5.4 minutes) longer on average during the peak period. The same trip in 2004 would require 27.6 minutes during the peak period, 38 percent longer than during off-peak noncongested conditions. This difference of 2.2 minutes per trip between the peak period in 1995 and the peak period in 2004 is extremely significant, if multiplied by the total number of such trips that are made on a daily basis.

Exhibit 4-6

Average Travel Time Index for All Urbanized Areas, 1995-2004

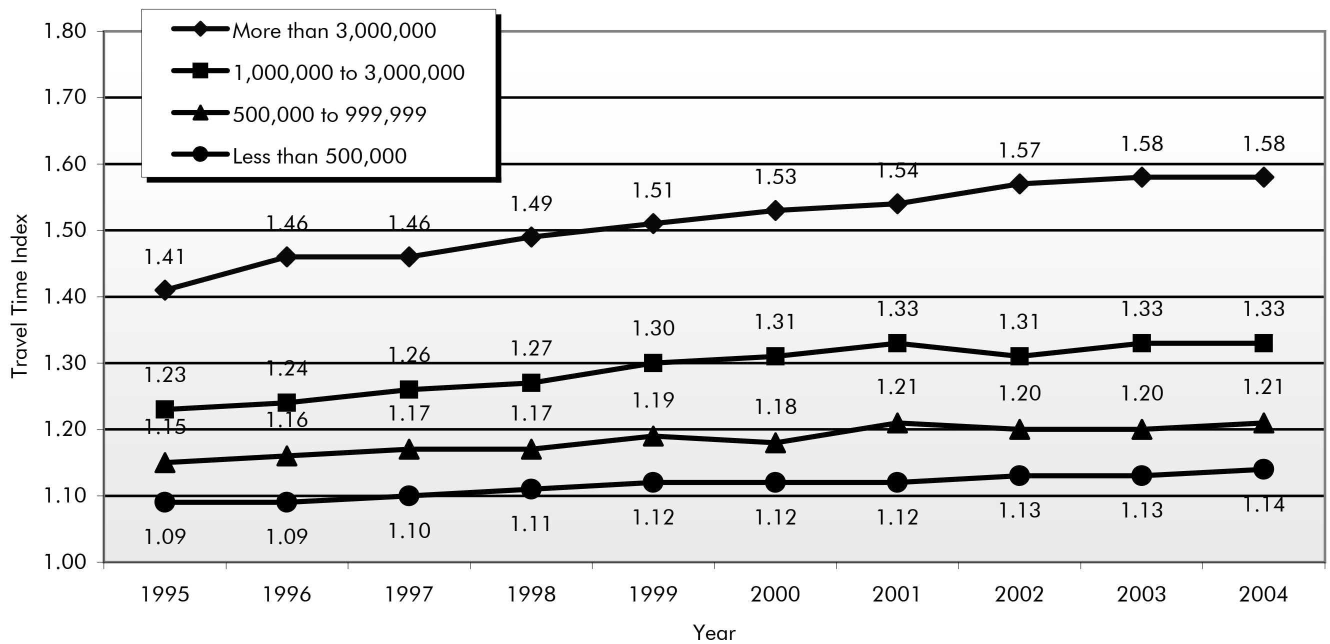


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-7 demonstrates that the additional travel time required because of congestion tends to be higher in larger urbanized areas than smaller ones. The largest increase from 1995 to 2004 occurred in urbanized areas with populations over 3 million, where the Travel Time Index increased from 1.41 to 1.58. This equates to a 3.4-minute increase (from 28.2 to 31.6 minutes) for an average trip that would require 20 minutes during noncongested periods.

Exhibit 4-7

Travel Time Index by Urbanized Area Size, 1995 –2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

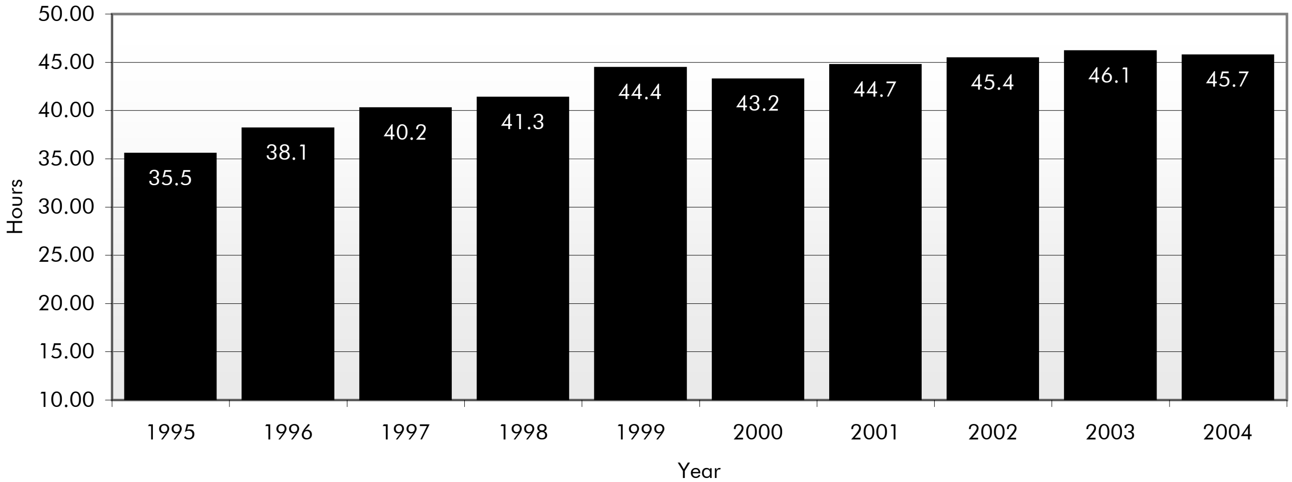
Annual Delay per Peak Period Traveler

Annual Delay per Peak Period Traveler (hours) is another measure of the **severity, duration, and extent** of congestion, defined as the total delay experienced by an average traveler under congested conditions. As shown in *Exhibit 4-8*, Annual Delay per Peak Period Traveler for all urbanized areas combined has increased from 35.5 hours in 1995 to 45.7 hours in 2004. This translates into an average annual increase of approximately 2.9 percent. The value of this metric in 2004 is 0.3 hour, or 18 minutes, higher than the value in 2002 of 45.4 hours.

Exhibit 4-9 presents the values of this metric by population category. All four population categories experienced an increase in this metric in this period. The largest increase in this metric was experienced by peak period travelers in communities in the Medium (population 500,000 to 999,999) category from 27.9 hours in 2002 to 29.9 hours in 2004, an increase in 2.0 hours. Peak period travelers in communities in the Small (population <500,000) category experienced an increase of 1.6 hours, from 14.3 hours of 15.9 hours. The communities in the Large (population 1 million to 3 million) category experienced an increase in the number of hours of Annual Delay per Peak Period Traveler from 37.6 hours in 2002 to 38.4 hours in 2004, a difference of 1.2 hours. Peak period travelers in communities in the Very Large (population > 3 million) group experienced the smallest increase of 0.3 hour, from 74.6 hours in 2002 to 74.9 hours in 2004. [Exhibit 4-9]

Exhibit 4-8

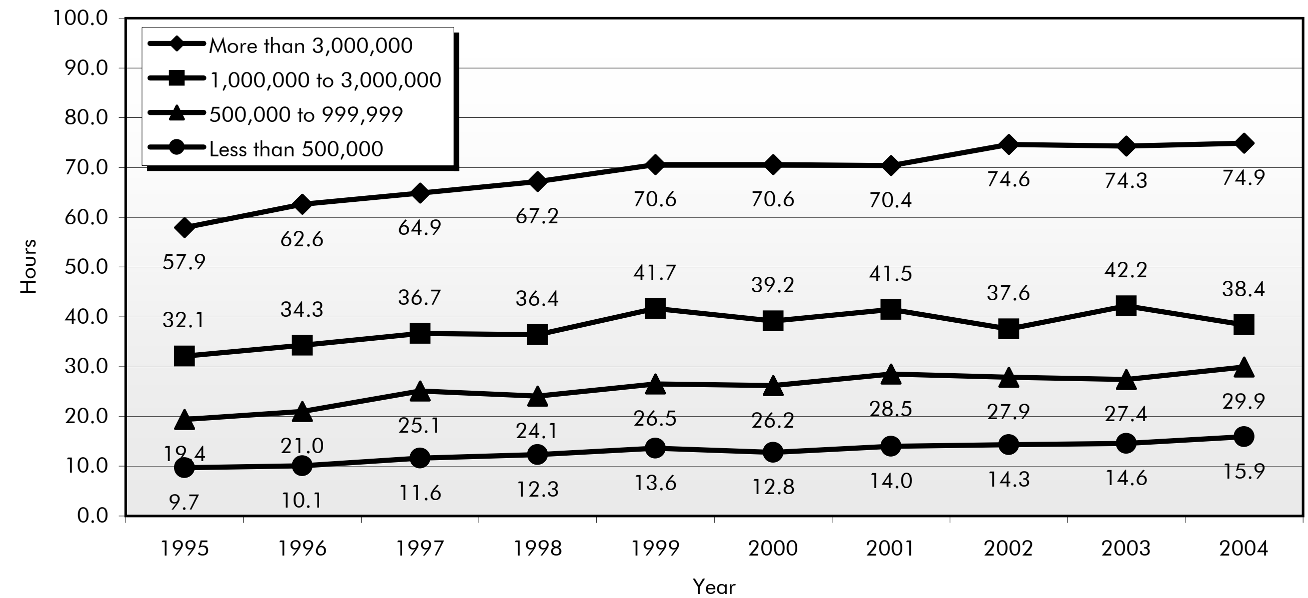
Annual Delay per Peak Period Traveler for All Urbanized Areas, 1995-2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-9

Annual Delay per Peak Period Traveler by Urbanized Area Size, 1995 –2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

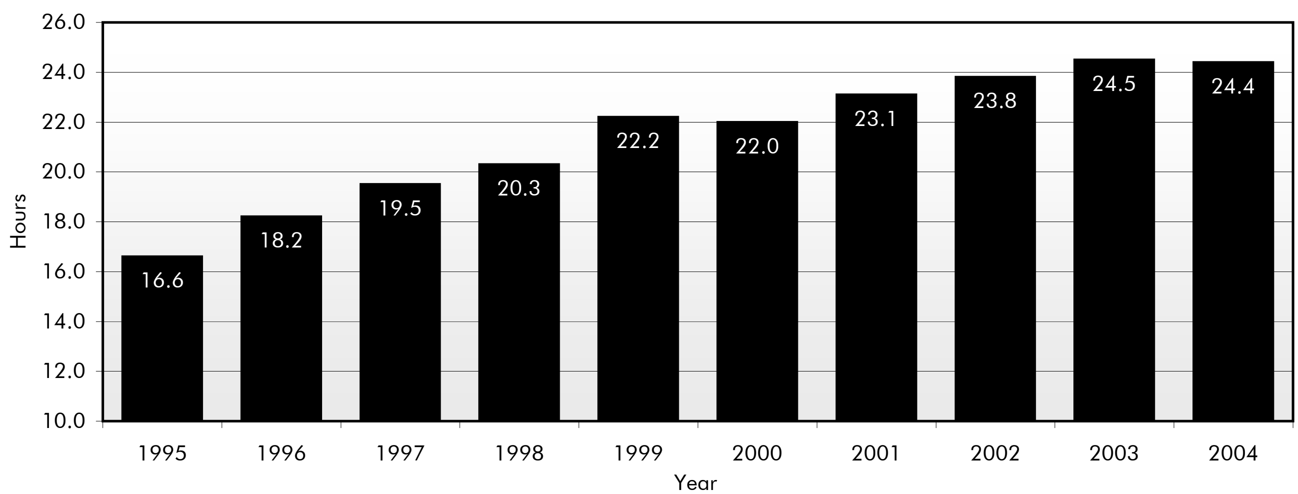
While there have been fluctuations in individual years (such as the decline for peak period travelers in the Large population category from 2003 to 2004), the longer term trend since 1995 has been an increase in this metric. Since 1995, travelers in Very Large (population > 3 million) communities have experienced the greatest increase in delay, with the amount of time lost due to traveling during congested periods increasing steadily from 57.9 hours in 1995 to 74.9 hours in 2004—an increase of 17 hours. The next largest increase has occurred in Medium (population 500,000 to 999,999) urbanized areas where travelers have contended with an increase from 19.4 hours in 1995 to 29.9 hours of annual delay in 2004. Travelers in communities in Small (population <500,000) urbanized areas experienced an increase from 9.7 hours in 1995 to 15.9 hours of annual delay in 2004, while travelers in the Large (population 1 million to 3 million) urbanized areas experienced the smallest increase, from 32.1 hours in 1995 to 38.4 hours in 2004.

Annual Delay per Capita

Annual Delay per Capita (hours) is another measure of the **severity, extent, and duration** of congestion, relating to the average hours of travel delay experienced by a resident of an urbanized area because of recurring congestion and incidents, such as vehicle breakdowns and crashes. Note that this measure reflects the average delay experienced by all residents of a given area, not just those who drive in the peak period. *Exhibit 4-10* shows that, in 2004, the average resident lost 24.4 hours because of congestion. This is an increase of 0.6 hour over the amount of annual delay since 2002, an increase of approximately 2.5 percent. Since 1995, the average for all urbanized areas combined has increased from 16.6 hours of delay per year to 24.4 hours of delay per year, or approximately 47 percent.

Exhibit 4-10

Average Annual Delay per Capita for All Urbanized Areas, 1995 –2004

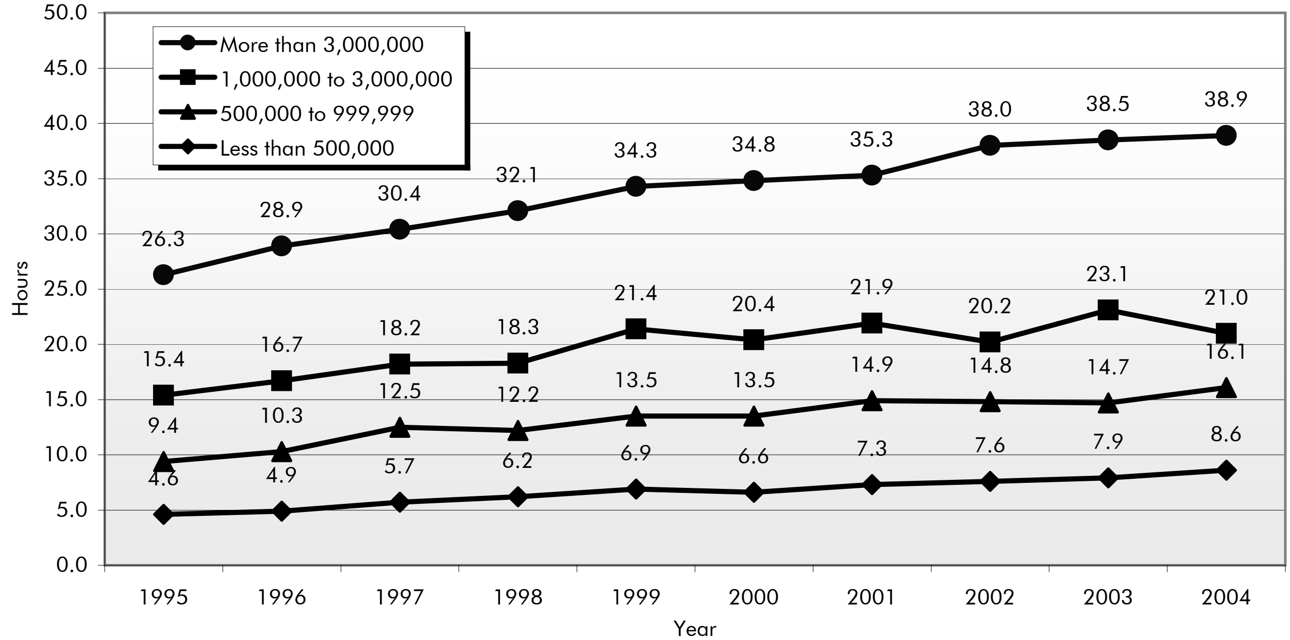


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-11 shows that cities over 3 million in population have experienced an increase of 0.9 hour in the Annual Delay per Capita between 2002 and 2004. The average value for these cities was 38.9 hours per driver per year in 2004. Cities with populations between 500,000 and 999,999 experienced the greatest increase in Annual Delay per Capita, from 14.8 hours in 2002 to 16.1 hours in 2004, an increase of 1.3 hours of delay per capita over the 2-year period. Cities with populations of less than 500,000 experienced an increase in delay per capita since 2002—from 7.6 hours to 8.6 hours, an increase of 1 hour in delay.

Exhibit 4-11

Average Annual Hours of Delay per Capita by Urbanized Area Size, 1995-2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Cost of Congestion

Congestion has an adverse impact on the American economy, which values speed, reliability, and efficiency. Transportation is a critical link in the production process for many businesses as they are forced to spend money on wasted fuel and drivers' salaries that might otherwise be invested in research and development, firm expansion, or other activities.

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, increasing storage costs. Congestion, then, imposes a real economic cost for businesses and these costs will ultimately impact consumer prices. [See Chapter 14 for additional details on the impacts of congestion on freight transportation.]

The TTI's *2005 Urban Mobility Report* estimates that, in the 85 urban areas studied in 2003, drivers experienced in excess of 3.7 billion hours of delay and wasted approximately 2.3 billion gallons of fuel in the year 2003. The total congestion cost for these areas, including wasted fuel and time, was estimated to be approximately $63.1 billion. Over 60 percent of that cost, or approximately $38 billion, was experienced in the 10 metropolitan areas with the most congestion. The estimated wasted fuel in the same top 10 metropolitan areas was approximately 58.6 percent, or over 1.3 billion gallons of fuel. When expanded to include the top 20 areas with the most congestion, the total annual cost is estimated at over $50.2 billion and the total estimated wasted fuel is approximately 1.8 billion gallons for 2003, or 79.7 percent and 79.1 percent, respectively, of the total wasted dollars and gallons of fuel for the top 85 urban areas studied.

DVMT per Lane Mile

As discussed earlier in this chapter, DVMT per Lane Mile is a basic measure of travel density that does not fully capture the effects of congestion. However, this measure does indicate that the demand for travel is growing faster than the supply of highways. *Exhibit 4-12* shows that the volume of travel per lane mile has increased from 1995 to 2004 on every functional highway system for which data are collected.

The largest magnitude increase occurred on the Interstate System in urbanized areas, where the DVMT per lane mile increased by 1,958 between 1995 and 2004. The largest percentage increase occurred on the Interstate System in rural areas, where the DVMT per lane mile increased by 21.5 percent, from 4,652 to 5,711 between 1995 and 2004.

Note that the declines in DVMT per lane mile between 2002 and 2004 for many functional classes are partially driven by boundary changes resulting from the 2000 decennial census, as many States adjusted their HPMS data during this time period to reflect the new boundaries. As the rural areas on the fringe of small urban or urbanized areas (which would tend to have higher DVMT per lane-mile values within the rural category) were reclassified as small urban or urbanized, this would tend to bring down the average rural DVMT values. The small urban averages would be affected both by the addition of areas formerly classified as rural and the subtraction of areas reclassified as urbanized. The urbanized area averages would also be affected by the reclassification of formerly small urban or rural areas as urbanized.

Exhibit 4-12

Daily Vehicle-Miles Traveled (DVMT) per Lane-mile by Population Area and Functional Class, 1995–2004

Functional System	1995	1997	1999	2000	2002	2004
Rural Areas (under 5,000 in population)						
Interstate	4,652	4,952	5,322	5,455	5,711	5,707
Other Principal Arterial	2,414	2,522	2,651	2,685	2,756	2,642
Minor Arterial	1,485	1,557	1,622	1,640	1,683	1,632
Major Collector	610	634	652	659	676	649
Small Urban Areas (5,000–49,999 in population)						
Interstate	6,524	6,842	7,457	7,545	7,955	7,925
Other Freeway and Expressway	5,025	5,339	5,639	5,841	6,106	5,888
Other Principal Arterial	3,925	4,032	4,173	4,204	4,258	4,092
Minor Arterial	2,424	2,488	2,595	2,601	2,673	2,529
Collector	1,199	1,224	1,254	1,253	1,306	1,214
Urbanized Areas (50,000 or more in population)						
Interstate	13,826	14,465	15,093	15,333	15,689	15,783
Other Freeway and Expressway	10,894	11,304	12,021	12,286	12,730	12,630
Other Principal Arterial	5,986	6,214	6,252	6,284	6,408	6,326
Minor Arterial	3,753	3,893	4,160	4,210	4,345	4,307
Collector	1,994	2,100	2,157	2,192	2,276	2,275

Source: Highway Performance Monitoring System.

V/SF Ratio

As discussed earlier in this chapter, the V/SF ratio compares the number of vehicles (V) traveling in a single lane in 1 hour with the theoretical service flow (SF), or the theoretical maximum number of vehicles that could utilize the lane in an hour. *Exhibit 4-13* shows the percentage of peak-hour travel meeting or exceeding a V/SF of 0.80 as well as that 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 is frequently described as "severely congested." For urbanized Interstates, 63.5 percent had peak-hour travel with a V/SF ratio of 0.80 or higher, while 38.4 percent had peak-hour travel with a V/SF ratio of 0.95 or higher.

Exhibit 4-13

Percent of Peak-hour Travel Exceeding V/SF Thresholds, 1995-2004

	1995		1997		2000		2002		2004	
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										
Interstate	9.9%	2.4%	11.0%	3.6%	10.4%	3.3%	15.9%	4.8%	15.1%	5.6%
Principal Arterial	6.8%	3.2%	7.0%	3.2%	7.4%	3.8%	6.9%	3.8%	6.3%	2.4%
Minor Arterial	4.4%	2.5%	4.2%	1.9%	4.6%	2.2%	4.8%	2.2%	4.0%	2.1%
Major Collector	2.8%	1.6%	2.4%	1.2%	2.3%	1.0%	2.3%	1.4%	1.8%	0.9%
Small Urban										
Interstate	15.2%	5.5%	13.2%	4.7%	7.7%	3.2%	13.2%	5.5%	17.8%	3.2%
Other Freeway & Expressway	12.7%	4.6%	11.3%	6.6%	12.5%	6.3%	17.9%	8.9%	17.6%	8.7%
Other Principal Arterial	12.1%	6.8%	11.6%	6.4%	13.2%	6.0%	9.0%	3.8%	8.5%	4.1%
Minor Arterial	14.0%	7.0%	13.1%	6.6%	14.3%	8.0%	12.3%	6.3%	10.7%	4.8%
Collector	9.7%	6.4%	9.7%	5.6%	9.9%	5.7%	8.4%	4.9%	7.1%	3.8%
Urbanized										
Interstate	53.4%	28.7%	55.0%	30.0%	50.0%	26.0%	64.3%	40.2%	63.5%	38.4%
Other Freeway & Expressway	46.8%	26.0%	47.5%	26.4%	46.4%	28.3%	56.7%	35.4%	55.3%	31.9%
Other Principal Arterial	33.1%	22.2%	29.6%	18.1%	29.3%	16.4%	22.3%	10.2%	21.5%	9.4%
Minor Arterial	26.7%	16.8%	25.2%	14.1%	26.4%	14.5%	18.6%	9.3%	17.1%	9.3%
Collector	24.4%	15.7%	21.0%	13.4%	20.3%	13.7%	18.2%	9.3%	15.5%	9.6%

Source: Highway Performance Monitoring System.

For most functional classes, the percent of peak-hour travel exceeding the 0.80 and 0.95 V/SF thresholds declined from 2002 to 2004. This is partially the result of the census boundary issues discussed in the preceding section. However, this is also an indication that this measure of the **severity** of congestion at the peak hour is missing some critical components of the Nation's congestion problems related to increases in the duration and extent of congestion.

Emerging Operational Performance Measures

Measurement of congestion is still a difficult problem. Substantial research has supported 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 relying on just-in-time delivery suffers. It cannot plan effectively for variable trip times. Additional research is needed to determine what measures should be used to describe congestion and what data will be required to supply these measures.

System Reliability

Travel time reliability measures are relatively new, but a few have proven effective at the localized level. Such measures typically compare high-delay days with average-delay days. The simplest method typically applied identifies days that exceed the 90th or 95th percentile in terms of travel times. This approach 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 in order to allow for congestion and be able to 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. The Planning Time Index is especially useful because it can be directly compared to the Travel Time Index presented earlier in this chapter on similar numeric scales. While data are not currently available to support these measures at the national level, data have been collected on these indicators for a number of locations and will be applied to additional cities as equipment is deployed and data are accumulated.

The importance of reliability is underscored by a recently completed study of temporary losses of capacity for the FHWA by 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

A February 2004 report prepared by Cambridge Systematics for the American Highway Users Alliance, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks 1999–2004*, listed 233 locations in urban areas that it classified as bottlenecks. Traffic congestion occurs in these areas because of sudden reduction in number of lanes or a major increase in traffic volume for a specific freeway section beyond its capacity. The report estimated the benefits resulting from eliminating the 24 worst bottleneck locations. Improvements to these locations may prevent an estimated 449,606 crashes, including 1,787 fatalities and 220,760 injuries. Major reductions in pollutants also were cited as a benefit, including 101,320 tons of carbon monoxide and 10,449 tons of volatile organic compounds. Peak period user delay for the 233 locations may be reduced by an estimated 74.5 percent, which translates to approximately 32 minutes each day per commuter.

An October 2005 report prepared by Cambridge Systematics for the FHWA, *An Initial Assessment of Freight Bottlenecks on Highways*, examines bottlenecks from the freight perspective. See Chapter 14 for additional information on this report and other freight operational performance measures.

Leading Indicators

The FHWA tracks the implementation of various operations strategies as leading indicators of potential future congestion trends. These include the deployment of ITS (see the ITS section in Chapter 2), as well as the deployment of regional ITS Architecture and the deployment of "511" travel information systems. The FHWA has also developed self-assessment tools for States and regions to measure their progress in work zone management, incident management, and congestion partnerships. FHWA's monitoring of the deployment of operations strategies is discussed in more detail in Chapter 15.

Measuring Performance Using ITS Technologies

The deployment of ITS technologies provides opportunities for improved measurement of performance. For example, speed and travel time could be measured directly and unobtrusively by sensors in or beside roadways, rather than through rough approximations based on vehicle counts or surveys. Travel time can also be measured through communications systems used in vehicles, such as monitoring truck movements on intercity and urban sections of the Interstate System as described in Chapter 14. Methods for compiling ITS data, removing spurious observations, and producing useful statistics are still under development.

The Real Time System Management Information Program authorized in section 1201 of the Safe, Accountable, Flexible and Efficient Transportation Equity Act: Legacy for Users (SAFETEA-LU) should provide additional momentum towards the establishment of the types of information systems that could significant improve our ability to measure highway congestion and operational performance. This program is discussed in more detail in Chapter 15.

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 towards 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 the same transit vehicle, 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 4-14*.

Exhibit 4-14

Average Transit Passenger-Carrying Speed, 2004

(Miles per Hour)	2004
Heavy Rail	21.0
Commuter Rail	32.2
Light Rail	17.7
Other Rail [1]	7.9
Motorbus	13.6
Demand Response	15.3
Vanpool	39.1
Other Nonrail [2]	8.3

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

[2] Aerial tramway, jitney, público, and trolleybus.

Source: National Transit Database.

The average speed of a transit mode is strongly affected by the number of stops it makes. Motorbus service, which typically makes frequent stops, has a relatively low average speed of 13.6 miles per hour. In contrast, commuter rail has high sustained speeds between infrequent stops, and a high average speed of 32.2 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 39.1 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 21.0 mph, while light rail, which often shares guideway, has an average speed of 17.7 mph.

Exhibit 4-15 provides average speed for each year from 1995 to 2004 for all rail modes, all nonrail modes, and all modes combined, as well as the overall average speed for these groups over the entire 1995–2004 time period. 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 1995 to 2004 was 20.1 miles per hour. The average speed on nonrail modes was 14.0 miles per hour in 2004, which is slightly above the long-term average of 13.8 miles per hour, and indicating an overall trend of increasing speed on nonrail modes. The average speed on rail modes, however, at 25.0 miles per hour in 2004, was below the long-term average of 25.6 miles per hour, and indicating an overall trend of declining average speed on rail modes.

Exhibit 4-15

Passenger-Mile Weighted Average Operating Speed by Transit Mode, 1995–2004

(Miles per Hour)	Rail	Nonrail	Total
1995	26.6	13.7	20.4
1996	26.0	13.8	20.4
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	19.9
2002	25.3	13.7	19.9
2003	25.4	13.9	20.1
2004	25.0	14.0	20.1
Average	**25.6**	**13.8**	**20.1**

Source: National Transit Database.

Vehicle Use

Vehicle Occupancy

Exhibit 4-16 shows vehicle occupancy by mode for selected years from 1995 to 2004. Vehicle occupancy is calculated by dividing PMT by vehicle revenue miles (VRM) and shows the average number of people carried in a transit vehicle. In 2004, heavy rail carried an average of 23 persons per vehicle and light rail an average of 24 persons per vehicle. Commuter rail had an average occupancy of 36 persons per vehicle, motorbus had an average of 10 persons per vehicle, vanpool had an average of 6 persons per vehicle, ferryboat had an average of 120 persons per vehicle, and demand response had an average of 1 person per vehicle.

Exhibit 4-16

Unadjusted Vehicle Occupancy: Passengers per Transit Vehicle, 1995–2004

	1995	1997	1999	2000	2002	2004
Rail						
Heavy Rail	20	22	23	24	23	23
Commuter Rail	38	35	36	38	37	36
Light Rail	25	26	25	26	24	24
Other Rail [1]	11	9	9	8	8	10
Nonrail						
Motorbus	11	11	11	11	10	10
Demand Response	1	2	1	1	1	1
Ferryboat	125	126	119	120	112	120
Trolleybus	14	14	14	14	14	13
Vanpool	8	8	7	7	6	6
Other Nonrail [2]	8	8	6	7	8	6

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

[2] Aerial tramway, jitney, and público.

Source: National Transit Database.

Exhibit 4-17 provides adjusted vehicle occupancy, or the average number of persons carried per capacity-equivalent vehicle, with the average carrying capacity of motorbus 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 motorbus, which is the base, adjusted vehicle occupancy in this report may differ slightly from the values in the 2004 C&P report.]

Exhibit 4-17

Adjusted Vehicle Occupancy:
Passengers per Capacity-Equivalent Transit Vehicle, 1995–2004

	1995	1997	1999	2000	2002	2004
Rail						
Heavy Rail	9	10	10	10	9	9
Commuter Rail	17	15	15	16	15	14
Light Rail	11	11	10	11	10	9
Other Rail [1]	6	5	5	6	6	8
Nonrail						
Motorbus	11	11	11	11	10	10
Demand Response	9	9	8	8	6	7
Ferryboat	11	10	10	10	9	11
Trolleybus	11	10	10	10	10	9
Vanpool	42	41	37	36	31	31
Other Nonrail [2]	32	32	24	28	30	23
Total	**11**	**11**	**11**	**11**	**11**	**10**

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

[2] Aerial tramway, jitney, and público.

Source: National Transit Database.

Vehicle Utilization

Exhibit 4-18 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 motorbus 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 2004 there were 1,615 thousand PMT per heavy rail vehicle, over four times the 373 thousand PMT per motorbus vehicle. However, since heavy rail vehicles have, on average, two and a half times the capacity of a motorbus, heavy rail provides 652 thousand PMT per CEV, or roughly 75 percent more than motorbus, 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 2004 C&P report, except for motorbus, 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 4-18, between 1995 and 2004, most modes reached their highest level of utilization in 2000 or 2001. All modes, except ferryboat, were at a lower level of capacity utilization in 2004 than the long-term average utilization from 1995 to 2004.

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 vehicle revenue mile (VRM), unlinked passenger trips per vehicle revenue hour, annual passenger miles per actual annual VRM, and passenger miles traveled per scheduled vehicle mile.

Exhibit 4-18

Transit Vehicle Utilization: Annual Passenger Miles per Capacity-Equivalent Vehicle by Mode, 1995 –2004

(Thousands of Passenger Miles)

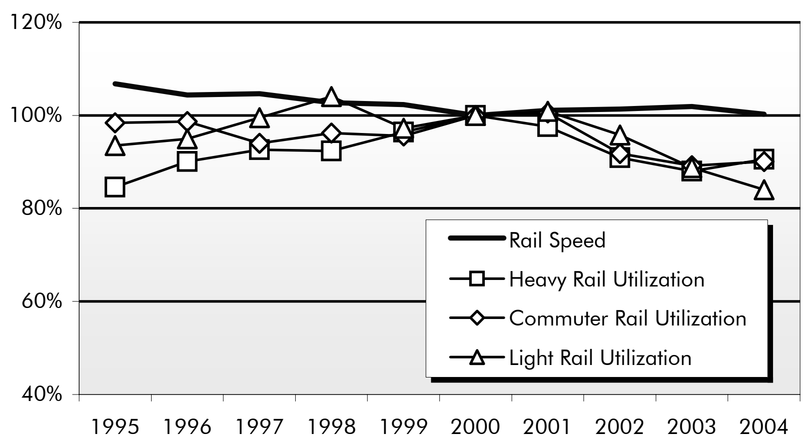
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
Heavy Rail	609	649	667	665	694	720	703	655	634	652	**665**
Commuter Rail	825	827	788	806	801	838	843	769	748	755	**800**
Light Rail	520	529	554	579	541	557	561	533	494	468	**534**
Motorbus	391	392	401	393	397	393	397	389	383	373	**391**
Demand Response	199	190	242	207	204	207	185	168	172	181	**195**
Vanpool	598	683	609	621	618	592	501	498	535	502	**576**
Ferryboat	304	307	298	298	294	305	284	297	350	328	**306**
Trolleybus	301	292	266	252	257	264	288	246	236	237	**264**

Source: National Transit Database.

Changes in the capacity utilization of rail vehicles have influenced these vehicles' operating speeds through changes in dwell times. As vehicles become more crowded, they take longer to unload and load, increasing wait times at stations, and hence, passengers' total travel time. *Exhibit 4-19* illustrates this relationship between capacity utilization and average speed by comparing an index of rail speed with indexes of the capacity utilization of commuter rail, heavy rail, and light rail vehicles between 1995 and 2004, with 2000 as the base year. As the capacity utilization of these rail vehicles increased between 1995 and 2000 (2001 in the case of commuter and light rail), average rail speed decreased. As the capacity utilization of these rail modes all declined from 2001 to 2003, average rail speed increased. Finally, the capacity utilization of heavy rail and commuter rail increased from 2003 to 2004, outweighing the continued decline in the capacity utilization of light rail, and leading to an overall decrease in average rail speed in 2004.

Exhibit 4-19

Index of Rail Speed and Capacity Utilization of Rail Vehicles (2000=100%)



Source: National Transit Database.

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. Revenue miles per active vehicle measures transit system performance. *Exhibit 4-20* provides vehicle service use by mode for selected years from 1995 to 2004. Heavy rail, generally offering long hours of frequent service, had the highest vehicle use over this period, increasing from 51 thousand miles per vehicle in 1995 to 57 thousand miles per vehicle in 2004. Vehicle service use for light rail increased from 34 thousand miles per vehicle in 1995 to 40 thousand miles per vehicle in 2004, vehicle service use for demand response increased from 16 thousand miles per vehicle in 1995 to 20 thousand miles per vehicle in 2004, and vehicle service use for vanpool increased from 11 thousand miles per vehicle in 1995 to 14 thousand miles per vehicle in 2004. Vehicle service use

Exhibit 4-20

Vehicle Service Utilization:
Vehicle Revenue Miles per Vehicle by Mode, 1995–2004

	(Thousands of Vehicle Revenue Miles)						Average Annual Rate of Change	
	1995	1997	1999	2000	2002	2004	2004/1995	2004/2002
Heavy Rail	51	54	54	56	55	57	1.3%	1.6%
Commuter Rail	40	41	41	42	44	41	0.3%	-3.3%
Light Rail	34	32	32	33	41	40	1.9%	-1.5%
Motorbus	29	29	29	28	30	30	0.3%	0.6%
Demand Response	16	19	19	18	21	20	2.3%	-2.3%
Vanpool	11	13	13	13	14	14	2.5%	1.9%
Ferryboat	23	24	24	24	24	25	0.9%	0.9%
Trolleybus	19	18	18	19	20	21	1.0%	2.0%

Source: National Transit Database.

by motorbus, ferryboat, and trolleybus increased more slowly. The number of service miles provided per commuter rail vehicle in active service reached a high of 44 thousand in 2002, compared with 40 thousand in 1995 and 41 thousand in 2004.

Frequency and Reliability of Services

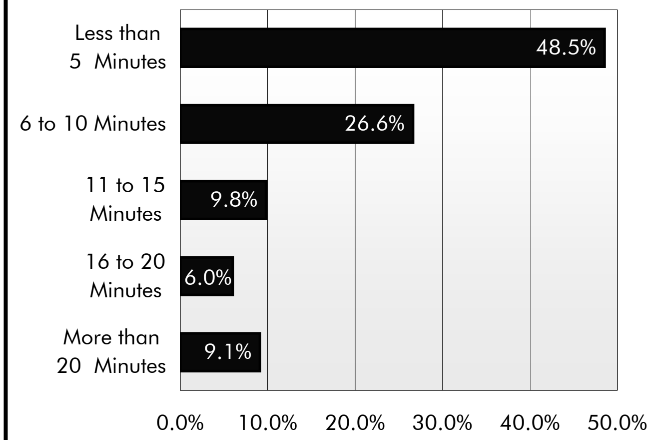
The frequency of transit service varies considerably according to location and time of day. Transit service is more frequent in urban areas and during rush hours, in locations and during times when the demand for transit is highest. Studies have found that transit passengers consider the time spent waiting 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 4-21 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 49 percent of all passengers who ride transit wait 5 minutes or less and 75 percent wait 10 minutes or less. Nine 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.

Waiting times are also correlated with incomes. 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 *(Exhibit 4-22).* 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 4-21

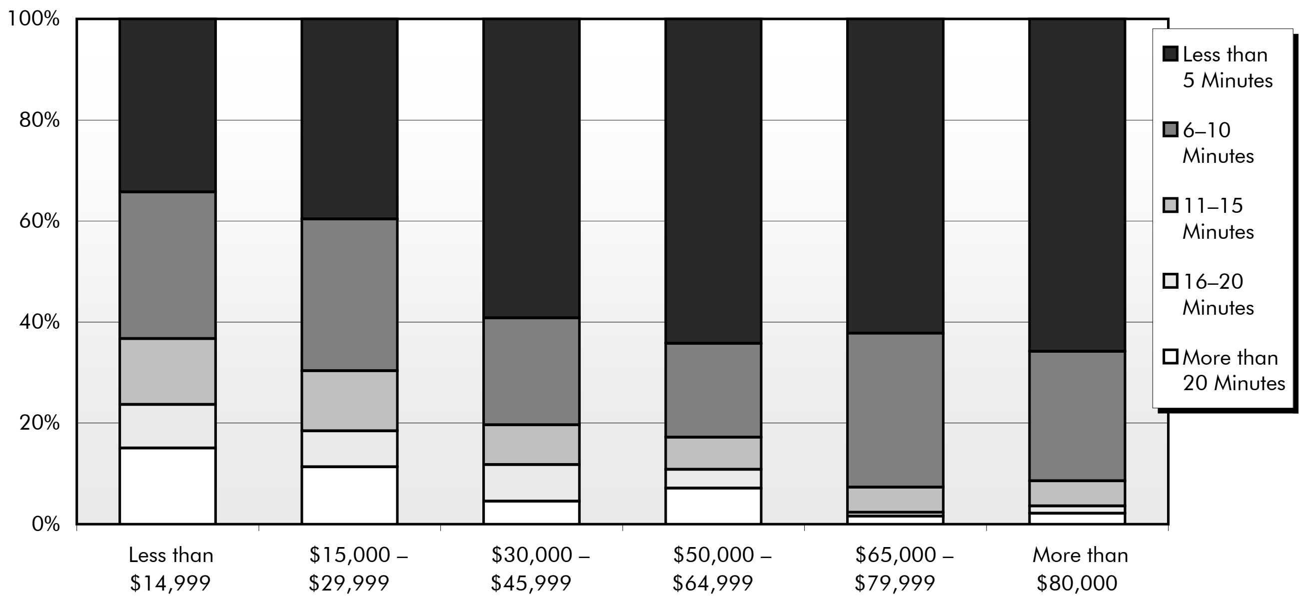
Distribution of Passengers by Waiting Times



Source: National Household Travel Survey, FHWA, April 2001.

Exhibit 4-22

Passenger Wait-Times 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.

CHAPTER 5

Safety Performance

Summary

This chapter describes the safety of highway and transit facilities across the United States. It looks at the number of fatalities and injuries from several different perspectives. For highway safety, this chapter examines fatalities and injuries on different functional systems, the causes of highway-related fatalities, fatalities and injuries by different vehicle groups, and the distribution of crashes by age of passengers. For transit safety, this chapter examines injuries and fatalities by mode and passenger miles of travel.

This chapter describes safety statistics. It does not describe the various programs used by the U.S. Department of Transportation (DOT) and its partners to increase highway and transit safety. See Chapter 11 of the 2004 edition of the C&P report for a discussion of such programs.

Exhibit 5-1 compares the key highway and transit statistics discussed in this chapter with the values shown in the last report. The first data column contains the values reported in the 2004 C&P report, which were based on 2002 data. Had any of the 2002 data been subsequently revised, updated values would have been shown in the second column. (Although this column is blank, it has been retained to maintain consistency with the comparable tables in other chapters and to indicate that no revisions have occurred). The third column contains comparable values, based on 2004 data.

Exhibit 5-1

Comparison of Safety Statistics with Those in the 2004 C&P Report

	2002 Data		
	2004 C&P Report	**Revised**	**2004 Data**
Highway Safety			
Number of Fatalities	43,005		42,636
Fatality Rate per 100,000 People	14.94		14.52
Fatality Rate per 100 Million VMT	1.5		1.4
Number of Injuries	2,926,000		2,788,000
Injury Rate per 100,000 People	1,016		950
Injury Rate per 100 Million VMT	102		94
Transit Safety			
Number of Fatalities	282		248
Fatalities per 100 Million PMT	0.66		0.55
Number of Injuries	19,367		18,982
Injuries per 100 Million PMT	46		42
Number of Incidents	24,247		20,939
Incidents per 100 Million PMT	57		46

Highway fatalities decreased by 0.86 percent between 2002 (43,005) and 2004 (42,636). Although the number of fatalities has fallen sharply since 1966, when Federal legislation first addressed highway safety, there has been a steady increase in the annual number of fatalities between 1994 and 2004.

In 2004, the fatality rate per 100,000 people was 14.52, down from the 2002 fatality rate of 14.94. The fatality rate per 100 million vehicle miles traveled (VMT) declined from 1.51 in 2002 to 1.44 in 2004.

Q&A

What do preliminary 2005 traffic fatality data show?

While this report focuses primarily on 2004 data, some 2005 traffic fatality data are available. The National Highway Traffic Safety Administration (NHTSA) has issued a set of *Transportation Safety Fact Sheets* dated September 2006. The *Overview* fact sheet indicates that in 2005, 43,443 people died on the Nation's highways, an increase of 1.4 percent from the total number of traffic fatalities in 2004. This fact sheet also indicates an increase in the fatality rate, from 1.44 per 100 million VMT in 2004 to 1.47 per 100 million VMT in 2005. Traffic-related injuries were estimated to have declined from 2.79 million in 2004 to 2.70 million in 2005. The *Overview* fact sheet can be viewed at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2005/OverviewTSF05.pdf.

Q&A

Where can I find additional information on fatalities and injuries?

The National Highway Traffic Safety Administration (NHTSA) has posted fatality and injury information on its public Web site at: www.nhtsa.dot.gov/people/ncsa. In addition, there are annual publications that focus on fatalities and injuries in general, along with fact sheets that focus on high-interest areas. The Web site also contains an interactive fatality encyclopedia that enables all national tables to be produced at the State level.

The number of highway injuries declined from 2.93 million in 2002 to 2.79 million in 2004. The injury rate per 100,000 people declined from 1,016 in 2002 to 950 in 2004, and the injury rate per 100 illion VMT dropped from 102 in 2002 to 94 in 2004.

Public transit in the United States has been and continues to be a highly 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 guideway have historically had a lower number of fatalities relative to use than rail transit vehicles that share their guideway with nontransit vehicles. Buses, which travel at slower speeds, have also had low fatalities per 100 million passenger miles traveled (PMT). Total fatalities have fluctuated from 274 in 1995, to 282 in 2002, and 248 in 2004. When adjusted for passenger use, however, the fatality rate per 100 million PMT decreased, falling from 0.77 in 1995, to 0.66 in 2002, to 0.55 in 2004.

Between 2002 and 2004 incidents and injuries both decreased, falling substantially from 2002 to 2003 before rising slightly in 2004. Adjusted for passenger use, however, both incidents and injuries per 100 million PMT declined over both years during this time period. In 2004, there were 20,939 incidents and 18,982 injuries on transit. When adjusted for passenger travel, there were 46 incidents per 100 million PMT and 42 injuries per 100 million PMT on transit in 2004.

Highway Safety Performance

This section describes highway safety performance. 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.

Statistics in this section are drawn from the Fatality Analysis Reporting System (FARS). The FARS is maintained by the National Highway Traffic Safety Administration (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 NHTSA publishes an annual Traffic Safety Facts report that comprehensively describes safety characteristics on the surface transportation network.

Overall Fatalities and Injuries

Exhibit 5-2 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 2004, the fatality rate had declined to 1.44 per 100 million VMT. This sharp decline in the fatality rate occurred even as the number of licensed drivers grew by 97 percent.

The number of traffic deaths also decreased between 1966 and 2004. In 1966, there were 50,894 traffic deaths. Fatalities reached their highest point in 1972 (54,598) and then declined sharply following the implementation of a national speed limit, reaching their lowest point in 1992 (39,250). Since then, the number of fatalities has steadily increased; by 2004, the number of traffic deaths had risen to 42,636. *Exhibits 5-3* and *5-4* compare the number of fatalities with fatality rates between 1980 and 2004.

The number of traffic-related injuries also decreased between 1988 and 2004, from 3,416,000 to 2,788,000; however, like the number of fatalities, injuries increased between 1992 and 1996. The injury rate also declined between 1988 and 2004, the years for which statistics are available. In 1988, the injury rate was 169 per 100 million VMT; by 2004, the number had dropped to 94 per 100 million VMT.

Fatalities by Functional Class

Exhibits 5-5 and *5-6* show the number of fatalities and fatality rates by rural and urban functional system between 1995 and 2004. These exhibits are important in describing the recent increase in fatalities and the distinction between fatalities and the fatality rate.

Exhibit 5-2

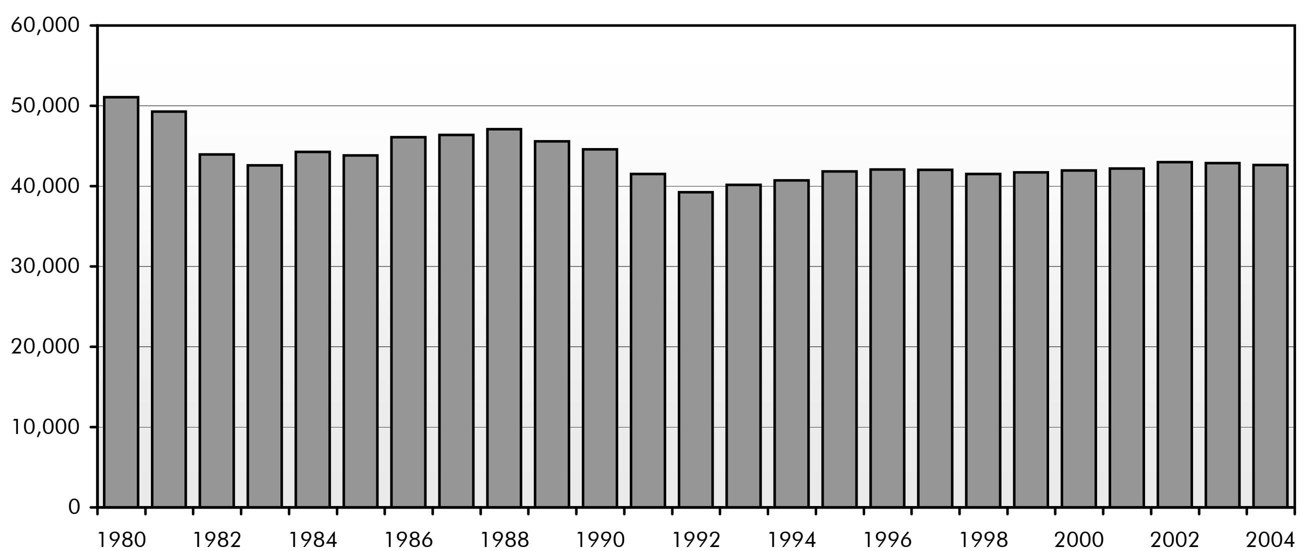
Summary of Fatality and Injury Rates, 1966–2004

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	5.5			
1968	52,725	200,706	26.27	105,410	5.2			
1970	52,627	205,052	25.67	111,543	4.7			
1972	54,589	209,896	26.01	118,414	4.3			
1974	45,196	213,854	21.13	125,427	3.5			
1976	45,523	218,035	20.88	134,036	3.3			
1978	50,331	222,585	22.61	140,844	3.3			
1980	51,091	227,225	22.48	145,295	3.4			
1982	43,945	231,664	18.97	150,234	2.8			
1984	44,257	235,825	18.77	155,424	2.6			
1986	46,087	240,133	19.19	159,486	2.5			
1988	47,087	244,499	19.26	162,854	2.3	3,416,000	1,397	169
1990	44,599	249,439	17.88	167,015	2.1	3,231,000	1,295	151
1992	39,250	254,995	15.39	173,125	1.7	3,070,000	1,204	137
1994	40,716	260,327	15.64	175,403	1.7	3,266,000	1,255	139
1996	42,065	265,229	15.86	179,539	1.7	3,483,000	1,313	140
1998	41,501	270,248	15.36	184,980	1.6	3,192,000	1,181	121
2000	41,945	282,192	14.86	190,625	1.5	3,189,000	1,130	116
2002	43,005	287,941	14.94	194,296	1.5	2,926,000	1,016	102
2004	42,636	293,655	14.52	198,889	1.4	2,788,000	950	94

Source: *Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.*

Exhibit 5-3

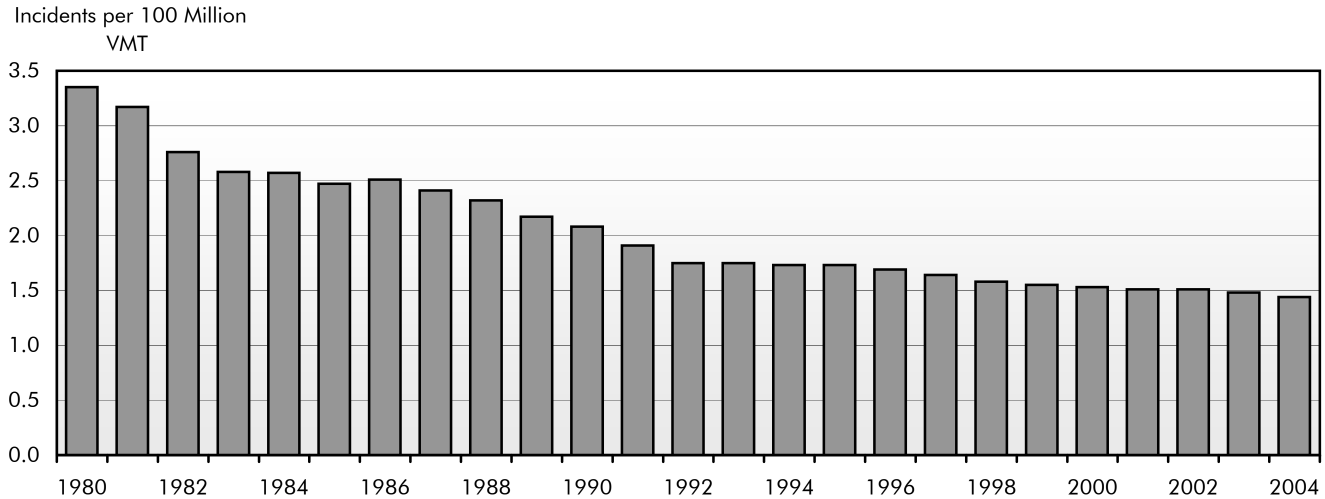
Fatalities, 1980–2004



Source: *Fatality Analysis Reporting System.*

Exhibit 5-4

Fatality Rate, 1980–2004



Source: Fatality Analysis Reporting System.

Exhibit 5-5

Fatalities by Functional System, 1995–2004

Functional System	1995	1997	2000	2002	2004
Rural Areas (under 5,000 in population)					
Interstate	2,658	3,040	3,254	3,298	3,246
Other Principal Arterial	4,965	5,394	4,917	4,894	5,012
Minor Arterial	4,406	4,284	4,090	4,467	5,049
Major Collector	6,218	5,920	5,501	6,014	5,552
Minor Collector	1,598	1,723	1,808	2,003	1,801
Local	4,556	4,450	4,414	5,059	4,080
Unknown Rural	48	324	854	161	235
Subtotal Rural	**24,449**	**25,135**	**24,838**	**25,896**	**24,975**
Urban Areas (5,000 and over in population)					
Interstate	2,177	2,292	2,419	2,482	2,516
Other Freeway and Expressway	1,807	1,296	1,364	1,506	1,656
Other Principal Arterial	5,041	5,420	4,948	5,124	4,811
Minor Arterial	3,732	3,523	3,211	3,218	3,536
Collector	1,213	1,163	1,001	1,151	1,339
Local	3,163	3,064	2,912	3,497	3,303
Unknown Urban	30	71	258	35	220
Subtotal Urban	**17,163**	**16,829**	**16,113**	**17,013**	**17,381**
Unknown Rural or Urban	205	49	994	96	280
Total Highway Fatalities	**41,817**	**42,013**	**41,945**	**43,005**	**42,636**

Source: Fatality Analysis Reporting System/ National Center for Statistics & Analysis, NHTSA.

Exhibit 5-6

Fatality Rates by Functional System, 1995–2004 (per 100 Million VMT)

Functional System	1995	1997	2000	2002	2004
Rural Areas (under 5,000 in population)					
Interstate	1.18	1.26	1.21	1.17	1.21
Other Principal Arterial	2.30	2.35	1.97	1.90	2.08
Minor Arterial	2.82	2.61	2.37	2.52	2.98
Major Collector	3.20	2.92	2.61	2.80	2.76
Minor Collector	3.17	3.26	3.11	3.22	2.99
Local	4.31	3.93	3.46	3.62	3.08
Subtotal Rural	**2.58**	**2.51**	**2.28**	**2.29**	**2.33**
Urban Areas (5,000 and over in population)					
Interstate	0.63	0.63	0.61	0.60	0.55
Other Freeway and Expressway	1.20	0.81	0.77	0.79	0.79
Other Principal Arterial	1.37	1.40	1.23	1.25	1.06
Minor Arterial	1.28	1.16	0.98	0.94	0.97
Collector	0.98	0.88	0.73	0.80	0.81
Local	1.53	1.48	1.23	1.45	1.33
Subtotal Urban	**1.16**	**1.08**	**0.95**	**0.98**	**0.98**
Total Highway Fatality Rate	**1.71**	**1.64**	**1.48**	**1.49**	**1.42**

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

As shown in Exhibit 5-5, the overall number of fatalities grew slightly between 1995 and 2004, largely because of deaths on rural roads. Between 1995 and 2004, the number of fatalities on rural roads grew from 24,449 to 24,975 and accounted for 58.6 percent of total 2004 fatalities. At the same time, the number of fatalities on urban roads increased from 17,163 to 17,381. The fatality rate, however, declined on both rural and urban roads. Although the absolute number of fatalities slightly increased, the fatality rate dropped due to a significant increase in the number of VMT.

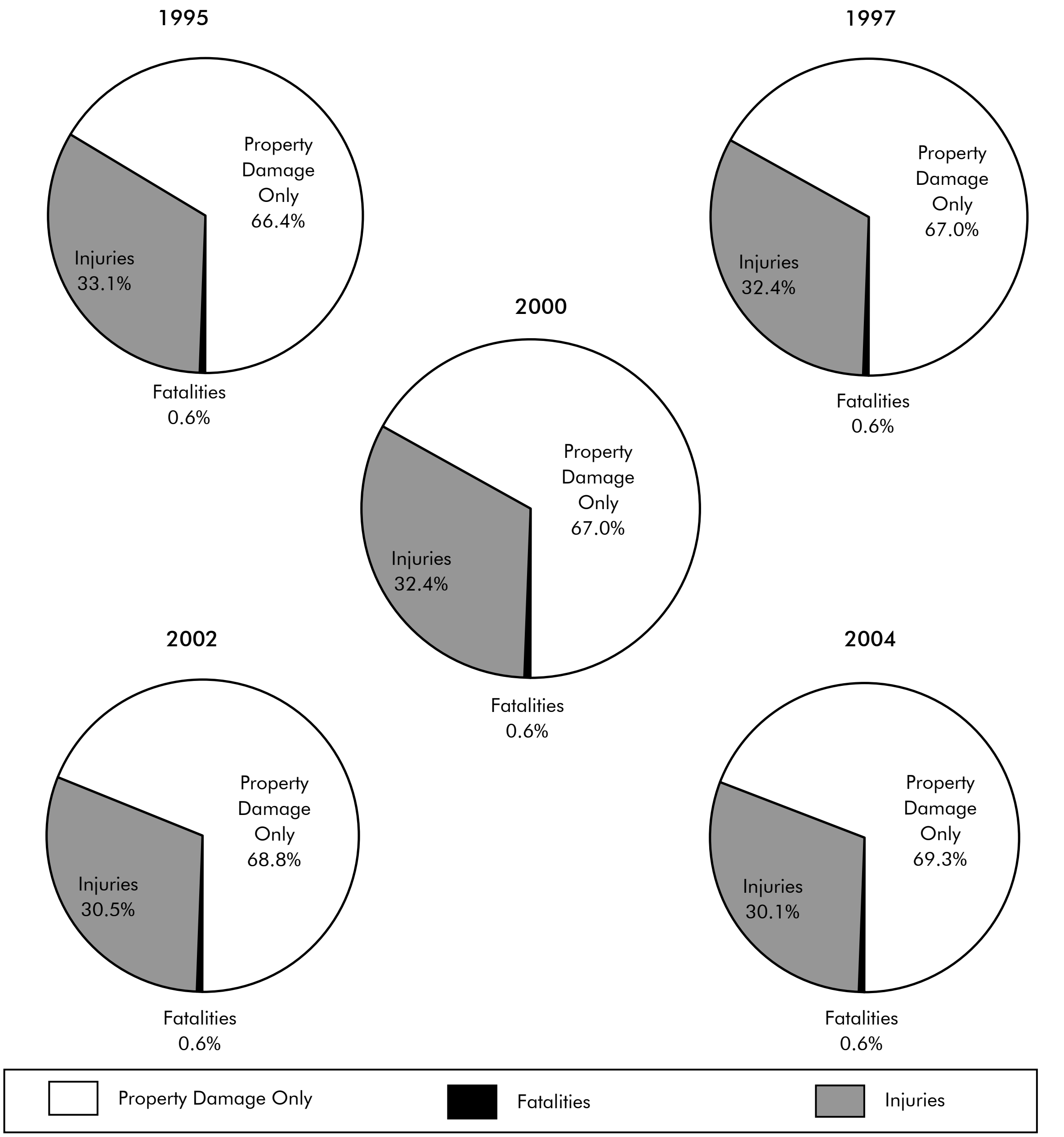
Exhibit 5-6 reveals that fatality rates declined on every urban functional system between 1995 and 2004. Urban Interstate highways were the safest functional system, with a 0.55 fatality rate in 2004. Other freeways and expressways, however, recorded the sharpest decline in fatality rates. The fatality rate for other urban freeways and expressways in 2004 was about 34.0 percent lower than in 1995.

Fatality rates declined by 9.7 percent on the rural functional system between 1995 and 2004; however, the fatality rate for rural Interstates has remained more constant. The rural Interstate fatality rate in 2004 was more than twice that of urban Interstates, as travel speeds tend to be higher on rural Interstates than urban Interstates.

There were a total of 6,181,000 crashes reported in 2004. Only a small percentage of these crashes, 0.6 percent, were severe enough to result in a fatality, while 69.3 percent of these crashes resulted in property damage only. *Exhibit 5-7* describes the number of crashes by severity between 1995 and 2004.

Exhibit 5-7

Crash by Severity, 1995–2004



Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

Highway Fatalities by Crash Type

Exhibit 5-8 displays three types of fatalities by roadway-related crash types that have been identified by the Federal Highway Administration (FHWA) as focus areas: roadway departures, intersection-related crashes, and pedestrian-related crashes. These categories are not mutually exclusive; the fatalities shown in Exhibit 5-8 can involve a combination of factors—intersection and pedestrian-related, for example—so that some fatalities will appear in more than one category.

Exhibit 5-8

Highway Fatalities by Crash Type, 1995 –2004

	1995	1997	2000	2002	2004
Roadway Departures	22,675	22,741	23,046	25,412	25,676
Intersection-related	9,148	9,093	8,689	9,273	9,117
Pedestrian-related	6,526	6,288	5,597	5,630	5,494

Some fatalities may overlap; for example, some intersection-related fatalities may involve pedestrians.

Roadway Departures

In 2004, there were a total of 25,676 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 rolled over and/or struck one or more man-made or natural objects (e.g., utility poles, bridge walls, embankments, guardrails, trees, or parked vehicles). *Exhibit 5-9* shows roadway departure-related fatalities by functional system. Almost two-thirds of roadway departure-related fatalities occurred on rural roads.

Exhibit 5-9

Roadway Departure-related Fatalities by Functional System, 2004

Functional System	Single-vehicle run-off-the-road	Other Roadway Departures	Total Roadway Departure Fatalities	Percent of Total
Rural Areas (under 5,000 in population)				
Interstate	1,567	393	1,960	7.6%
Other Principal Arterial	1,297	1,789	3,086	12.0%
Minor Arterial	1,818	1,670	3,488	13.6%
Major Collector	2,617	1,320	3,937	15.3%
Minor Collector	1,027	376	1,403	5.5%
Local	2,517	516	3,033	11.8%
Unknown Rural	133	28	161	0.6%
Subtotal Rural	**10,976**	**6,092**	**17,068**	**66.5%**
Urban Areas (5,000 and over in population)				
Interstate	1,057	247	1,304	5.1%
Other Freeway and Expressway	652	217	869	3.4%
Other Principal Arterial	937	1,034	1,971	7.7%
Minor Arterial	1,003	718	1,721	6.7%
Collector	548	227	775	3.0%
Local	1,341	383	1,724	6.7%
Unknown Urban	54	30	84	0.3%
Subtotal Urban	**5,592**	**2,856**	**8,448**	**32.9%**
Unknown Rural or Urban	115	45	160	0.6%
Total Highway Fatalities	**16,683**	**8,993**	**25,676**	

Source: Fatality Analysis Reporting System/ National Center for Statistics & Analysis, NHTSA.

Rollovers

Exhibit 5-10 displays rollover crash data by vehicle type. Of the 25,676 roadway departure fatalities that occurred in 2004, 41.1 percent involved the rollover of a passenger vehicle. The total number of passenger vehicle occupant fatalities in rollovers has shown a steady increase, from 9,527 in 1997 to 10,553 in 2004 (an increase of 10.8 percent). While the number of occupant fatalities in rollovers among passenger cars decreased slightly, from 4,765 in 1997 to 4,334 in 2004 (a 9.0 percent decrease), the number of occupant fatalities in rollovers among sport utility vehicles (SUVs) nearly doubled from 1,489 in 1997 to 2,920 in 2004 (an increase of 96.1 percent). The number of occupant fatalities in rollovers among pickups for the same period has shown an increase of 4.5 percent (from 2,479 in 1997 to 2,591 in 2004) and among vans a decrease of 9.9 percent (from 768 in 1997 to 692 in 2004).

Among the vehicles that rolled over, the occupant fatality rates for SUVs were the highest, followed by the rates for pickup trucks, vans, and passenger cars. In 2004, in fatal crashes where a rollover occurred, the occupant fatality rate per 100,000 registered vehicles for SUVs was 9.29, 6.72 for pickup trucks, 3.66 for vans, and 3.25 for passenger cars.

The fatality rate for roadway departure-related crashes per 100 million VMT in 2004 was 0.87; the FHWA target goal in 2004 was 0.82.

Exhibit 5-10

Summary of Fatalities and Fatality Rates for Vehicles Involved in Rollover Crashes, 1997 & 2004

	Fatalities	Registered Passenger Vehicles	Fatality Rate per 100,000 Registered Vehicles
1997			
Passenger Cars	4,765	124,672,920	3.82
Vans	768	16,159,473	4.75
SUVs	1,489	14,531,850	10.25
Pickup Trucks	2,479	34,314,455	7.22
Other	26	2,281,692	1.14
Total	9,527	191,960,390	4.96
2004			
Passenger Cars	4,334	133,275,377	3.25
Vans	692	18,931,753	3.66
SUVs	2,920	31,415,143	9.29
Pickup Trucks	2,591	38,557,291	6.72
Other	16	1,034,394	1.55
Total	10,553	223,213,958	4.73
Percent Change	10.8%	16.3%	

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

Intersection-related Crashes

Another frequent type of highway fatality occurs at intersections. *Exhibit 5-11* displays intersection-related fatalities by functional system. As previously stated, of the 42,636 fatalities that occurred in 2004, 21.4 percent (9,117) was attributed to crashes that were related to intersections.

Q&A

What is the distribution of intersection-related fatalities among functional systems?

Combining rural and urban functional systems, about 62.2 percent of intersection-related fatalities were on arterials, 18.6 percent were on collector roads, 17.5 percent were on local roads, and 1.7 percent were on unspecified roads.

More than one-half (55.7 percent) of intersection-related fatalities occurred on urban roadways, compared with 44 percent that occur in rural areas. The majority of urban fatalities (22.2 percent) occurred on urban other principal arterials. Rural other principal arterials, rural minor arterials, rural major collectors, and urban local roads each account for between 11.0 to 11.5 percent of intersection-related fatalities in 2004.

Exhibit 5-11

Intersection-related Fatalities by Functional System, 2004

Functional System	Fatalities	Percent of Total
Rural Areas (under 5,000 in population)		
Interstate	6	0.1%
Other Principal Arterial	1,051	11.5%
Minor Arterial	1,049	11.5%
Major Collector	1,004	11.0%
Minor Collector	279	3.1%
Local	569	6.2%
Unknown Rural	26	0.3%
Subtotal Rural	**3,984**	**43.7%**
Urban Areas (5,000 and over in population)		
Interstate	17	0.2%
Other Freeway and Expressway	169	1.9%
Other Principal Arterial	2,026	22.2%
Minor Arterial	1,349	14.8%
Collector	415	4.6%
Local	1,025	11.2%
Unknown Urban	77	0.8%
Subtotal Urban	**5,078**	**55.7%**
Unknown Rural or Urban	55	0.6%
Total Highway Fatalities	**9,117**	

Source: Fatality Analysis Reporting System/ National Center for Statistics & Analysis, NHTSA.

Older drivers and pedestrians are particularly at risk at intersections; half of the fatal crashes for drivers aged 80 or older and one-third of the pedestrian deaths among people aged 70 or older occurred at intersections.

The fatality rate for intersection-related crashes per 100,000 in 2004 was 3.10; the FHWA target goal in 2004 was 2.96.

Pedestrian-related Crashes

Exhibit 5-12 displays pedestrian-related fatalities that occurred from 1997 to 2004. The number of pedestrian-related fatalities decreased from 6,526 in 1995 to 5,494 in 2004, a decrease of 15.8 percent. Note that the term "pedestrian-related" in this report refers to fatalities and crashes that involve pedestrians, pedalcyclists, and other nonmotorists (skateboard riders, roller skaters, etc.).

As previously stated, nonmotorist fatalities accounted for 12.9 percent of all traffic fatalities in 2004. Among nonmotorist fatalities, pedestrians accounted for 84.5 percent, pedalcyclists for 13.2 percent, with the remaining 2.3 percent being skateboard riders, roller skaters, etc.

In 2004, pedestrian fatalities occurred most frequently in urban areas, at non-intersections, in normal weather conditions, and at night. Pedalcyclist fatalities occurred most frequently in urban areas, at non-intersections, in the early evening hours (5 p.m. to 9 p.m.), during the summer months (June, July, and August). Cross-sectioning intersection-related fatalities, 950 pedestrians and 236 pedalcyclists were fatally injured at intersections.

Exhibit 5-12

Pedestrian-related Fatalities, 1995 –2004

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Pedestrians	5,584	5,449	5,321	5,228	4,939	4,763	4,901	4,851	4,774	4,641
Pedalcyclists	833	765	814	760	754	693	732	665	629	725
Other Nonmotorists	109	154	153	131	149	141	123	114	140	128
Total	6,526	6,368	6,288	6,119	5,842	5,597	5,756	5,630	5,543	5,494

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

Of the traffic crashes that resulted in pedestrian fatalities in 2004, 47 percent were alcohol-related, as 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. More than one-third of crashes that occurred in 2004 involving pedalcyclists and drivers who had consumed alcohol resulted in fatality.

The fatality rate for pedestrian-related crashes per 100,000 in 2004 was 1.87; the FHWA target goal in 2004 was 1.5.

Highway Fatalities by Contributing Factor

Alcohol-related Crashes

Alcohol-impaired driving is a serious public safety problem in the United States. The NHTSA estimates that alcohol was involved in 39 percent of all traffic fatalities and 7 percent of all crashes in 2004. The 16,694 fatalities in 2004 represent an average of one alcohol-related fatality every 31 minutes.

Exhibit 5-13 shows the number of fatalities attributable to alcohol between 1995 and 2004. The number of fatalities dropped from 17,732 in 1995 to 16,694 in 2004, although the pattern of alcohol-related fatalities has been uneven—declining between 1996 and 1999, then increasing between 1999 and 2002, then declining until 2004.

Q&A

How is "alcohol-related" defined in this report?

The term "alcohol-related" does not indicate that a crash or fatality was caused by the presence of alcohol. As defined by the NHTSA, a motor vehicle crash is considered to be alcohol-related if at least one driver or non-occupant (pedestrian or pedalcyclist) involved in the crash is determined to have a BAC of 0.01 or higher. Thus, any fatality that occurs in an alcohol-related crash is considered an alcohol-related fatality.

Exhibit 5-13

Alcohol-related Fatalities, 1995 –2004

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
17,732	17,749	16,711	16,673	16,572	17,380	17,400	17,524	17,105	16,694

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA; Traffic Safety Facts 2004; National Center of Statistics & Analysis, NHSTA.

There are three main groups involved in alcohol-impaired driving. In 2004, 32 percent of drivers between the ages of 21 and 24 who were involved in fatal crashes had a BAC of 0.08 grams per deciliter, the highest for all age groups. Recent statistical reports show that drivers in this age group tend to have much higher levels of intoxication than other age groups. Drivers involved in fatal crashes with a BAC greater than 0.08 grams per deciliter were eight times more likely than sober drivers to have a prior conviction for driving while impaired.

Speed-related Crashes

Speeding is one of the most prevalent factors contributing to traffic crashes. In 2004, nearly 13,192 lives were lost in speed-related crashes. The estimated annual economic costs of speed-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.

For drivers involved in fatal crashes, young males are most likely to speed. The relative proportion of speed-related crashes to all crashes decreases with increasing driver age. For example, in 2004, 38 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 20 percent.

Q&A

What is the distribution of speed-related fatalities among functional systems?

About 14 percent of fatalities were on Interstates, 37 percent were on other arterial roads, 24 percent were on collector roads, and 25 percent were on local roads.

Research completed by NHTSA shows the correlation between speeding and alcohol consumption in fatal crashes. In 2004, 40 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 with a BAC of 0.00 involved in fatal crashes.

Many speeding crashes also occur during bad weather. Speeding was a factor in 29 percent of the fatal crashes that occurred on dry roads in 2004 and in 34 percent of those that occurred on wet roads. Speeding was a factor in 50 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. Almost half of speed-related fatalities occur on lower functional systems.

Crashes by Vehicle Type

Exhibit 5-14 shows the number of occupant fatalities by vehicle type from 1995 to 2004. The number of occupant fatalities that involved passenger cars decreased from 22,423 in 1995 to 19,091 in 2004, while occupant fatalities involving light and large trucks, motorcycles, and other vehicles all increased during this period. *Exhibit 5-15* presents the number of occupant injuries by vehicle type from 1995 to 2004.

The number of occupant fatalities in light trucks increased sharply between 1995 and 2004. Fatalities in these vehicles increased from 9,568 in 1995 to 12,602 in 2004, or an increase of 31.7 percent. There were 900,171 light truck occupants injured in 2004, up from 722,496 in 1995.

The number of occupant fatalities in large trucks increased 17.4 percent, from 648 in 1995 to 761 in 2004. There were 27,287 large truck occupants injured in 2004.

Exhibit 5-14

Fatalities for Vehicle Occupants by Type of Vehicle, 1995–2004

Type of Vehicle	1995	1997	2000	2002	2004
Motorists					
Passenger Cars	22,423	22,199	20,699	20,569	19,091
Light Trucks	9,568	10,249	11,526	12,274	12,602
Large Trucks	648	723	754	689	761
Motorcycles	2,227	2,116	2,897	3,270	4,008
Buses	33	18	22	45	41
Other & Unknown Vehicles	392	420	450	528	639
Nonmotorists					
Pedestrians	5,584	5,321	4,763	4,851	4,641
Pedalscyclists	833	814	693	665	725
Other & Unknown	109	153	141	114	128
Total	**41,817**	**42,013**	**41,945**	**43,005**	**42,636**

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

Exhibit 5-15

Injuries for Vehicle Occupants by Type of Vehicle, 1995–2004

Type of Vehicle	1995	1997	2000	2002	2004
Motorists					
Passenger Cars	2,469,358	2,340,612	2,051,609	1,804,788	1,642,549
Light Trucks	722,496	754,820	886,566	879,338	900,171
Large Trucks	30,344	30,913	30,832	26,242	27,287
Motorcycles	57,480	52,574	57,723	64,713	76,379
Buses	19,214	16,887	17,769	18,819	16,410
Other & Unknown Vehicles	4,468	5,602	10,120	6,187	7,262
Nonmotorists					
Pedestrians	86,000	77,000	78,000	71,000	68,000
Pedalscyclists	67,000	58,000	51,000	48,000	41,000
Other & Unknown	10,000	11,000	5,000	7,000	9,000
Total	**3,466,360**	**3,347,408**	**3,188,619**	**2,926,087**	**2,788,058**

Source: Fatality Analysis Reporting System / National Center for Statistics & Analysis, NHTSA.

The number of motorcyclists who died in crashes increased significantly between 1995 and 2004, from 2,227 in 1995 to 4,008 in 2004, an 80.0 percent increase; there were 76,379 motorcyclists injured in 2004, an increase of 32.9 percent from the 57,480 motorcyclists who were injured in 1995.

Motorcycle crashes are frequently speed-related. In 2004, for instance, about 36 percent of all motorcyclists involved in fatal crashes were speeding. Speed was 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 was more likely to have been a factor in motorcycle crashes than passenger car or light truck crashes.

Crashes by Age Group

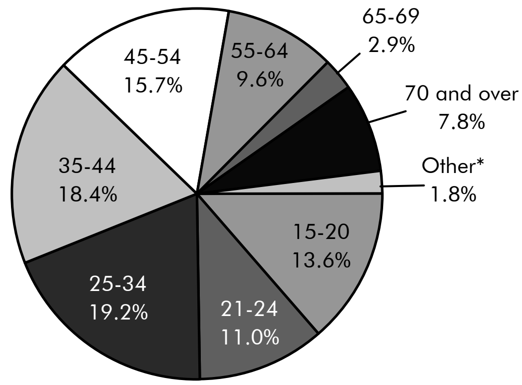
Another important way of examining highway crashes is by demographic segment. *Exhibit 5-16* shows the breakdown of drivers, by age, involved in fatal crashes in 2004.

Drivers between the ages of 15 and 20 constitute 6.3 percent of licensed drivers, but 13.6 percent of total drivers involved in fatal crashes. In 2004, 29 percent of the drivers killed in this age group had been drinking. Drivers in the next oldest age category, those between 21 and 24 years, made up 6.9 percent of licensed drivers and 11.2 percent of drivers involved in fatal crashes.

On the other end of the spectrum, there were 20.0 million drivers aged 70 or older in 2004, accounting for 10.0 percent of licensed drivers in 2004. This age group accounted for 7.9 percent of drivers involved in fatal crashes and 11.2 percent of driver fatalities in 2004.

Exhibit 5-16

Age of Drivers Involved in Fatal Crashes, 2004



*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 & Analysis, NHTSA

Older drivers tend to take shorter trips. They usually avoid driving during bad weather and at night; in 2004, for instance, most traffic fatalities involving older drivers occurred during the daytime (81 percent). Older drivers involved in fatal crashes also had the lowest proportion of intoxication of all adult drivers.

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 services only, in order to facilitate comparisons with data in previous editions of the C&P report.

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 2002 to 2004 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.

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.

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 due to 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.

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 1995 through 2004.

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 5-17 shows annual fatalities for directly operated transit services in both absolute numbers and adjusted according to the number of passenger miles traveled (PMT) in each year for 1995 to 2004. Between 1995 and 2004, total fatalities fluctuated between a high of 299 in 1999 and a low of 234 in 2003. There were 282 fatalities in 2002 and 248 in 2004. When adjusted for passenger use, however, the fatality rate per PMT has decreased over this time period, falling from 0.77 fatalities per 100 million PMT in 1995, to 0.66 per 100 million PMT in 2002, and to 0.55 fatalities per 100 million PMT in 2004.

Exhibit 5-17

Annual Transit Fatalities, 1995 –2004: Directly Operated Service

Year	Total	Per 100 Million PMT
1995	274	0.77
1996	265	0.73
1997	275	0.73
1998	286	0.73
1999	299	0.73
2000	292	0.69
2001	268	0.61
2002	282	0.66
2003	234	0.56
2004	248	0.55

Source: National Transit Database —Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-18 provides total incidents and injuries for directly operated services in both absolute terms and per 100 million PMT. Incidents and injuries both decreased from 2002 to 2004, falling substantially from 2002 to 2003 before rising slightly in 2004. Adjusted for passenger use, however, both incidents and injuries per 100 million PMT declined in both years during this time period.

Exhibit 5-18

Annual Incidents and Injuries, 2002 –2004: Directly Operated Service

	Incidents		Injuries	
Year	Total	Per 100 Million PMT	Total	Per 100 Million PMT
2002	24,247	57	19,367	46
2003	19,797	47	18,235	44
2004	20,939	46	18,982	42

Source: National Transit Database —Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-19 shows fatality rates per 100 million PMT for motorbus, heavy rail, commuter rail, light rail, and demand response, the five largest transit modes in terms of PMT. Together, these modes accounted for 97 percent of total PMT in 2004. [Absolute fatalities are not comparable across modes because of the wide range of passenger miles traveled on each mode and are therefore not provided.] This information is presented graphically in *Exhibit 5-20* for all these modes except demand response. Fatalities per 100 million PMT for demand response are excluded from the graph due to their volatility.

Exhibit 5-19

Transit Fatalities by Mode, 1995–2004:
Annual Rates per 100 Million Passenger Miles, Directly Operated Service

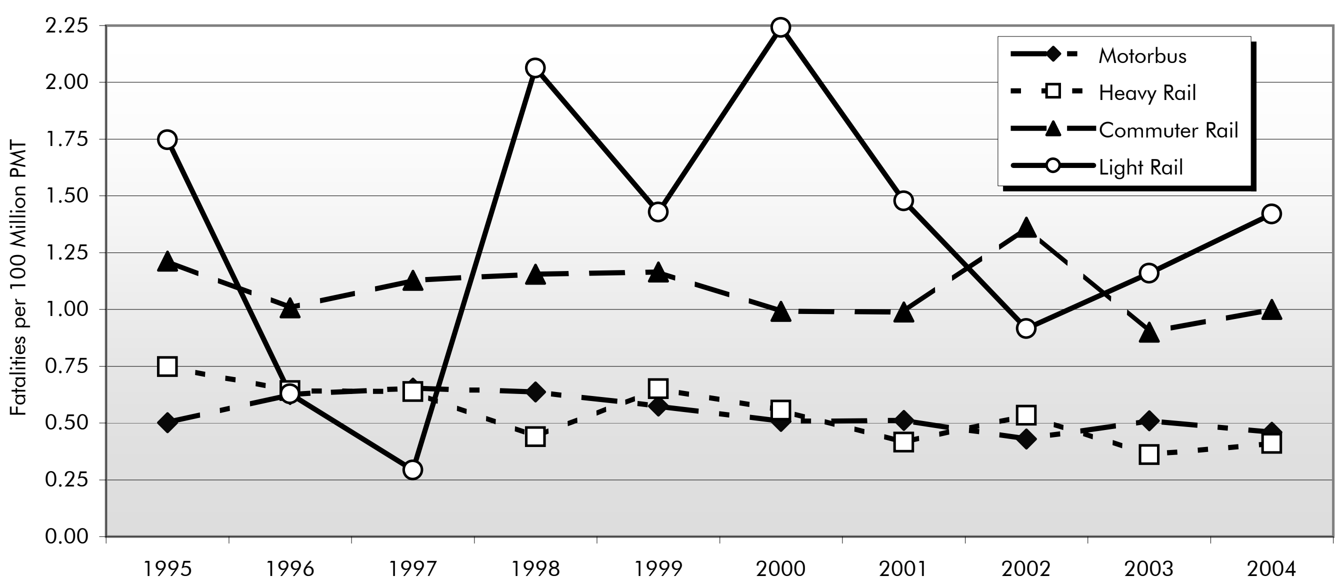
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Motorbus	0.50	0.63	0.65	0.64	0.57	0.51	0.51	0.43	0.51	0.46
Heavy Rail	0.75	0.64	0.64	0.44	0.65	0.56	0.42	0.53	0.36	0.41
Commuter Rail	1.21	1.01	1.13	1.16	1.16	0.99	0.99	1.36	0.90	1.00
Light Rail	1.75	0.63	0.29	2.06	1.43	2.24	1.48	0.92	1.16	1.42
Demand Response	4.04	8.26	3.00	2.07	0.48	3.77	0.42	0.00	1.81	0.00

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Rail transit vehicles that travel on separate fixed guideway have historically had a lower number of fatalities relative to use than rail transit vehicles that share their guideway with nontransit vehicles. Motorbuses, which travel at slower speeds, have also had a relatively low number of fatalities per 100 million PMT. Between 1995 and 2004, heavy rail and motorbus had the fewest fatalities per 100 million PMT among the five largest modes. In 2004 heavy rail had 0.41 fatalities per 100 million PMT and motorbus had 0.46 fatalities per 100 million PMT. [Heavy rail fatalities per 100 million PMT were above those for motorbus 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 1995 to 2004. Light rail had the highest number of fatalities per 100 million PMT among the rail modes in 7 of the 10 years from 1995 to 2004; light rail guideway is often at grade level and has minimal barriers between streets and sidewalks.

Exhibit 5-20

Fatality Rates by Mode, 1995–2004



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 1995 and 2004, ranging from no fatalities in 2004 to 8.26 fatalities per 100 million PMT in 1996. Demand response accounts for only 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 5-21 provides data on injuries and incidents per 100 million PMT for directly operated services on the five largest modes from 2002 to 2004. In 2004, commuter rail, which provides longer trips than other modes, had 19 incidents per 100 million PMT and 16 injuries per 100 million PMT, similar to the preceding 2 years. Heavy rail had 43 incidents and 33 injuries per 100 million PMT, light rail had 60 incidents and 41 injuries per 100 million PMT, and motorbuses had 70 incidents and 71 injuries per 100 million PMT. Demand response had the highest number of incidents and injuries per 100 million PMT from 2002 to 2004. Incidents on demand response systems declined from 225 per 100 million PMT in 2002 to 156 per 100 million PMT in 2004, and injuries declined from 173 per 100 million PMT to 131 per 100 million PMT. It is not clear, however, if this decline indicates a longer-term trend because, under the old definitions, incidents and injuries per 100 million PMT on demand response systems shown in the 2004 C&P Report did not decline between 1998 and 2002.

Exhibit 5-21

Transit Incidents and Injuries by Mode, 2002–2004: Directly Operated Service

Incidents per 100 Million PMT			
	2002	**2003**	**2004**
Motorbus	76	65	70
Heavy Rail	51	41	43
Commuter Rail	20	20	19
Light Rail	76	67	60
Demand Response	225	187	156
Injuries per 100 Million PMT			
	2002	**2003**	**2004**
Motorbus	66	67	71
Heavy Rail	35	31	33
Commuter Rail	17	19	16
Light Rail	39	37	41
Demand Response	173	181	131

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

Exhibit 5-22 shows the number of fatalities per 100 incidents for each of the five largest transit modes from 2002 to 2004. 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. Motorbuses, 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 on almost any other mode. While light rail and motorbus have similar numbers of incidents per PMT, an incident on light rail is two to three times more likely to produce a fatality than an incident on a motorbus.

Exhibit 5-22

Fatalities per 100 Incidents by Mode, 2002–2004

	2002	**2003**	**2004**
Motorbus	0.57	0.79	0.65
Heavy Rail	1.05	0.88	0.95
Commuter Rail	6.74	4.40	5.38
Light Rail	1.20	1.73	2.36
Demand Response	0	0.97	0

Source: National Transit Database—Transit Safety and Security Statistics and Analysis Reporting.

CHAPTER 6

Finance

Summary

Exhibit 6-1 compares the key highway and transit statistics discussed in this chapter with the values shown in the last report. The first data column contains the values reported in the 2004 C&P report, which were based on 2002 data. Where the 2002 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2004 data.

Exhibit 6-1

Comparison of Highway and Transit Finance Statistics with Those in the 2004 C&P Report

Statistic	2002 Data: 2004 C&P Report	2002 Data: Revised	2004 Data
Total Funding for Highways (all govts.)	$134.8 bil		$145.3 bil
Total Funding for Transit	$36.5 bil		$39.5 bil
Total Public Funding for Transit	$26.6 bil		$28.4 bil
Percent of Public Funding for Transit Funded by Federal Government	23.7%		24.3%
Total Highway Expenditures (all govts.)	$135.9 bil		$147.5 bil
Percent of Total Highway Expenditures Funded by Federal Government	24.1%		22.6%
Total Highway Capital Outlay (all govts.)	$68.2 bil		$70.3 bil
Percent of Total Highway Capital Outlay Funded by Federal Government	46.1%		43.8%
Percent of Total Highway Capital Outlay Used for System Rehabilitation	52.6%		51.8%
Total Transit Capital Outlay	$12.3 bil		$12.6 bil
Percent of Total Transit Capital Outlay Funded by Federal Government	40.6%		39.0%
Percent of Total Transit Capital Outlay Used for Rail	71%		70%
Total Highway-User Revenues (motor-fuel and vehicle taxes and tolls)	$100.5 bil	$100.5 bil	$106.8 bil
Highway-User Revenues Used for Roads	$79.6 bil		$83.0 bil
Total Transit Fares and Other System-Generated Revenue	$9.9 bil		$9.1 bil

Note that this chapter focuses on traditional revenue sources that supply most of the funding to support highways and bridges, other sources are playing an increasingly critical role in highway finance. The Innovative Finance section included in Chapter 6 of the 2004 C&P report has been expanded and moved to a stand-alone chapter. See Chapter 13 for information on public-private partnerships, as well as various Federal credit assistance programs.

Highways and Bridges

All levels of government generated $145.3 billion in 2004 to be used for highways and bridges. In addition to this total, $2.2 billion was drawn from reserves, so cash outlays for highways and bridges in 2004 totaled $147.5 billion, an increase of 8.5 percent compared to 2002. Highway expenditures grew more quickly than inflation over this period, rising 3.6 percent in constant dollar terms (based on the FHWA Construction Bid Price Index for highway capital outlay and the Consumer Price Index [CPI] for all other types of highway expenditures). Since 2002, highway capital expenditures by all levels of government grew 3.1 percent to $70.3 billion in 2004. The Federal government contributed $30.8 billion (43.8 percent) of total highway capital expenditures.

In 2004, 51.8 percent of highway capital outlay was used for system rehabilitation, down from 52.6 percent in 2002. Highway user revenues (the total amount generated from motor-fuel taxes, motor-vehicle taxes and fees, and tolls imposed at the Federal, State, and local level) rose from $100.5 billion in 2002 to $106.8 billion in 2004. Of this total, $83.0 billion (77.7 percent) was used for highway programs.

Transit

In 2004, $39.5 billion was available from all sources to finance transit investment and operations compared with $36.5 billion in 2002. 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 2004 Federal funding was $7.0 billion (18 percent of total transit funds), State funding was $7.8 billion (20 percent of total transit funds, local funding was $13.7 billion (35 percent of total transit funds), and system-generated revenues were $11.1 billion (28 percent of total transit funds). Between 2002 and 2004 total Federal funding increased by 10.5 percent, total State and local funding increased by 6.5 percent, and total system-generated revenues by 12.1 percent.

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 2004, total public transit agency expenditures for capital investment were $12.6 billion in current dollars (compared with $12.3 billion in current dollars in 2002) and accounted for 32 percent of total available funds. Federals funds were $4.9 billion (compared with $5.0 billion in 2002), State funds were $1.8 billion (compared with $1.4 billion in 2002), and local funds were $5.9 billion (the same as in 2002). The share of capital funds from Federal sources fell from 40.6 percent in 2002 to 39.0 percent in 2004.

Q&A

How was the $30.8 billion figure for Federal contributions to total highway capital 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 Tables HF 10 and HF-10A in *Highway Statistics,* which in turn are linked to Tables FA-5 and FA-5R, which list highway expenditures on an agency-by-agency basis 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 reported in Table FA-5 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 are able to report to the FHWA what portion was used for roads, so that this information may be included in Table FA-5.

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 Table HF-10. Such amounts would appear as Federal funding for transit in this report.

The $30.8 billion figure cited for the Federal contribution to total capital expenditures represents total Federal expenditures for highway purposes of $33.1 billion, less direct Federal expenditures for noncapital purposes such as maintenance on Federally owned roads, administrative costs, and research.

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2004, $26.9 billion was available for operating expenses (compared with $24.4 billion in 2002) and accounted for 68 percent of total available funds. Of this amount, $2.0 billion was provided by the Federal government (compared with $1.3 billion in 2002), 6.0 billion was provided by State governments (compared with $6.1 billion in 2002), $7.9 billion by local governments (compared with $6.9 billion in 2002), and $10.9 billion by system-generated revenues (compared with $9.9 billion in 2002). In 2004, transit operators' actual operating expenditures were $25.4 billion compared with $22.9 billion in 2002, a total increase of 11 percent.

The Federal share of funds for operating expenses increased from 5.4 percent in 2002 to 7.5 percent in 2004. 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 to as a result of the Transit Operating Flexibility Act passed in September 2002. 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.

Highway and Bridge Finance

This section presents information on the revenue sources that support public investment in highways and bridges and on 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 concludes with a more detailed analysis of capital expenditures.

While this chapter focuses on the traditional revenue sources that supply most of the funding to support highways and bridges, other sources are playing an increasingly critical role in highway finance. See Chapter 13 for a discussion of public private partnerships, as well as various Federal credit assistance programs.

Note that private sector investment in highways would generally show up in the "miscellaneous income" category in the tables in this section, to the extent such investment is captured in State and local accounting systems.

Revenue Sources

As shown in *Exhibit 6-2*, $145.3 billion was generated by all levels of government in 2004, to be used for highways and bridges. Actual cash expenditures in 2004 for highways and bridges were higher, totaling $147.5 billion; the difference of $2.2 billion drawn from reserves by various governmental units. The $2.2 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 2004. The

Exhibit 6-2

Revenue Sources for Highways, 2004
(Billions of Dollars)

	Federal	State	Local	Total	Percent
User Charges					
Motor-Fuel Taxes	$25.5	$29.2	$1.1	$55.7	38.3%
Motor-Vehicle Taxes and Fees	3.1	16.8	0.9	20.8	14.3%
Tolls	0.0	5.6	0.9	6.6	4.5%
Subtotal	**$28.6**	**$51.6**	**$2.9**	**$83.0**	**57.1%**
Other					
Property Taxes and Assessments	0.0	0.0	7.5	7.5	5.1%
General Fund Appropriations	2.0	4.8	16.8	23.6	16.2%
Other Taxes and Fees	0.3	3.5	4.1	7.9	5.5%
Investment Income and Other Receipts	0.0	2.6	4.9	7.6	5.2%
Bond Issue Proceeds	0.0	10.4	5.4	15.8	10.9%
Subtotal	**$2.4**	**$21.3**	**$38.7**	**$62.3**	**42.9%**
Total Revenues	**$30.9**	**$72.9**	**$41.5**	**$145.3**	**100.0%**
Funds Drawn from or (Placed in) Reserves	2.2	0.0	0.0	2.2	1.5%
Total Expenditures Funded During 2004	**$33.1**	**$72.8**	**$41.6**	**$147.5**	**101.5%**

Source: Highway Statistics 2004, Table HF-10, and unpublished FHWA data.

combined amount placed in reserves by States was less than $50 million, as was the estimated combined amount drawn from reserves by local governments. Both amounts round to the $0.0 billion shown in the State and local columns.

Highway-user charges, including motor-fuel taxes, motor-vehicle taxes and fees, and tolls, were the source of 57.1 percent of the $145.3 billion of total revenues for highways and bridges in 2004. The remaining 42.9 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 6-2.

Q&A

Were all revenues generated by motor-fuel taxes, motor-vehicle taxes and fees, and tolls in 2004 used for highways?

No. The $83.0 billion identified as highway-user charges in Exhibit 6-2 represents only 78.4 percent of total highway-user revenue, defined as all revenue generated by motor-fuel taxes, motor-vehicle taxes, and tolls. Exhibit 6-3 shows that combined highway-user revenue collected in 2004 by all levels of government totaled $105.8 billion.

Exhibit 6-3

Disposition of Highway-User Revenue by Level of Government, 2004 (Billions of Dollars)

Portion used for:	Federal	State	Local	Total
Highways	28.6	51.6	2.9	83.0
Transit	5.9	3.7	1.1	10.7
Other	0.3	11.6	0.1	12.1
Total Collected	**34.8**	**66.9**	**4.1**	**105.8**

Source: Highway Statistics 2004, Table HF-10 and unpublished FHWA data.

In 2004, $10.7 billion of highway-user revenue was used for transit, and $13.1 billion was used for other purposes, such as ports, schools, collection costs, and general government activities. The $0.3 billion shown as Federal highway-user revenue used for other purposes reflects the difference between total collections in 2004 and the amounts deposited into the HTF during FY 2004. 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 $5.9 billion shown as Federal highway-user revenue used for transit includes $4.8 billion deposited into the Transit Account of the HTF, as well as $1.1 billion that was deposited in the Highway Account of the HTF that States elected to use for transit purposes. Flexible funding provisions that allow States to reprogram certain highway funds for transit purposes are discussed in the "Transit Finance" section of this chapter.

The degree to which highway programs are funded by highway-user charges differs widely among the different levels of government. At the Federal level, 92.4 percent of highway revenues came from motor-fuel and motor vehicle taxes in 2004. The remainder came from general fund appropriations, timber sales, lease of Federal lands, oil and mineral royalties, and motor carrier fines and penalties.

Highway-user charges also provided the largest share, 70.8 percent, of highway revenues at the State level in 2004. Bond issue proceeds were another significant source of funding, providing 14.3 percent of highway funds at the State level. The remaining 14.9 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 6.9 percent of highway funding was provided by highway-user charges in 2004. Local general funds, property taxes, and other taxes and fees were the sources of 68.3 percent of local highway funding. Bond issue proceeds provided 13.0 percent of local highway funding, while investment income and miscellaneous receipts provided the remaining 11.9 percent.

Historical Revenue Trends

Exhibits 6-4 and *6-5* show how highway revenue sources have varied over time. Exhibit 6-4 identifies the different sources of highway revenue since 1921 for all levels of government combined. Exhibit 6-5 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 6-4 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 1999, property taxes dropped to an all-time low of 4.8 percent of total highway revenue and remained at roughly that level through 2002; in 2003, property taxes began to climb slightly, reaching 5.1 percent of total highway revenues in 2004. 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.

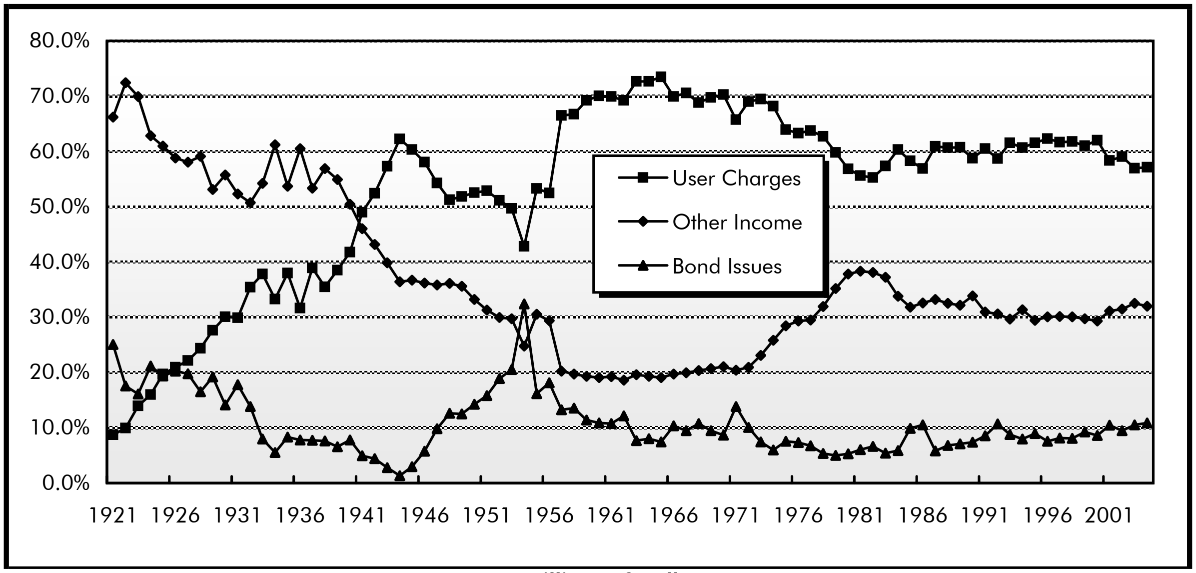
After peaking at an all-time high of 73.5 percent of highway revenues in 1965, the share represented by highway-user charges dropped to 55.2 percent in 1982. As shown in Exhibit 6-4, until 2000, the percentage had rebounded and stabilized in a range of about 60 to 62 percent. Since 2001, it has been slightly below 60 percent, ranging from 57 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 6-5. 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 61.6 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. In 1981, general fund revenues of $2.6 billion provided 25.1 percent of total Federal highway funding. 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 92.4 percent in 2004.

Exhibit 6-5 shows that the share of State government highway funding contributed by highway-user charges has generally declined over time. From 1997 to 2004, the percentage dropped from 76.3 percent to 70.8 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.

Exhibit 6-4

Highway Revenue Sources by Type, All Units of Government, 1921–2004

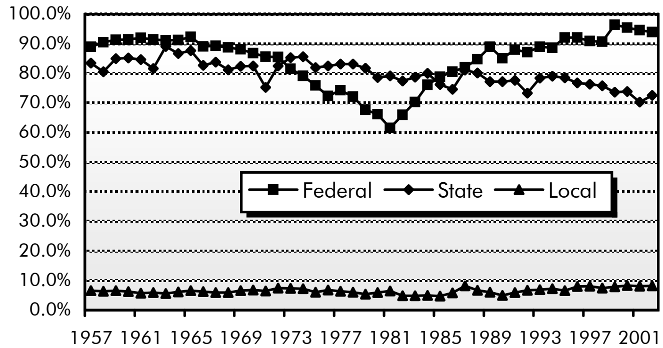


	Billions of Dollars							
Year	**Fuel and Vehicle Taxes**	**Tolls**	**Property Taxes**	**General Fund Approps.**	**Other Taxes and Fees**	**Investment Income and Other**	**Issue Proceeds**	**Total**
1921	$0.1	$0.0	$0.7	$0.1	$0.0	$0.1	$0.4	$1.4
1925	0.4	0.0	0.9	0.2	0.0	0.0	0.4	2.0
1929	0.7	0.0	1.2	0.2	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
1995	55.4	3.9	4.9	13.2	3.7	6.6	8.6	96.3
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

Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics Tables HF-10A and HF-10, various years.

Exhibit 6-5

Percent of Highway Revenue Derived from User Charges, Each Level of Government, 1957–2004



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%
1995	92.1%	78.5%	6.6%	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%

Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

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, for the reasons outlined earlier. 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 percent in each of 2003 and 2004.

Q&A

Why did the percentage of Federal revenue for highways derived from the highway-user charges increase sharply between 1998 and 1999?

In 1998, 4.8 percent of total Federal revenues for highways came from interest income credited to the Highway Account of the HTF based on its invested balance. Due to a legislative change, starting in FY 1999, the HTF no longer earns interest on its balances. With this revenue source eliminated, the Federal highway program now relies even more heavily on motor-fuel and motor-vehicle taxes for funding.

Highway Expenditures

Exhibit 6-2 indicates that total expenditures for highways in 2004 equaled $147.5 billion and identifies the portion of this total funded by each level of government. *Exhibit 6-6* classifies this total by type of expenditure and by the level of government. The "Federal," "State," and "Local" columns in this table 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. (Note that all amounts cited as "expenditures," "spending," or "outlays" in this report represent cash expenditures rather than authorizations or obligations.)

Exhibit 6-6

Direct Expenditures for Highways, by Expending Agencies and by Type, 2004 (Billions of Dollars)

	Federal	State	Local	Total	Percent
Capital Outlay	**$1.2**	**$50.9**	**$18.2**	**$70.3**	**47.6%**
*Funded by Federal Government**	*1.2*	*28.4*	*1.2*	*30.8*	*20.9%*
*Funded by State or Local Govt's**	*0.0*	*22.5*	*17.0*	*39.5*	*26.8%*
Noncapital Expenditures					
Maintenance	0.2	9.8	17.4	27.3	18.5%
Highway and Traffic Services	0.0	4.7	4.3	9.0	6.1%
Administration	2.1	6.6	4.1	12.7	8.6%
Highway Patrol and Safety	0.0	7.4	6.9	14.3	9.7%
Interest on Debt	0.0	4.0	1.9	5.8	3.9%
Subtotal	**$2.3**	**$32.5**	**$34.4**	**$69.2**	**46.9%**
Total, Current Expenditures	**$3.5**	**$83.4**	**$52.6**	**$139.5**	**94.6%**
Bond Retirement	**$0.0**	**$4.7**	**$3.3**	**$8.0**	**5.4%**
Total All Expenditures	**$3.5**	**$88.0**	**$56.0**	**$147.5**	**100.0%**
*Funded by Federal Government**	*3.5*	*28.4*	*1.2*	*33.1*	*22.4%*
*Funded by State Governments**	*0.0*	*57.9*	*15.0*	*72.9*	*49.4%*
*Funded by Local Governments**	*0.0*	*1.7*	*39.8*	*41.5*	*28.1%*

*Amounts shown in italics are provided to link this table back to revenue sources shown in Exhibit 6-2. These are non-additive to the rest of the table, which classifies spending by expending agency.

Source: Highway Statistics 2004, Table HF-10 and unpublished FHWA data.

While the Federal government funded $33.1 billion (22.4 percent) of total highway expenditures of $147.5 billion in 2004, 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 $3.5 billion (2.4 percent). The remaining $29.6 billion was in the form of transfers to State and local governments.

State governments combined $28.4 billion of Federal funds with $57.9 billion of State funds and $1.7 billion of local funds to make direct expenditures of $88.0 billion (59.7 percent). Local governments combined $1.2 billion of Federal funds with $15.0 billion of State funds and $39.8 billion of local funds to make direct expenditures of $56.0 billion (38.0 percent).

Types of Highway Expenditures

Current highway expenditures can be divided into two broad categories: non-capital and capital. Non-capital 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, including land acquisition and other right-of-way costs; preliminary and construction engineering; new construction, reconstruction, resurfacing, rehabilitation, and restoration costs of roadways, bridges, and other structures; and installation of traffic service facilities such as 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.

As shown in Exhibit 6-6, all levels of government spent $70.3 billion on capital outlay in 2004, or 47.6 percent of total highway expenditures. Highway capital outlay expenditures are discussed in more detail later in this chapter.

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.

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 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.

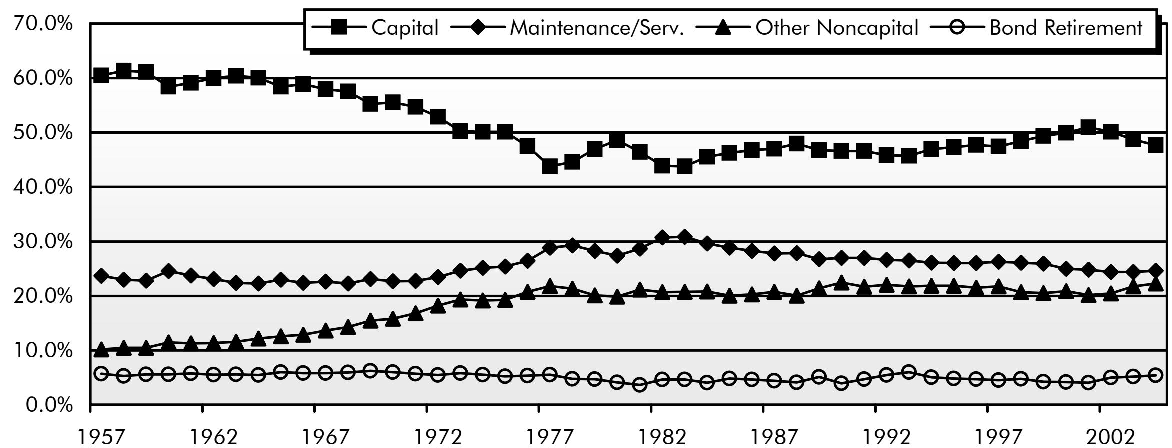
Current non-capital expenditures consumed $69.2 billion (46.9 percent), while the remaining $8.0 billion (5.4 percent) went for bond redemption. Most Federal funding for highways goes for capital items. Non-capital expenditures are funded primarily by State and local governments. In 2004, spending by local governments on non-capital expenditures exceeded spending by State governments on non-capital expenditures, with local governments spending $34.4 billion and State governments spending $32.5 billion. The majority of maintenance expenditures occurred at the local government level, or $17.4 billion (63.5 percent) of the $27.3 billion total.

Historical Expenditure and Funding Trends

Exhibits 6-7 and *6-8* provide historical perspective for the 2004 values shown in Exhibit 6-6. Exhibit 6-7 shows how the composition of highway expenditures by all levels of government combined has changed over time. Exhibit 6-8 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 6-7

Expenditures for Highways by Type, All Units of Government, 1957–2004



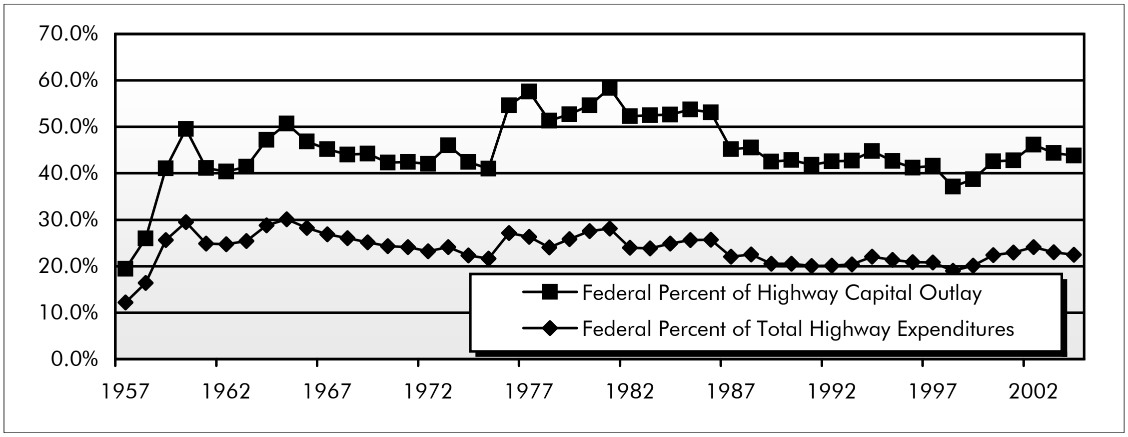
(Billions of Dollars)

			Other Noncapital					
Year	Capital Outlay	Mainten-ance and Services	Adminis-tration	Highway Patrol & Safety	Interest On Debt	Total Other Non-Capital	Debt Retire-ment	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
1995	$44.2	$24.3	$8.4	$8.2	$3.8	$20.4	$4.5	$93.5
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

Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

Exhibit 6-8

Funding for Highways by Level of Government, 1957–2004



Year	Funding for Total Highway Expenditures Billions of Dollars Federal	State	Local	Total	Percent Federal	Funding for Capital Outlay Billions of Dollars Federal	Total	Percent 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%
1995	$19.9	$48.8	$24.7	$93.5	21.3%	$18.9	$44.2	42.6%
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%

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) contributed to a 44.7 percent increase (from $102.0 billion to $147.5 billion) in total highway spending by all levels of government between 1997 and 2004. Capital outlay by all levels of government increased by 45.2 percent from $48.4 billion to $70.3 billion over the same period.

The percentage of total highway expenditures that went for capital outlay peaked at 61.3 percent in 1958. Subsequently, capital outlay's share of total spending gradually declined to a low of 43.8 percent in 1983. As shown in Exhibit 6-7, this share climbed up in 2001 and 2002, exceeding 50 percent for the first time since 1975. Since then, this share has fallen below 50 percent to 47.6 percent in 2004.

Exhibit 6-8 shows that the portion of total highway funding provided by the Federal government rose from 20.8 to 22.4 percent from 1997 to 2004. The Federal share of capital funding also increased significantly (from 41.6 to 43.8 percent) over this same period. Federal cash expenditures for capital purposes increased 52.9 percent from 1997 to 2004, while State and local capital investment increased by 39.9 percent. 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 has gradually declined, but remained above 20.0 percent until 1998, when it dropped to 19.0 percent. Because TEA-21 was not enacted until late in Federal FY 1998, the increased funding under the legislation did not immediately translate into increased cash outlays during that year. 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 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 subsequently been declining.

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 it in 2000 and has remained in it since. After rising to 46.1 percent in 2002, it has fallen to 43.8 percent in 2004.

Spending by all levels of government on maintenance and traffic services increased by 35.7 percent from 1997 to 2004, but declined as a percentage of total highway spending, since other types of expenditures grew even faster. As shown in Exhibit 6-7, maintenance and traffic services' share of total highway spending dropped to 24.6 percent. Spending on other non-capital expenditures, including highway law enforcement and safety, administration and research, and interest payments, also grew slightly faster than overall highway spending from 1997 to 2004, increasing from 21.8 percent of total spending to 22.3 percent.

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. As discussed earlier, 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 involved, State and local recipients of transfer payments from other governments have a varying degree of autonomy and discretion in how they use the funds. The implication of this is that 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.

The 2004 edition of this report noted that expenditures for highway law enforcement and safety grew more slowly than other spending categories from 1997 to 2002. This trend has not been maintained in subsequent years, as spending growth in this category reached 46.7 percent from 1997 to 2004. Expenditures for administration and research and for debt service grew slightly slower than overall highway spending over the same period. Debt retirement expenditures were the fastest-growing category of expenses between 1997 and 2004.

Constant Dollar Expenditures

Highway expenditures grew more quickly than inflation between 1997 and 2004. As noted earlier, total highway expenditures increased 44.7 percent from $102.0 billion to $147.5 billion between 1997 and 2004, which equates to an average annual growth rate of 5.4 percent. Over the same period, it is estimated that highway construction costs increased at an annual rate of 3.4 percent, and other costs rose at an annual rate of 3.3 percent. In constant dollar terms, total highway expenditures grew by 22.7 percent between 1997 and 2004.

Q&A

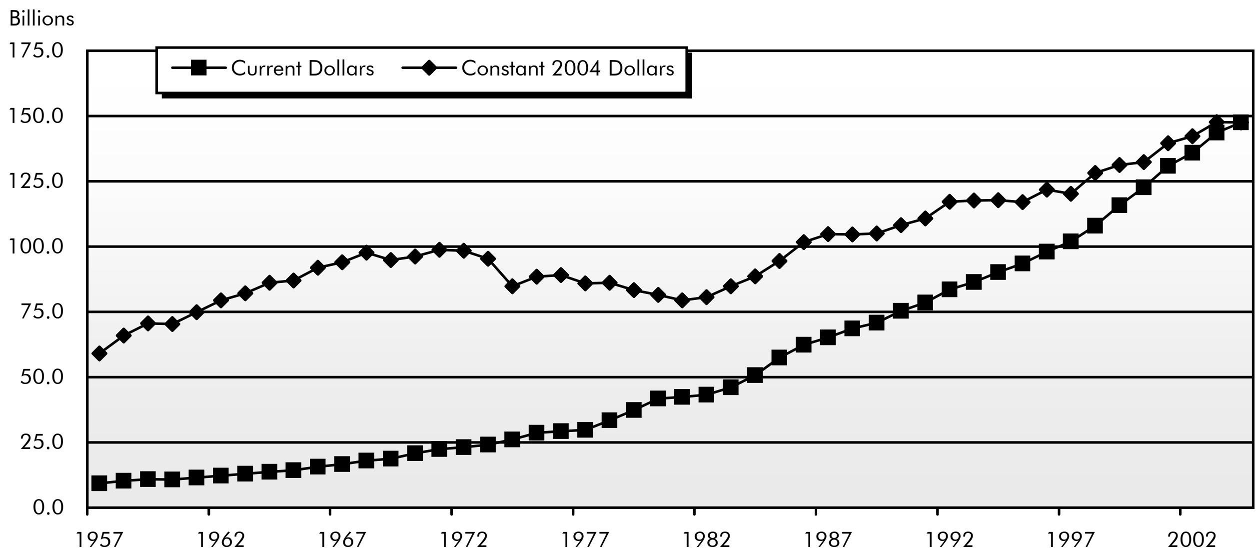
What indices are used to convert current dollars to constant dollars in this report?

For capital outlay expenditures, the FHWA Construction Bid Price Index is used. For all other types of highway expenditures, the CPI was used.

Exhibit 6-9 shows that highway expenditures have grown in current dollar terms in each of the years from 1957 through 2004. In constant dollar terms, total highway expenditures by all levels of government reached a plateau in 1971. From 1972 to 1981, highway spending did not keep pace with inflation. 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.

Exhibit 6-9

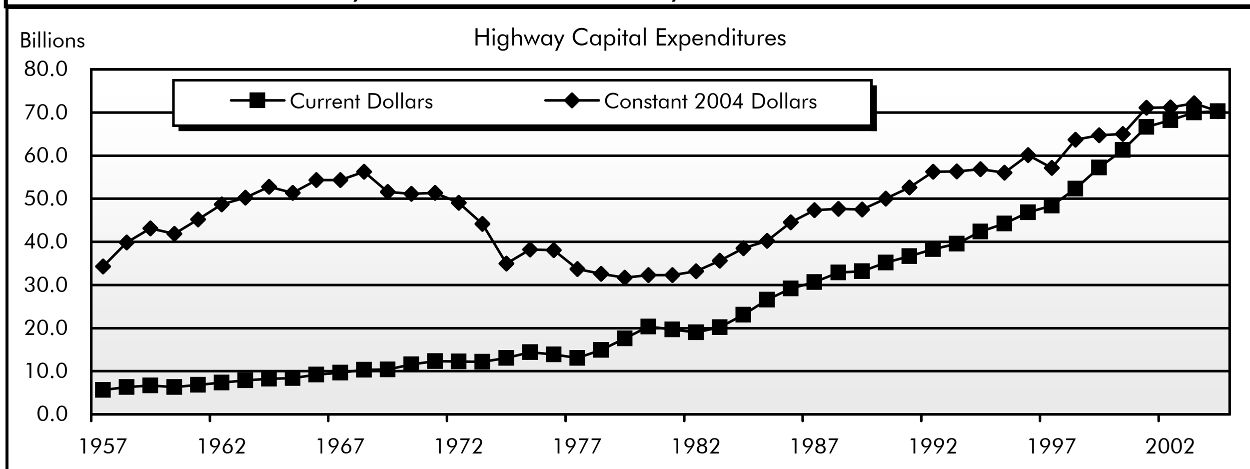
Total Highway Expenditures in Current and Constant 2004 Dollars, All Units of Government, 1957–2004

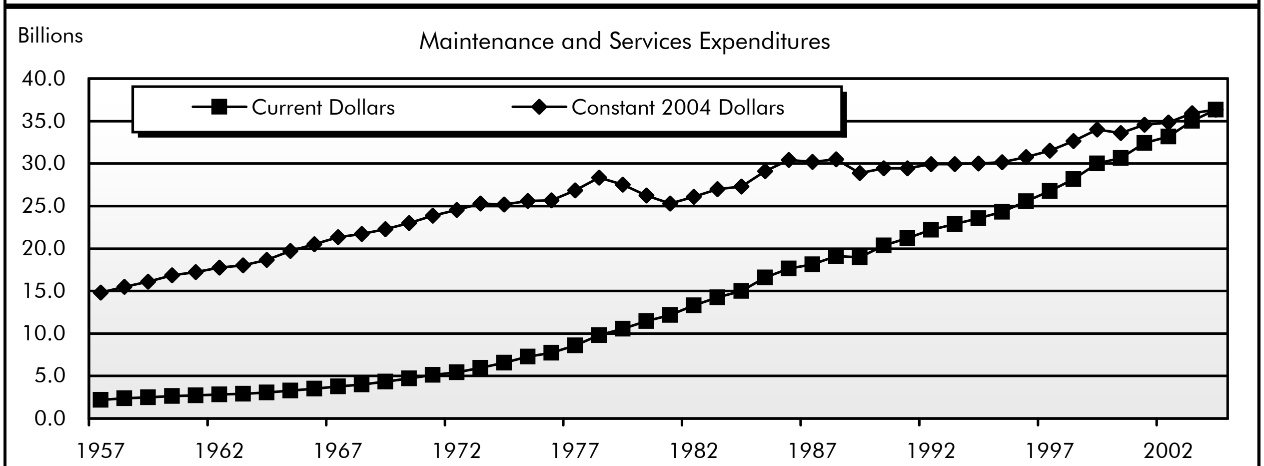


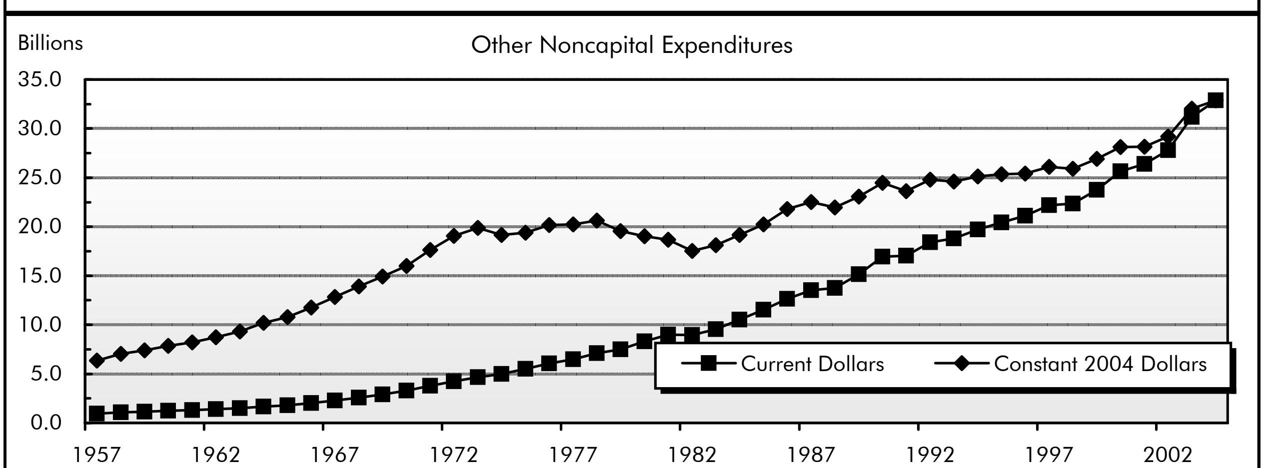
Much of the increase in constant dollar spending since 1981 has been driven by highway capital outlay expenditures, which have grown more quickly than maintenance and other non-capital expenditures in both current and constant dollar terms. Over this 23-year period, highway capital outlay grew at an average annual rate of 5.7 percent from $19.0 billion to $70.3 billion; in constant dollar terms, this equates to a 117.6 percent increase. Over this same period, maintenance and traffic services grew by 43.7 percent in constant dollar terms, and other non-capital expenditures grew by 76.1 percent in constant dollars. Highway construction costs grew more slowly than the CPI during this period, so the purchasing power of funds used for capital outlay expenditures has not eroded as quickly. Highway construction costs grew at an average annual rate of 2.2 percent since 1981, compared with an average annual increase in the CPI of 3.2 percent. *Exhibit 6-10* compares current dollar and constant dollar spending for capital outlay, maintenance and traffic services, and other non-capital expenditures (including highway law enforcement and safety, administration and research, and interest payments)

Exhibit 6-10

Highway Capital, Maintenance, and Other Noncapital Expenditures in Current and Constant 2004 Dollars, All Units of Government, 1957–2004







Looking at the more recent period between 1997 and 2004, highway capital outlay expenditures grew 22.9 percent in constant dollar terms. Federal spending, which accounted for nearly half (43.8 percent) of all highway capital outlay expenditures in 2004, increased 29.4 percent in constant dollars, while State and local capital investment increased by 18.3 percent in constant dollars. During this same period, maintenance and traffic services grew by 15.3 percent in constant dollar terms, and other noncapital expenditures grew by 25.9 percent in constant dollars.

Constant Dollar Expenditures per VMT

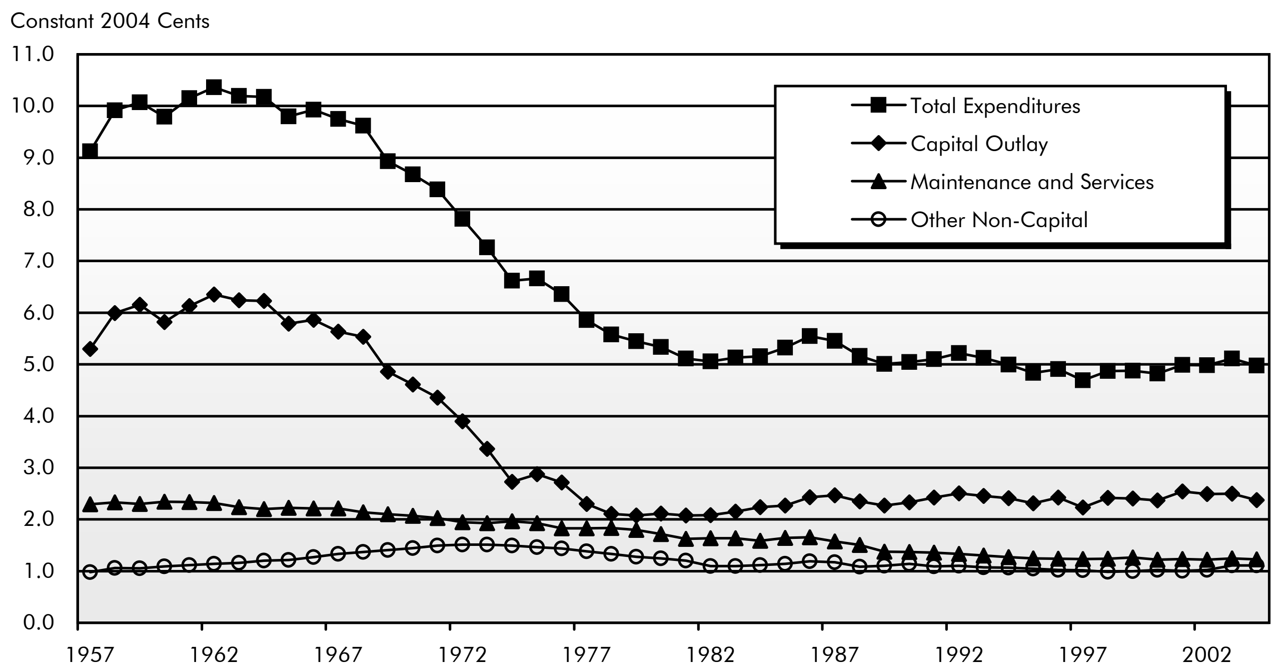
While not all types of highway expenditures would necessarily be expected to grow in proportion to vehicle miles traveled (VMT), increases in VMT do increase the wear and tear on existing roads, leading to higher capital and maintenance costs. The addition of new lanes and roads to accommodate additional 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 2004, expenditures per VMT rose from 4.0 cents to 5.0 cents. Expenditures per VMT in constant dollars also rose during this period, increasing 6.1 percent. During the 1960s and 1970s, total expenditures per VMT declined steadily in constant dollar terms, but the rate of decline slowed during the 1980s and early 1990s.

Capital outlay per VMT increased 6.3 percent between 1997 and 2004 in constant dollar terms. As shown in *Exhibit 6-11,* capital spending in 2001 was the highest since 1976. Spending on maintenance and traffic services declined 0.3 percent over this same period on a constant cents per VMT basis, but constant spending per VMT on other non-capital items rose 8.9 percent.

Exhibit 6-11

Highway Expenditures per Vehicle Mile Traveled, All Units of Government, 1957–2004



Highway Capital Outlay Expenditures

State governments directly spent $50.9 billion on highway capital outlay in 2004. As discussed earlier in the chapter, and as shown in Exhibit 6-6, this figure includes the $28.4 billion received in grants from the Federal government for highways.

Exhibit 6-12 shows how States applied this $50.9 billion to different functional systems and also includes an estimate of how the total $70.3 billion spent by all levels of government was applied. State government capital outlay is concentrated on the higher-order functional systems; local governments apply the larger part of their capital expenditures to lower-order systems.

Total highway capital expenditures by all levels of government amounted to $8,427 per lane-mile in 2004, or 2.4 cents per VMT. Capital outlay per lane-mile was highest for the higher-order functional systems and was higher on urban roads than rural roads. Capital outlay per VMT ranged from 3.4 cents on rural other principal arterials to 1.6 cents on urban minor arterials. On a cents-per-VMT basis, capital outlay for rural roads is about 12 percent higher than for urban roads.

Exhibit 6-12

Highway Capital Outlay by Functional System, 2004

Functional Class	Direct State Capital Outlay ($Billions)	Capital Outlay, all Jurisdictions Total ($Billions)	Per Lane Mile (Dollars)	Per VMT (Cents)
Rural Arterials and Collectors				
Interstate	$4.5	$4.5	$35,082	1.7
Other Principal Arterial	8.0	8.1	32,662	3.4
Minor Arterial	4.0	4.7	16,518	2.8
Major Collector	2.8	4.2	4,942	2.1
Minor Collector	0.5	1.5	2,738	2.4
Subtotal	**$19.9**	**$22.9**	**$11,243**	**2.4**
Urban Arterials and Collectors				
Interstate	11.0	11.0	133,238	2.4
Other Freeway & Expressway	5.8	6.1	127,962	2.9
Other Principal Arterial	7.9	9.9	47,095	2.2
Minor Arterial	3.2	5.9	23,892	1.6
Collector	1.1	3.3	15,138	2.0
Subtotal	**$28.9**	**$36.2**	**$44,938**	**2.2**
Subtotal, Rural and Urban	**$48.8**	**$59.2**	**$20,783**	**2.3**
Rural and Urban Local	**$2.1**	**$11.1**	**$2,024**	**2.8**
Total, All Systems	**$50.9**	**$70.3**	**$8,427**	**2.4**
*Funded by Federal Government**	*$28.4*	*$30.8*	*$3,692*	*1.0*

*Amounts shown in italics are non-additive to the rest of the table.

Source: Highway Statistics 2004 and unpublished FHWA data.

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. Note that the term "System Rehabilitation" replaces the term "System Preservation" used in previous C&P reports.

Exhibit 6-13 shows the distribution of the $48.8 billion in State expenditures among these three categories. Detailed data on Federal government and local expenditures are unavailable, so the combined $59.2 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 $70.3 billion invested on all systems in 2004, it was assumed that expenditure patterns were roughly equivalent to those observed for arterials and collectors.

Q&A

Why has the term "system preservation" been replaced by "system rehabilitation" in this edition of the C&P report?

Over time, the term "preservation" has been adopted within the asset management community to mean "a strategy of improvements on existing roads and bridges, intended to extend service life of the existing pavement and bridge infrastructure without increasing its structural capacity." That definition would include some items classified as maintenance expenditures in this report, but would not include heavy rehabilitation or reconstruction.

To avoid confusion, this edition of the report has dropped the general term "preservation" in favor of "rehabilitation," which is more widely understood to refer only to capital expenditures, rather than maintenance expenditures.

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, intended to preserve the existing pavement and bridge infrastructure. This includes reconstruction, resurfacing, pavement restoration or rehabilitation, widening of narrow lanes or shoulders, bridge replacement, and bridge rehabilitation. Also included is the portion of widening projects estimated to be related to reconstructing or improving the existing lanes. System rehabilitation does not include routine maintenance costs.

Note that system rehabilitation as defined in this report does not include routine maintenance. As shown in Exhibit 6-6, an additional $27.3 billion was spent by all levels of government in 2004 on routine maintenance.

System expansion includes the construction of new roads and new bridges, as well as those costs associated with adding 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 of the C&P report. 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.

In 2004, about $36.4 billion was spent on system rehabilitation (51.8 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, but does not include routine maintenance.

About $14.7 billion (20.9 percent of total capital outlay) was spent on the construction of new roads and bridges in 2004. An additional $12.8 billion (18.3 percent) is estimated to have been used to add lanes to existing roads. Another $6.4 billion (9.0 percent) was spent on system enhancement, including safety enhancements, traffic operations improvements, and environmental enhancements.

Exhibit 6-13

Highway Capital Outlay by Improvement Type, 2004 (Billions of Dollars)

		System Expansion			
	System Rehabilitation	New Roads & Bridges	Existing Roads	System Enhancement	Total
Direct State Expenditures on Arterials and Collectors					
Right-of Way		$2.2	$1.9		$4.0
Engineering	$3.3	1.3	1.1	$0.6	6.3
New Construction		6.8			6.8
Relocation			1.3		1.3
Reconstruction-Added Capacity	1.4		3.3		4.8
Reconstruction-No Added Capacity	3.6				3.6
Major Widening			2.3		2.3
Minor Widening	0.5				0.5
Restoration & Rehabilitation	7.3				7.3
Resurfacing	0.3				0.3
New Bridge		1.2			1.2
Bridge Replacement	3.0				3.0
Major Bridge Rehabilitation	1.9				1.9
Minor Bridge Work	2.0				2.0
Safety				1.4	1.4
Traffic Management/Engineering				0.9	0.9
Environmental and Other				1.3	1.3
Total, State Arterials & Collectors	**$23.1**	**$11.6**	**$9.9**	**$4.1**	**$48.8**
Total, Arterials and Collectors, All Jurisdictions (estimated)*					
Highways and Other	20.6	11.8	11.8	5.2	49.4
Bridge	8.3	1.4			9.7
Total, Arterials and Collectors	**$28.9**	**$13.2**	**$11.8**	**$5.2**	**$59.2**
Total Capital Outlay on all Systems (estimated)*					
Highways and Other	26.0	13.1	12.8	6.4	58.3
Bridges	10.5	1.6			12.0
Total, All Systems	**$36.4**	**$14.7**	**$12.8**	**$6.4**	**$70.3**
Percent of Total	**51.8%**	**20.9%**	**18.3%**	**9.0%**	**100.0%**

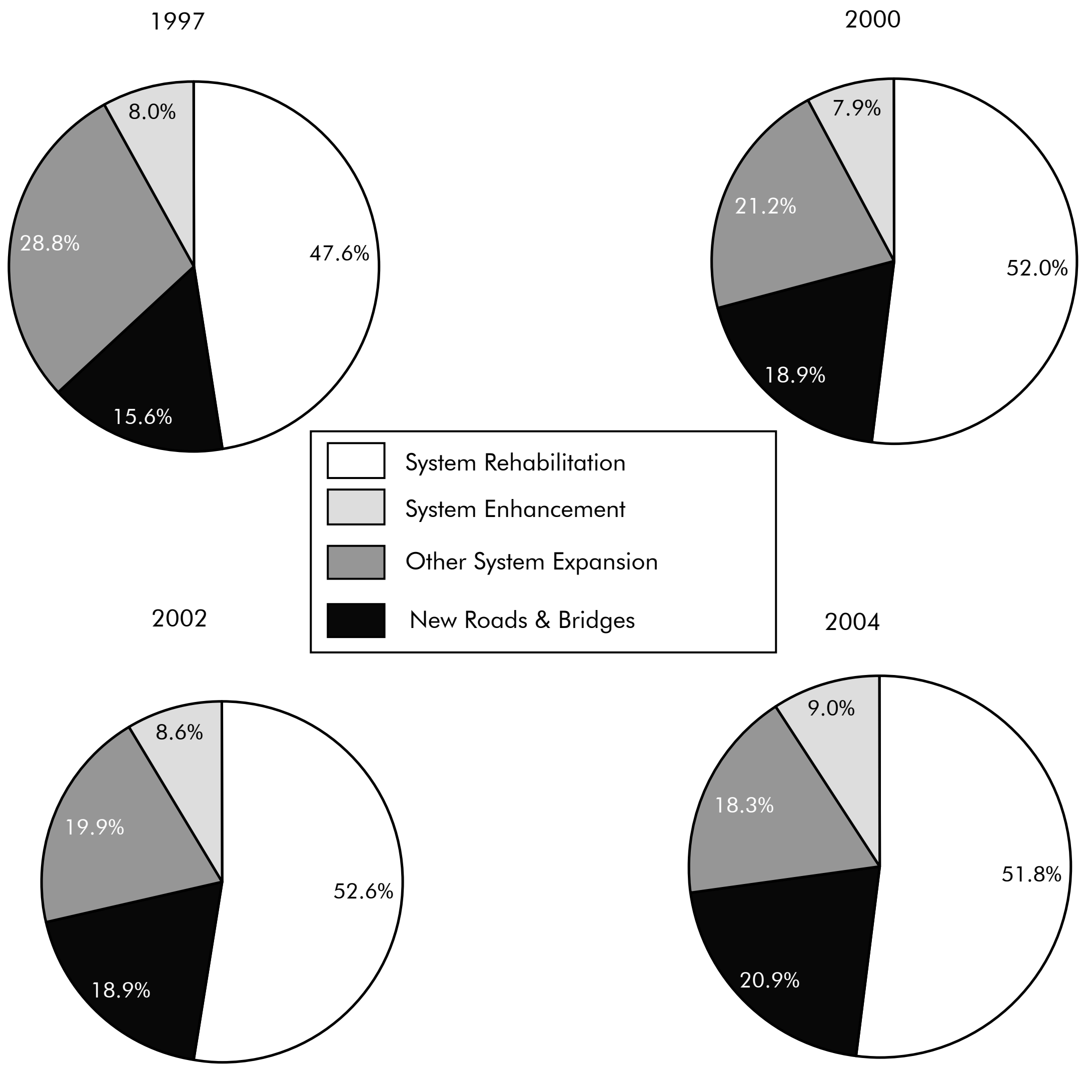
*Improvement type distribution was estimated based on State arterial and collector data.

Source: Highway Statistics 2004, Table SF-12A and unpublished FHWA data.

Exhibit 6-14 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 increased significantly from 1997 to 2002, reaching 52.6 percent. From 2002 to 2004, the rehabilitation share decreased slightly, to 51.8 percent. The share devoted to system enhancements decreased between 1997 and 2000, but has significantly increased since then to 9.0 percent in 2004.

Exhibit 6-14

Highway Capital Outlay by Improvement Type: 1997, 2000, 2002, and 2004



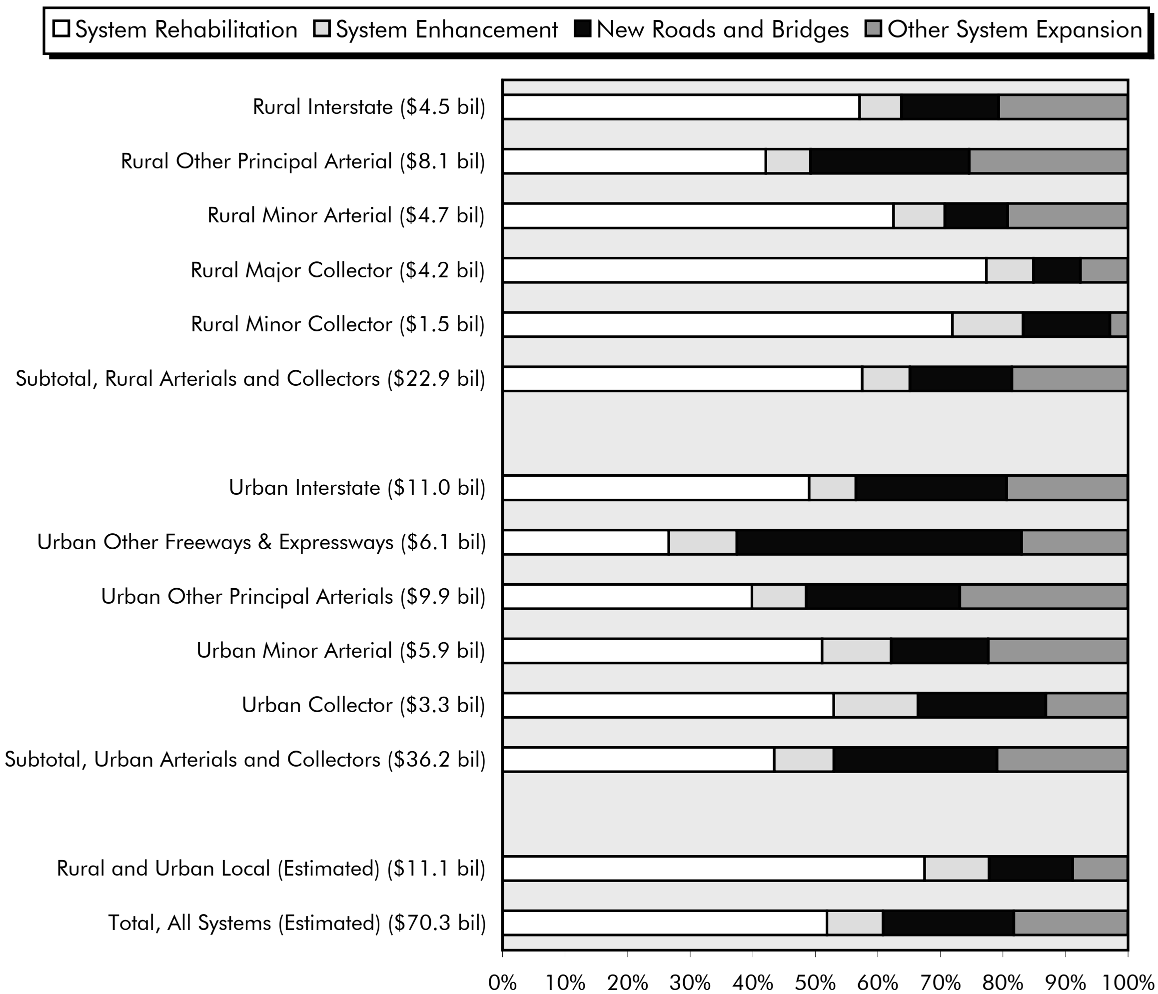
Expenditures for new roads and bridges relative to other improvement expenditures increased from 15.6 percent in 1997 to 18.9 percent 2000, and remained steady at that level in 2002. In 2004, expenditures for new roads and bridges relative to other improvement expenditures reached 20.9 percent. Other system expansion decreased significantly, however (18.3 percent in 2004 versus 19.9 percent in 2002, and down from 28.8 percent in 1997). As a result, overall outlays for system expansion continued to decrease proportionally, compared with rehabilitation and enhancements.

Exhibit 6-15 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 39.9 percent on urban other principal arterials to 77.4 percent on rural major collectors. Overall, system rehabilitation's share on arterials and collectors in rural areas (57.5 percent) was greater than in urban areas (43.5 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 45.5 percent, while urban other principal arterials have the largest share going to other system expansion improvements (26.9 percent). Urban other freeways and expressways have over 62.5 percent of capital investment devoted to system expansion. Total system expansion shares are lower on collectors (22.2 percent) than on Interstates (41.4 percent) and other arterials (47.9 percent).

Exhibit 6-15

Distribution of Capital Outlay by Improvement Type and Functional System, 2004



Constant Dollar Expenditures by Improvement Type

As indicated earlier, highway capital outlay expenditures grew 22.9 percent in constant dollar terms during the period from 1997 to 2004. Spending on system enhancements grew more quickly than spending on other components of highway capital outlay, increasing 38.9 percent in constant dollar terms from 1997 to 2004. System rehabilitation (also known as system preservation in previous reports) increased 33.9 percent in constant dollar terms, while investment in system expansion (the construction of new roads and bridges and widening of existing roadways) grew more slowly, rising 8.3 percent in constant dollar terms.

Transit Finance

Transit Funding

In 2004, $39.5 billion was available from all sources to finance transit investment and operations (compared with $36.5 billion in 2002). 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. 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 [*Exhibit 6-16*]. 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. More than two-thirds of the increase in transit funding between 2002 and 2004 comes from increases in local funding and system-generated revenues.

Exhibit 6-16

Revenue Sources for Transit Financing, 2004
(Millions of Dollars)

	Federal	State	Local	Total	Percent
Public Funds	**$6,954**	**$7,792**	**$13,659**	**$28,406**	**71.9%**
General Fund	1,391	2,043	2,692	**$6,126**	**15.5%**
Fuel Tax	5,564	505	148	**$6,216**	**15.7%**
Income Tax		187	98	**$285**	**0.7%**
Sales Tax		2,106	4,765	**$6,871**	**17.4%**
Property Tax		63	490	**$553**	**1.4%**
Other Dedicated Taxes		1,044	784	**$1,828**	**4.6%**
Other Public Funds		1,844	4,682	**$6,526**	**16.5%**
System-Generated Revenue				**11,093**	**28.1%**
Passenger Fares				9,114	**23.1%**
Other Revenue				1,979	**5.0%**
Total All Sources				**$39,499**	**100.0%**

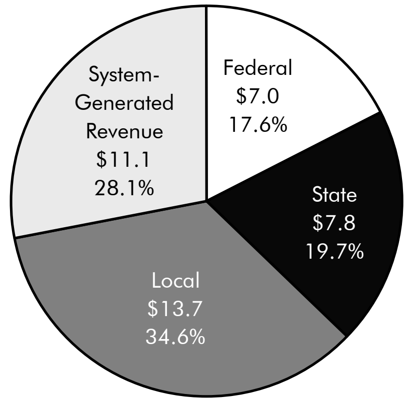
Source: National Transit Database.

Level and Composition of Transit Funding

Exhibit 6-17 breaks down the sources of total transit funding. In 2004, public funds of $28.4 billion were available for transit and accounted for 72 percent of total transit funding. Of this amount, Federal funding was $7.0 billion, accounting for 25 percent of total public funding and for 18 percent of all available funding from both public and nonpublic sources. State funding was $7.8 billion, accounting for 27 percent of total public funds and 20 percent of funding from all sources. Local jurisdictions provided the bulk of transit funds, $13.7 billion in 2004, or 48 percent of total public funds and 35 percent of all funding. System-generated revenues were $11.1 billion, 28 percent of all funding.

Exhibit 6-17

2004 Public Transit Revenue Sources (Billions of Dollars)



Source: National Transit Database.

Q&A

What type of dedicated funding does mass transit receive from Federal highway-user fees?

Prior to FY 1983, all Federal funding for transit was from general revenue sources. In 1983 the Mass Transit Account 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 Mass Transit Account 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 (TEA-21). 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 Mass Transit Account. (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.)

Since 1997, the Mass Transit Account 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). (The total Federal fuel tax for a gallon of LPG has been 11.9 cents, and the total tax for a gallon of LNG has been 48.54 cents.) The Mass Transit Account 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 Mass Transit Account. Prior to SAFETEA-LU, the Mass Transit Account was used to fund other FTA programs.

Federal Funding

Federal funding for transit comes from two sources, the general revenues of the U.S. government and revenues credited to the Mass Transit Account of HTF generated from fuel taxes. The Mass Transit Account, a transit trust fund for capital projects in transit, is the largest source of Federal funding for

Q&A

What comprises a general fund?

A general fund is made up of all appropriation, expenditure, and receipt transactions, except for those required, generally by statute, to be accounted for in a separate fund.

transit. Eighty-two percent of the transit funds authorized for transit by SAFETEA-LU ($37.2 billion) will be derived from the Mass Transit Account. Funding from the Mass Transit Account in nominal dollars increased from $0.5 billion in 1983 to $4.9 billion in 2004.

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 transfer highway trust funds for transit funding from general revenues. Federal-aid highway dollars could be converted to 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 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. In 2004, $1,475.4 million in flexible funds were available to transit for obligation, of which $980.0 million was transferred to FTA in FY 2004 and $494.5 million was the unobligated carryover from prior years' transfers. In 2002, $1.1 billion was "flexed" from highways to transit, and $1.6 billion in 2000. Since the program's beginning in FY 1992, through FY 2004, a total of $10.9 billion has been transferred from highways to transit.

Of the $980.0 million flexed by 43 states during FY2004, $975.4 million was obligated; $842.9 million was obligated to the Urbanized Area Formula program, $99.7 million to the Elderly and Persons with Disabilities Program, and $32.7 million to the Non-Urbanized Area Formula Program.

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.

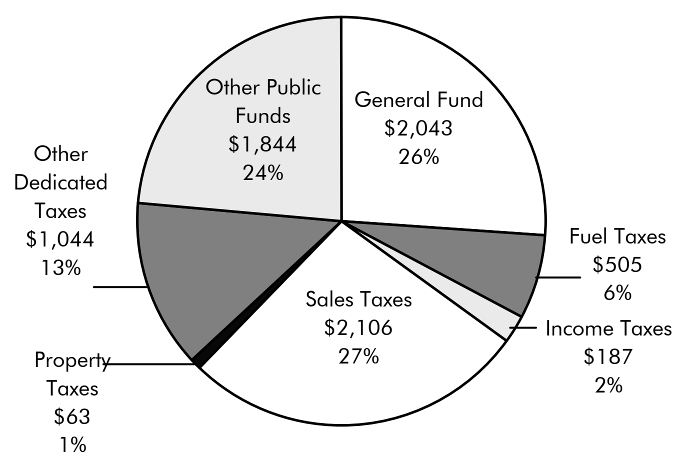
The flexible program also allows funds from the FTA Urbanized Area Formula Program to be transferred to FHWA. In 2004, a total of $1.7 million was transferred. During the 11 years of the flexible fund program, from FY 1992 to FY 2004, $43.6 million has been transferred to FHWA. This amount is less than one-half of one percent of total flexible funding.

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 [*Exhibits 6-18 and 6-19*]. In 2004, 26 percent of State funds and 20 percent of local funds came from general revenues. Allocations from other public funds accounted for 24 percent of total State and 34 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 2004, they accounted for 27 percent of total State and 34 percent of total local funding for transit. Dedicated income and property taxes provide more modest levels of funding at

Exhibit 6-18

2004 State Sources of Transit Funding (Millions of Dollars)



Source: National Transit Database.

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.

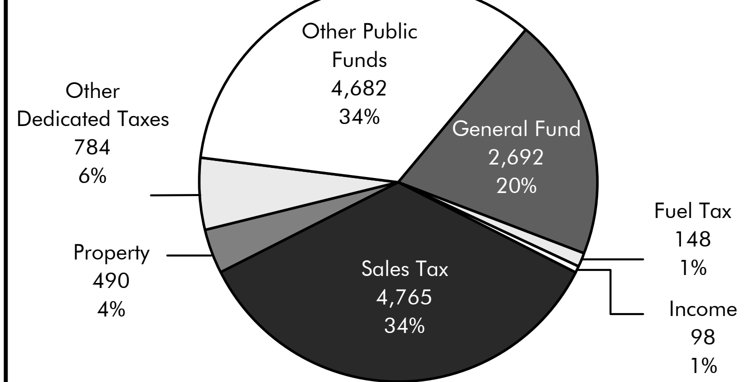
> **Q&A**
>
> **What are other public funds?**
>
> Other public funds are those funds that are not dedicated to transit at their source or are not included in the budgeting process of general revenue funds. These funds include vehicle licensing and registration fees, communications access fees, surcharges and taxes, lottery and casino, and the proceeds from property and asset sales.

Level and Composition of System-Generated Funds

In 2004, system-generated funds were $11.1 billion and provided 28 percent of total transit funding. Passenger fares contributed $9.1 billion, accounting for 82 percent of system-generated funds and 23 percent of total transit funds. These passenger fare figures do not include payments by State entities to transit systems to 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.

Exhibit 6-19

2004 Local Sources of Transit Funding (Millions of Dollars)



Source: National Transit Database.

Trends in Public Funding

Prior to 1962, there was no Federal funding for transit. State and local funding was limited, equal to 12 percent of total public funding for transit in 2004 in real terms. Public funding for transit grew rapidly in the 1970s. 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 throughout the decade. 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 2004 than in the 1980s and 1990s, growing at an average annual rate of 8.0 percent; Federal funding increased at an average annual rate of 7.2 percent, and State and local funding grew at an average annual rate of 8.3 percent. The average annual increase in Federal funding between 2002 and 2004 was 5.1 percent and the average annual increase in State and local funding over this period was 3.2 percent [*Exhibit 6-20*].

Federal funding for transit, as a percentage of total public funding for transit from Federal, State, and local sources combined, reached a peak of 43 percent in the early 1980s [*Exhibit 6-21*]. However, by 1990, the Federal government share had fallen to 26 percent as the result of the growth in State and local funding for transit vastly exceeding the growth of Federal funding during the 1980s. Since 1990, the Federal

Exhibit 6-20

Public Funding for Transit by Government Jurisdiction, 1960–2004

Year	Federal	State and Local	Total	Federal Share
	Millions of Current Dollars			Dollars
1960	$0	$683	**$683**	0.0%
1970	124	1,499	**1,623**	7.6%
1980	3,307	4,617	**7,924**	41.7%
1990	3,458	9,823	**13,281**	26.0%
1991	3,395	11,116	**14,511**	23.4%
1992	3,448	11,195	**14,643**	23.5%
1993	3,297	11,991	**15,287**	21.6%
1994	3,380	12,522	**15,902**	21.3%
1995	4,082	12,971	**17,053**	23.9%
1996	4,060	12,643	**16,703**	24.3%
1997	4,742	12,728	**17,470**	27.1%
1998	4,421	13,200	**17,620**	25.1%
1999	4,586	15,166	**19,752**	23.2%
2000	5,259	15,739	**20,999**	25.0%
2001	6,586	17,631	**24,216**	27.2%
2002	6,296	20,294	**26,590**	23.7%
2003	6,688	21,107	**27,796**	24.1%
2004	6,954	21,452	**28,406**	24.5%

Source: National Transit Database/Office of Management and Budget.

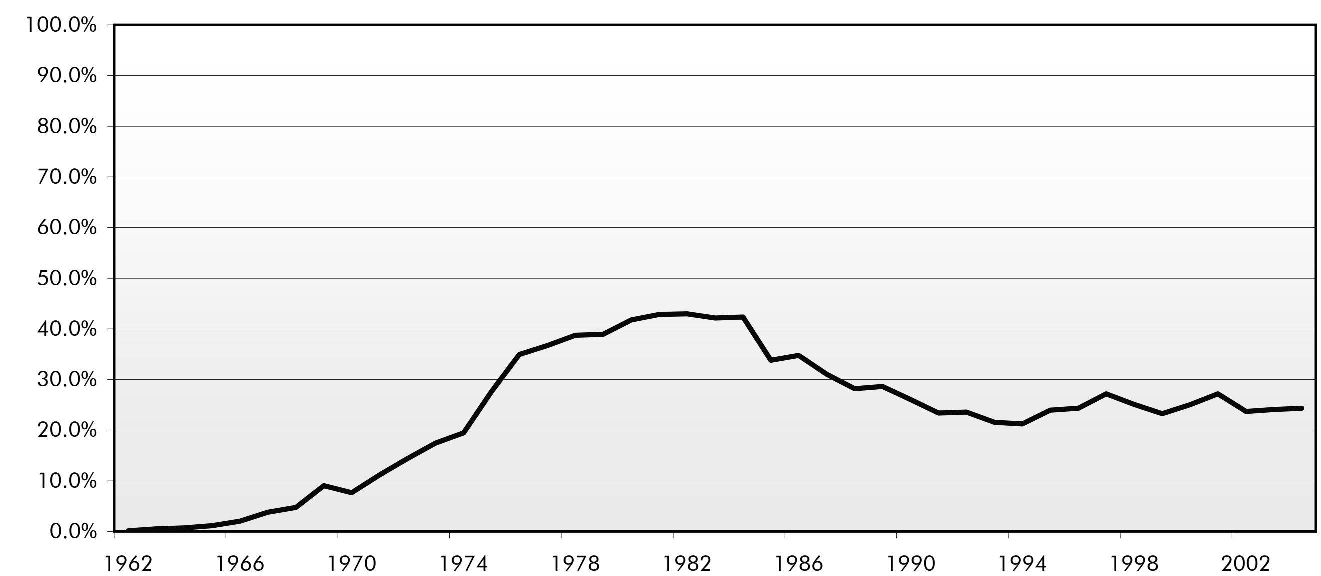
government has provided between 27 and 21 percent of total public funding for transit; in 2004, it provided 24.5 percent of these funds.

Funding in Current and Constant Dollars

Total public funding for transit in current dollars reached its highest level of $28.4 billion in 2004, compared with $26.6 billion in 2002, a total increase of 7.5 percent. Federal funding in current dollars was 10.5 percent higher in 2004 than in 2002, increasing from $6.3 billion in 2002 to $7.0 billion in 2004; and State and local funding in current dollars was 6.5 percent higher, increasing from $20.3 billion in 2002 to $21.5 billion in 2004. Total public funding for transit in constant dollars increased by 3.4 percent between 2002 and 2004; funding in constant dollars from Federal sources increased by 6.3 percent over this period and from State and local sources by 2.5 percent [*Exhibit 6-22*].

Exhibit 6-21

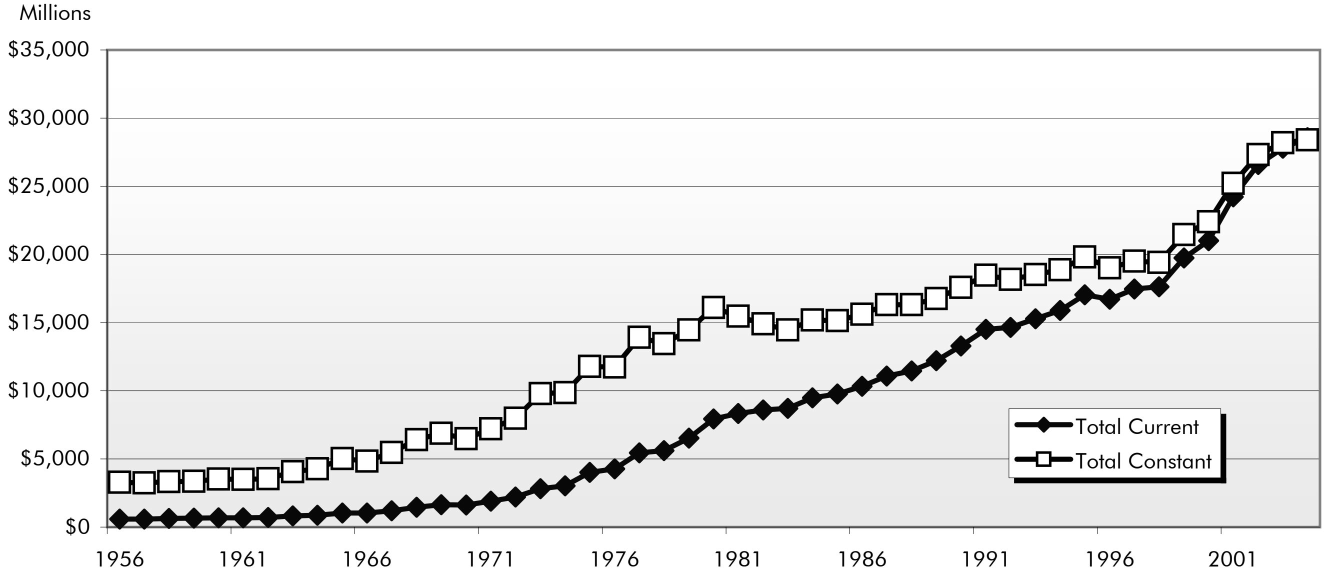
Federal Share of Public Funding for Transit, 1962–2004



Source: National Transit Database.

Exhibit 6-22

Current and 2004 Constant Dollar Public Funding for Public Transportation, 1956–2004



Source: National Transit Database.

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, which are discussed in Chapter 13.

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, and locomotives and service vehicles).

In 2004, total public transit agency expenditures for capital investment were $12.6 billion in current dollars and accounted for 32 percent of total available funds. Federals funds were $4.9 billion (39.0 percent of total transit agency capital expenditures), State funds were $1.8 billion (13.9 percent of total transit agency capital expenditures), and local funds were $5.9 billion (47.1 percent of total transit agency capital expenditures).

While the share of these funding sources was only very slightly different in 2004 than in 2002, it is notable that the 39 percent share of Federal funds for capital expenses in 2004 was well below the 47 percent in 1995, the 54 percent share in 1997, and the 1995 to 2004 average of 46 percent [*Exhibit 6-23*]. As will be discussed later in this chapter, this may be related to an increase in the Federal share of funds for operating expenses in 2004.

As shown in *Exhibit 6-24,* 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 2004, $8.8 billion, or 70 percent of total transit capital expenditures, was invested in rail modes of transportation, compared with $3.8 billion, or 30 percent of the total, which was invested in nonrail modes. This split was virtually the same in 2002.

Exhibit 6-24 shows the capital investment expenditures by asset type in 2004. The columns shown in the table are in descending order of the value of the amount invested with the exception of "other capital expenditures," which are provided at the end. Fluctuations in the levels of capital investment in different types of transit assets reflect normal rehabilitation and replacement cycles, in addition to new investment. Capital investment expenditures have only been reported to the NTD at the level of detail in Exhibit 6-24 since 2002.

Exhibit 6-23

Sources of Funds for Transit Capital Expenditures, 1995–2004 (Millions of Dollars)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average Annual Growth 2004/1995	Average Annual Growth 2004/2002
Federal	$3,314	$3,506	$4,138	$3,680	$3,726	$4,275	$5,468	$4,994	$5,092	$4,930	4.5%	-0.6%
Share	47.3%	50.4%	54.2%	49.7%	44.1%	47.2%	50.5%	40.6%	39.9%	39.0%		
State	$989	$895	$1,007	$875	$858	$973	$1,011	$1,433	$1,623	$1,756	6.6%	10.7%
Share	14.1%	12.9%	13.2%	11.8%	10.2%	10.7%	9.3%	11.6%	12.7%	13.9%		
Local	$2,706	$2,553	$2,492	$2,856	$3,860	$3,808	$4,345	$5,874	$6,061	$5,943	9.1%	0.6%
Share	38.6%	36.7%	32.6%	38.5%	45.7%	42.0%	40.1%	47.8%	47.4%	47.1%		
Total	**$7,008**	**$6,955**	**$7,636**	**$7,411**	**$8,443**	**$9,056**	**$10,825**	**$12,301**	**$12,775**	**$12,629**	**6.8%**	**1.3%**

Source: National Transit Database.

Exhibit 6-24

Transit Capital Expenditures by Mode and by Type, 2004 (Millions of Dollars)

	Guideway	Rolling Stock	Systems	Maintenance Facilities	Stations	Fare Revenue Collection Equipment	Administrative Buildings	Other Vehicles	Other Capital Expenditures[1]	Total	Percent of Total
Rail	**3,754**	**1,439**	**1,610**	**633**	**732**	**66**	**17**	**26**	**551**	**8,829**	**70%**
Commuter Rail	937	726	390	156	84	16	4	4	260	**2,577**	**20%**
Heavy Rail	1398	330	978	350	496	39	12	18	175	**3,796**	**30%**
Light Rail	1414	381	240	126	150	10	1	4	116	**2,441**	**19%**
Other Rail [2]	5	3	2	1	3	0	0	0	1	**15**	**0%**
Nonrail	**283**	**1,922**	**451**	**484**	**237**	**65**	**113**	**27**	**217**	**3,800**	**30%**
Motorbus	211	1665	296	427	219	61	102	25	191	**3,196**	**25%**
Demand Response	0	100	8	43	11	2	11	2	9	**187**	**1%**
Ferryboat	0	94	145	2	0	1	0	0	15	**257**	**2%**
Trolleybus	71	51	1	12	5	1	0	0	1	**143**	**1%**
Other Nonrail [3]	0	13	1	0	1	0	0	0	1	**16**	**0%**
Total	**4,036**	**3,362**	**2,062**	**1,117**	**969**	**131**	**130**	**54**	**768**	**12,628**	**100%**
Percent of Total	**32%**	**27%**	**16%**	**9%**	**8%**	**1%**	**1%**	**0%**	**6%**	**100%**	

[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, Publico and vanpool, aerial tramway.

Source: National Transit Database.

Guideway investment was $4.0 billion in 2004; investment in *systems* in 2004 was $2.1 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. A *system* is a group of devices or objects forming a network, especially for distributing something or serving a common purpose (e.g., telephone systems). [Note that these systems are different from the rail systems discussed in Chapters 3 and 7.]

Investment in *rolling stock* in 2004 was $3.4 billion, investment in *stations* was $1.0 billion, and investment in *maintenance facilities* was $1.1 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 platforms, shelters, and parking and crime prevention and security equipment at stations. *Facilities* include the purchase, construction, and rehabilitation of maintenance facilities, including design and engineering, demolition, and land acquisition. Facilities also include investment in transit malls, transfer facilities, intermodal terminals, shelters, passenger stations, depots, terminals, high-occupancy vehicle facilities, transit ways, park-and-ride facilities, and a range of equipment—crime prevention and security equipment, service and support equipment, operational support equipment (e.g., computer hardware and software), line equipment and structures, signals and communication equipment, and power equipment and substations—is also included. [Note that the facilities include guideway and rail systems reported separately in Chapters 3 and 7.] In 2004, $768 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. 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.

Operating Expenditures

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2004, $26.9 billion was available for operating expenses and accounted for 68 percent of total

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 construction of new fixed guideway systems, fixed guideway modernization and expansion, and bus capital requirements. 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 with alternative transportation strategies before deciding upon a locally preferred alternative. FTA evaluates proposed projects on the basis of financial criteria and project justification criteria (including cost-effectiveness) as prescribed by statute. Initial planning efforts are not funded through the Section 5309 program, but may be funded through Section 5303 Metropolitan Planning 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, however, 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; $2.8 billion dollars of New Starts funding was authorized for 2004.

available funds. Of this amount, $2.0 billion was provided by the Federal government (7.5 percent of total transit agency operating expenditures), $6.0 billion was provided by State governments (22.5 percent of total transit agency operating expenditures), $7.9 billion by local governments (29.4 percent of total transit agency operating expenditures), and $10.9 billion by system-generated revenues (40.6 percent of total transit agency operating expenditures) [*Exhibit 6-25*]. The Federal share of operating expenditures of 7.5 percent was higher in 2004 than in any other year during the 1995 to 2004 period, up from a 5.4 percent share in 2002; the State share of operating expenditures of 22.5 percent in 2004 declined from 25.3 percent in 2002. The share of operating expenditures provided by local governments and system-generated revenues was virtually unchanged from 2002 to 2004.

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 FY2003, 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 6-25

Sources of Funds for Transit Operating Expenditures,* 1995–2004 (Millions of Dollars)

											Average Annual	
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004/ 1995	2004/ 2002
Federal	$768	$554	$604	$741	$860	$984	$1,117	$1,302	$1,596	$2,024	**11.4%**	24.7%
Share	4.6%	4.6%	3.3%	4.0%	3.9%	4.5%	4.8%	5.4%	6.3%	7.5%		
State	$3,599	$3,789	$3,661	$3,819	$3,819	$4,351	$5,127	$6,113	$6,043	$6,036	**5.9%**	-0.6%
Share	21.8%	21.8%	20.0%	20.5%	17.4%	20.1%	21.8%	25.3%	23.8%	22.5%		
Local	$5,146	$5,406	$5,568	$5,649	$6,097	$6,513	$7,147	$6,874	$7,382	$7,887	**4.9%**	7.1%
Share	31.1%	31.1%	30.4%	30.3%	27.8%	30.0%	30.4%	28.4%	29.1%	29.4%		
System-generated Revenues	$7,015	$8,185	$8,477	$8,438	$11,128	$9,832	$10,112	$9,890	$10,355	$10,922	**5.0%**	5.1%
Share	42.4%	42.4%	46.3%	45.2%	50.8%	45.3%	43.0%	40.9%	40.8%	40.6%		
Total	**$16,527**	**$17,933**	**$18,310**	**$18,647**	**$21,905**	**$21,680**	**$23,503**	**$24,179**	**$25,376**	**$26,870**	5.5%	5.4%

* These are sources of funds for operating expenditures.
They differ slighlty from the amounts disbursed for operating expenditures provided in Exhibits 6-26 and 6-27.

Source: National Transit Database.

Operating Expenditures by Transit Mode

In 2004, transit operators' actual operating expenditures were $25.4 billion, compared with $22.9 billion in 2002 [*Exhibit 6-26*]. These expenditures increased at an average annual rate of 5.4 percent between 2002 and 2004, at about the same pace as the 4.9 percent average annual increase between 1995 and 2004. Demand response systems experienced the largest percentage increase in operating expenditures among the modes shown during the 2002 to 2004 period, rising at an average annual rate of 7.8 percent, which was below the 10.8 percent average annual increase between 1995 and 2004. The rapid increases in demand response operating expenditures reflect increased services to the elderly and persons with disabilities pursuant to the Americans with Disabilities Act of 1990 and new programs targeted toward the provision of services to these groups. Operating expenditures for heavy rail and commuter rail increased more rapidly between 2002 and 2004 (at average annual rates of 5.3 percent and 7.1 percent) than between 1995 and 2004 (at average annual rates of 3.3 percent and 5.0 percent). In contrast, the operating expenditures for light rail increased at an average annual rate of 3.0 between 2002 and 2004, much more slowly than the 9.2 percent average annual increase over the 1995 to 2004 period. Operating expenditures for buses increased at an average annual rate of 4.7 percent between 2002 and 2004, closely in line with the 1995 to 2004 average. Operating expenditures for the remaining modes combined as "Other" increased at an average annual rate of 7.1 percent between 2002 and 2004, relatively close to the 6.6 percent experienced, on average, over the 1995 to 2004 period.

Buses accounted for the largest percentage of transit operating expenditures, $13.8 billion in 2004, or 54 percent of the operating expenditure total. Operating expenditures for heavy rail in 2004 were $4.7 billion, or 19 percent of the total; operating expenditures for commuter rail were $3.4 billion, or 14 percent of the total, and operating expenditures for demand response systems were $1.9 billion, or 7.5 percent of the total. Operating expenditures for light rail were $0.8 billion, and operating expenditures for the remaining modes $0.7 billion, each accounting for less than 3.0 percent of the total [Exhibit 6-26].

Exhibit 6-26

Transit Operating Expenditures by Mode, 1995–2004 (Millions of Dollars)

Year	Motorbus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other	Total
1995	9,247	3,523	2,211	375	757	415	**16,528**
1996	9,324	3,402	2,294	440	849	440	**16,748**
1997	9,777	3,474	2,278	471	1,009	454	**17,462**
1998	10,120	3,530	2,360	493	1,134	498	**18,135**
1999	10,841	3,693	2,574	536	1,275	540	**19,460**
2000	11,026	3,931	2,679	592	1,225	549	**20,003**
2001	11,814	4,180	2,854	676	1,410	595	**21,529**
2002	12,586	4,267	2,995	778	1,636	643	**22,905**
2003	13,316	4,446	3,173	754	1,779	718	**24,185**
2004	13,790	4,734	3,436	826	1,902	739	**25,427**
Percent of Total							
1995	55.9%	21.3%	13.4%	2.3%	4.6%	2.5%	100.0%
2004	54.2%	18.6%	13.5%	3.2%	7.5%	2.9%	100.0%
Average Annual Growth Rate							
2004/2002	**4.7%**	**5.3%**	**7.1%**	**3.0%**	**7.8%**	**7.1%**	**5.4%**
2004/1995	**4.5%**	**3.3%**	**5.0%**	**9.2%**	**10.8%**	**6.6%**	**4.9%**

Source: National Transit Database.

Operating Expenditures by Type of Cost

In 2004, $13.4 billion, or 53 percent of total transit operating expenditures, were for vehicle operations [*Exhibit 6-27*]. Expenditures on vehicle maintenance were $5.0 billion, or 20 percent of the total; expenditures on nonvehicle maintenance were $2.7 billion, or 11 percent of the total; and expenditures on general administration were $4.2 billion, or 17 percent of the total. The distribution of these expenses across cost categories is virtually the same as in 2002. Expenditures increased for vehicle operations at an average annual rate of 7 percent between 2002 and 2004, for vehicle maintenance at an average annual rate of 4 percent, for nonvehicle maintenance at an average annual rate of 6 percent, and for general administration at an average annual rate of 3 percent.

Exhibit 6-27

Operating Expenditures by Mode and Type of Cost, 2004 (Millions of Dollars)

Mode	Vehicle Operations		Vehicle Maintenance		Nonvehicle Maintenance		General Administration		Total	
Motorbus	$8,006	60%	$2,862	57%	$631	23%	$2,291	54%	$13,790	54%
Heavy Rail	2,015	15%	813	16%	1,224	45%	683	16%	4,734	19%
Commuter Rail	1,380	10%	820	16%	623	23%	613	15%	3,436	14%
Light Rail	374	3%	206	4%	156	6%	152	4%	887	3%
Demand Response	1,264	9%	234	5%	40	1%	364	9%	1,902	7%
Other	393	3%	107	2%	61	2%	117	3%	677	3%
Total	**$13,431**	**100.0%**	**$5,042**	**100.0%**	**$2,735**	**100.0%**	**$4,219**	**100.0%**	**$25,427**	**100.0%**
	53%		**20%**		**11%**		**17%**		**100%**	

Source: National Transit Database.

Bus and rail operations have inherently different cost structures. While 67 percent of total operations expenditures for demand response transit (e.g., demand response operating expenses of $1,264 million as a percentage of demand response total operating expenses of $1,902 million) and 58 percent of total operations expenditures for buses were spent for actual operation of the vehicles, only 42 percent of rail operations expenditures were spent on the operation of rail vehicles. A significantly higher percentage of expenditures for rail modes of transportation are classified as nonvehicle maintenance for the repair and maintenance of fixed guideway systems.

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. In 2004, operating expenditures per VRM for all transit modes combined was $6.42 [*Exhibit 6-28*]. The average annual increase in operating expenditures per VRM for all modes combined was higher between 2002 and 2004 (at an average annual rate of 3.5 percent) than between 1995 and 2004 (at an average annual rate of 1.9 percent.) Commuter rail experienced the most rapid average annual increase in operating expenditures per VRM between 2002 and 2004 at an average annual rate of 5.2 percent. Operating expenditures per VRM for demand response systems also increased briskly during this period at an average rate of 4.3 percent. In contrast, operating expenditures per VRM for light rail decreased at an average rate of 2.3 percent between 2002 and 2004, declining from a peak of $12.98 in 2002. Between 2002 and 2004, light rail operating expenses increased by 3.0 percent and light rail VRM increased by 5.4 percent. [Note that operating expenses per VRM for light rail increased very rapidly between 2000 and 2002.]

Exhibit 6-28

Operating Expenditures per Vehicle Revenue Mile, 1995–2004

Year	Motorbus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other *	Total
1995	5.81	6.52	10.15	11.07	2.55	5.86	6.05
1996	5.91	6.44	10.36	12.01	2.76	5.53	6.09
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	7.33	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
Average (1995–2004)	**$6.44**	**$6.82**	**$10.95**	**$11.98**	**$2.95**	**$5.36**	**$6.42**
Average Annual Rate of Change							
2004/2002	**4.1%**	**3.5%**	**5.2%**	**-2.3%**	**4.3%**	**-3.5%**	**3.5%**
2004/1995	**2.6%**	**1.7%**	**2.6%**	**1.3%**	**3.2%**	**-1.3%**	**1.9%**

* Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Publico, trolleybus, and vanpool.

Source: National Transit Database.

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 [*Exhibit 6-29*]. 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 the least efficient. Operating expenses

Exhibit 6-29

Operating Expenditures per Capacity-Equivalent Vehicle Revenue Mile, 1995–2004

Year	Motorbus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other *	Total
1995	5.81	2.93	5.49	4.73	18.25	7.42	4.96
1996	5.91	2.90	5.61	5.13	19.76	7.43	5.00
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
Average (1995–2002)	**$6.22**	**$2.94**	**$4.99**	**$4.91**	**$18.10**	**$7.73**	**$5.11**
Average Annual Rate of Change							
2004/2002	**4.1%**	**2.6%**	**4.5%**	**-5.9%**	**7.3%**	**3.9%**	**3.4%**
2004/1995	**2.6%**	**0.5%**	**-1.0%**	**-0.3%**	**0.3%**	**2.3%**	**1.5%**

* Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Publico, tramway, trolleybus, and vanpool.

Source: National Transit Database.

per capacity-equivalent VRM for all modes, except light rail, increased more rapidly between 2002 and 2004 than the average level of inflation in the economy as measured by the GDP deflator. Operating expenses per capacity-equivalent VRM for light rail decreased between 2002 and 2004 because operating expenses grew at 3.0 percent and capacity-equivalent VRM grew by 9.4 percent. [Note that annual changes in operating expense per capacity-equivalent VRM and unadjusted VRM for bus are the same. Annual changes in operating expense per capacity-equivalent VRM and 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. The 2004 report used constant carrying capacity adjustment factors across all years.]

Operating Expenditures per Passenger Mile

Operating expenditures per passenger mile is an indicator of the cost effectiveness of providing a transit service [*Exhibit 6-30*]. 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 3.2 percent between 1995 and 2004 (from $0.41 to $0.55), approximately twice as fast as the 1.7 percent average annual increase in the GDP deflator. This indicates that, on average, the cost of providing transit services in terms of passenger miles provided was double the rate of inflation in the rest of the economy over the same time period. The increase in operating costs per passenger mile between 2002 and 2004 was particularly noticeable for bus, commuter rail, and demand response services. Operating expenditures per passenger mile for buses increased at an average annual rate of 6.4 percent over this time period because of a decline in passenger miles traveled coupled with increases in operating costs. Operating expenditures per passenger mile for commuter rail also increased at an average annual rate of 5.4 percent over this period as a result of an increase in operating costs well in excess of the increases in passenger miles. Operating expenditures per passenger mile for demand response systems, heavy rail, and light rail increased over the 2002 to 2004 period at average annual rates of 3.7 percent, 2.8 percent, and 1.5 percent.

Exhibit 6-30

Operating Expenditures per Passenger Mile Traveled by Mode, 1995–2004

Year	Motorbus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other	Total
1995	0.54	0.32	0.27	0.44	1.91	0.47	0.41
1996	0.55	0.30	0.27	0.46	2.17	0.46	0.43
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
Average (1993-2004)	**$0.61**	**$0.30**	**$0.30**	**$0.48**	**$2.26**	**$0.49**	**$0.46**
Average Annual Rate of Change							
2004/2002	**6.4%**	**2.8%**	**5.4%**	**1.5%**	**3.7%**	**-1.8%**	**5.0%**
2004/1995	**3.3%**	**0.3%**	**3.0%**	**2.8%**	**3.9%**	**1.4%**	**3.2%**

* Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Publico, trolleybus, aerial tramway, and vanpool.

Source: National Transit Database.

Farebox Recovery Ratios

The farebox recovery ratio is calculated as 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 2002 to 2004 are provided in *Exhibit 6-31*. The average farebox recovery ratio over this period for all transit modes combined was 35 percent; heavy rail had the highest average farebox recovery ratio (60 percent), followed by commuter rail (48 percent), light rail (28 percent), bus (27 percent), and demand response (10 percent). The farebox recovery ratios for the remaining "other" modes averaged 33 percent; of these modes, automated guideway had the lowest average recovery ratio (3 percent) and inclined plane the highest (123 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 6-31

Farebox Recovery Ratio by Mode, 2002 –2004

Year	Motorbus	Heavy Rail	Commuter Rail	Light Rail	Demand Response	Other	Total
2002	28%	58%	48%	29%	11%	30%	35%
2003	27%	60%	49%	28%	9%	32%	35%
2004	27%	61%	47%	26%	9%	36%	35%
Average (2002–2004)	**27%**	**60%**	**48%**	**28%**	**10%**	**33%**	**35%**

* Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, Publico, trolleybus, aerial tramway, and vanpool.

Source: National Transit Database.

Rural Transit

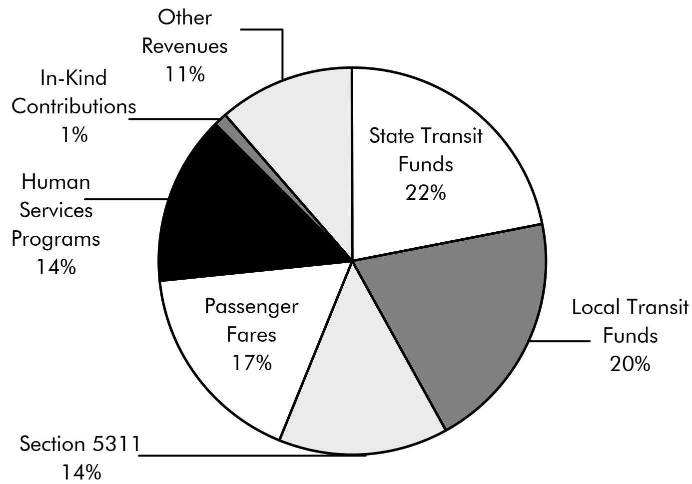
Since 1978, the Federal Government has contributed to the financing of transit in rural areas, i.e., areas with populations of less than 50,000. These rural areas are estimated to account for 36 percent of the U.S. population and 38 percent of the transit-dependent population.

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.

On average, 14 percent of rural transit authorities' operating budgets come from Section 5311 funds [*Exhibit 6-32*]. State and local governments cover, respectively, 22 and 20 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. In 2000, the last year for which information is available, total State and local contributions to rural transit operating budgets increased to a total of $431 million, up from $145 million in 1994. Human Services programs, including Medicaid, cover about 14 percent of rural operating budgets, and in-kind contributions and other revenues cover the remainder.

Exhibit 6-32

Rural Transit Operators' Budget Sources for Operating Expenditures, 2000



Source: Status of Rural Public Transportation, 2000, Community Transportation Association of America, April 2001.

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, however, directly address which revenue sources 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, **Capital Investment Scenarios,** provides estimates of future capital investment under different scenarios. The "Cost to Maintain" scenarios for highways and bridges and for transit are designed to show a level of investment estimated to be sufficient to keep future indicators of conditions and performance at current levels. The "Cost to Improve" scenarios for highways and bridges and for transit are intended to define the upper limit of appropriate national investment based on engineering and economic criteria. **The benchmarks included in this chapter are intended to be illustrative and do not represent comprehensive alternative transportation policies.**

Chapter 8, **Comparison of Spending and Investment Scenario Estimates,** relates the estimates presented in Chapter 7 to current and anticipated highway and transit capital expenditures in the United States. The chapter identifies "gaps" that may exist between current funding levels and future investment levels under different scenarios. It also compares the current mix of highway and transit capital spending by type of improvement (especially rehabilitation and expansion) to the future investment mix suggested by the models.

Chapter 9, **Impacts of Investment,** relates historic capital funding levels to recent condition and performance trends. It also analyzes the projected impacts of different future levels of investment on measures of physical condition, operational performance, and system use.

Chapter 10, **Sensitivity Analysis,** explores the impact that varying travel growth forecasts and some other key assumptions would have on the investment scenario estimates. 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.

Implications of the 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. While the discussion focuses heavily on the impacts of investing in a manner consistent with "Cost to Maintain" and "Cost to Improve" scenarios, these represent only two points on a continuum of alternative investment levels. **The Department does not endorse either of these scenarios 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 in the future.**

This report has traditionally identified the amount of additional spending above current levels that would be required to achieve certain performance benchmarks, without considering the types of revenues required to support this additional spending. The implicit assumption has been that the financing mechanisms would not have any impact on the investment scenario estimates. In reality, however, increased funding from general revenue sources (such as property taxes, sales taxes, income taxes, etc.) could have different implications than increased funding from user charges (such as fuel taxes, tolls, and fares). This is particularly important on the highway side, where such user charges are one of the primary funding sources for capital investment (it is a lesser issue for transit, where farebox revenues are generally used only to fund a portion of operating costs). As discussed in the "Financing Mechanisms and Investment Analysis" section below, however, this edition of the report represents the first attempt to address this issue directly in the highway investment scenarios. The section on "Congestion Pricing and Investment Analysis" further expands on this discussion, noting the inefficiencies associated with current financing mechanisms and their implications for the investment scenario estimates.

Highway and Bridge Investment Scenarios

Future investments in highways and bridges are analyzed independently by separate models and techniques, and the results are combined for the key investment scenarios. The **Cost to Maintain** Highways and Bridges combines the **Maintain User Costs** scenario from the Highway Economic Requirements System (HERS), and the **Maintain Economic Backlog** scenario from the National Bridge Investment Analysis System (NBIAS). The **Maximum Economic Investment** for Highways and Bridges (Cost to Improve) combines the comparable scenarios from HERS and NBIAS.

The costs reported for the two 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.

Investment scenario estimates are also reported and analyzed in Chapters 7 and 8 by highway functional class and by improvement type. Chapters 11 and 12 also include investment analyses focused on the Interstate System and the National Highway System, respectively.

Investment Scenario Estimates for Capacity Expansion and Highway Resurfacing and Reconstruction

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. All highway and bridge investments related to capacity are modeled in HERS; NBIAS considers only investments related to bridge repair, rehabilitation, and replacement.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires that this report include information on the backlog of infrastructure needs. It also requires that this report allow for comparability with previous versions of the C&P report. As in the 2004 edition, this report defines the highway investment backlog as all highway improvements that could be economically justified to be implemented immediately, based on the current condition and operational performance of the highway system. An improvement is considered economically justified when it corrects an existing deficiency, and the benefits of making the improvement are greater than or equal to the cost of the improvement (i.e., the benefit-cost ratio [BCR] is greater than or equal to 1). Appendix A includes a discussion of changes in modeling techniques and the impact of such changes on investment analysis.

Two HERS scenarios, related to the "Cost to Maintain" and "Cost to Improve" scenarios, are developed fully in this report: the **Maintain User Costs** scenario and the **Maximum Economic Investment** scenario. Other benchmarks are also identified in Chapter 9. These scenarios and benchmarks were developed by imposing a budget constraint placed on the HERS analysis. Under this procedure, potential highway improvements are implemented (in descending order of BCR) until the funding constraint is reached. The budget constraint can then be varied sequentially to find the funding levels that produce the results consistent with the definitions of the scenarios and benchmarks.

For the **Maintain User Costs** scenario, the funding constraint was lowered until the point where average highway user costs (travel time costs, vehicle operating costs, and crash costs) in 2024 would match the baseline highway user costs calculated from the 2004 data. Under this investment strategy, existing and accruing system deficiencies would be selectively corrected. Some highway sections would improve, some would deteriorate. Overall, average highway user costs in 2024 would match the level observed in 2004.

The **Maintain User Costs** scenario is a performance-based target, corresponding to maintaining conditions and performance as reflected by the impact that this has on highway users via travel time, safety, and vehicle operating costs. **It does not include taxes and tolls**. While such fees can *affect* conditions and performance (by raising the costs of travel to drivers and thus discouraging highway usage), they do not *reflect* conditions and performance, and are thus excluded from the calculation of the target. In economic terms, tolls and taxes are simply considered to be "transfer payments," which are excluded from the computation of user costs in evaluating the benefits of improvements. See the "Financing Mechanisms and Investment Analysis" section below for more discussion of the impact of user fees in the investment scenario analysis.

One concern that has been raised with this scenario is whether the specified performance goal could actually be attained at this level of capital investment. While the **Maintain User Costs** scenario assumes that projects would be carried out strictly in descending order of benefit-cost ratio, this is unlikely to be the case in reality. While the model focuses on engineering impacts and economic benefits, other factors do in fact influence project selection. If some projects with lower BCRs were carried out instead of projects with higher BCRs, then the actual amount necessary to achieve this performance objective would be higher. 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?"

The **Maximum Economic Investment** scenario shows the highest funding level that could be justified while making investments that HERS deems to be cost-beneficial. While this scenario does not target any particular level of desired system performance, it would address the existing highway investment backlog and other deficiencies that will develop over the next 20 years because of pavement deterioration and travel growth. This scenario was generated by sequentially adjusting the funding constraint in HERS upward until the supply of cost-beneficial improvements evaluated by the model was exhausted. Under this scenario, key indicators such as pavement condition, total highway user costs, and travel time would all improve.

It should be noted, however, that simply increasing 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 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 when compared with an array of investment options that potentially produce higher return at equivalent or lower risk.

Further information on changes in the highway investment methodology is provided in Appendix A.

Investment Scenario Estimates for Bridge Rehabilitation and Replacement

The bridge section of Chapter 7 begins with a discussion of the NBIAS model, now being used for the third time in the C&P report. Unlike previous bridge models, NBIAS incorporates benefit-cost analysis into the bridge investment evaluation.

This section discusses the current investment backlog and two future investment scenarios. As noted earlier, the amounts reported in this section relate only to bridge repair, rehabilitation, and replacement. All investments related to highway and bridge capacity are analyzed using the HERS model.

The investment backlog for bridges is calculated as the total investment that would be required to address deficiencies in bridge elements and some functional deficiencies when it is cost-beneficial to do so. Note that this analysis takes a broader approach to assessing deficiencies and does not focus on whether a bridge would be considered structurally deficient or functionally obsolete by the criteria outlined in Chapter 3.

Under the **Maintain Economic Backlog** scenario, existing deficiencies and newly accruing deficiencies would be selectively corrected such that the total economic backlog of cost-beneficial investments to correct bridge deficiencies at the end of the 20-year analysis period would be the same as the current amount. Under the **Maximum Economic Investment** scenario, all cost-beneficial bridge replacement, improvement, repair, or rehabilitation improvements would be implemented.

Changes to the NBIAS model and other aspects of the bridge investment modeling in this report are presented in Appendix B.

Investment Scenario Estimates for System Enhancement

The FHWA currently does not have a model for analyzing future investment in system enhancement (e.g., traffic control, targeted safety enhancements, and environmental enhancements). As a result, the methodology employed in Chapter 7 assumes that the share of future investment for these types of improvements under each scenario is proportional to their current share of the overall highway capital program. The purpose of this adjustment is to allow the total highway and bridge capital investment scenario estimates to be directly compared with the capital spending data presented in Chapter 6.

A similar procedure is applied to investment on rural minor collectors and rural and urban local roads, which are not included in the data used in the HERS model. Chapter 7 includes more information on the nonmodeled portion of the highway investment scenario estimates.

Transit Investment Scenarios

The transit section of Chapter 7 begins with a discussion of the Transit Economic Requirements Model (TERM), used to develop the investment scenarios for this report. 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. The TERM subjects projected investments at each transit operator to a benefit-cost test. Only those with a benefit-cost ratio greater than 1.0 eligible for inclusion in TERM's final investment scenarios. The TERM methodology is presented in greater detail in Appendix C.

The **Cost to Maintain** scenario would maintain equipment and facilities in their current state of repair and maintains current operating performance by accommodating future transit ridership growth. These investments are modeled at the transit agency level on a mode-by-mode basis. The **Cost to Improve** scenario determines the level of additional investment projected to be sufficient to improve the condition of transit assets to an average rating of "good" and to improve the performance of transit operations to targeted levels.

Transit investments are also disaggregated by type of improvement, type of asset, and urbanized area size for both the **Cost to Maintain** and the **Cost to Improve** scenarios.

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 several factors when making such comparisons:

<u>Different Base Years</u>. 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 estimates to tend to rise over time.

<u>Changes in Condition or Performance</u>. Changes in the physical condition or operational performance of the highway or transit systems may affect the investment scenario estimates between reports. However, the effects are likely to be different for the "Maintain" and "Improve" scenarios.

Cost to Maintain. The "Maintain" scenarios for both highways and transit are tied to the conditions and performance of the system in the base year. If conditions and performance are deteriorating over time, however, the "target level" of the "Maintain" scenarios will be likewise declining between reports (resulting in a "lowered bar" for these scenarios). As a result, the Cost to Maintain would be likely to decrease over time for this reason alone. Conversely, if system conditions and performance are improving over time, then the "Maintain" scenarios in subsequent reports would represent an increasing standard that is being maintained.

Cost to Improve. If the conditions or performance of the underlying system deteriorates over time, then the models are likely to find more improvement projects to be cost beneficial, or to find more improvements necessary to improve the conditions or performance of the system. As a result, the Cost to Improve would be likely to increase over time. The opposite would be true if system conditions and performance were to improve over time.

Expansion of the Asset Base. 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.

Changes in Technology. 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.

Changes in Scenario Definitions. 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.

Changes in Analytical Techniques. 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.

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 (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 practice to potentially correct given deficiencies, but without consideration of comparative economic benefits and costs.

In 1988, the FHWA 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 HERS model. HERS 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, FTA introduced the TERM model, 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 NBIAS model, 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 nonusers and recognize how investments in transportation infrastructure can alter the economic costs of these impacts.

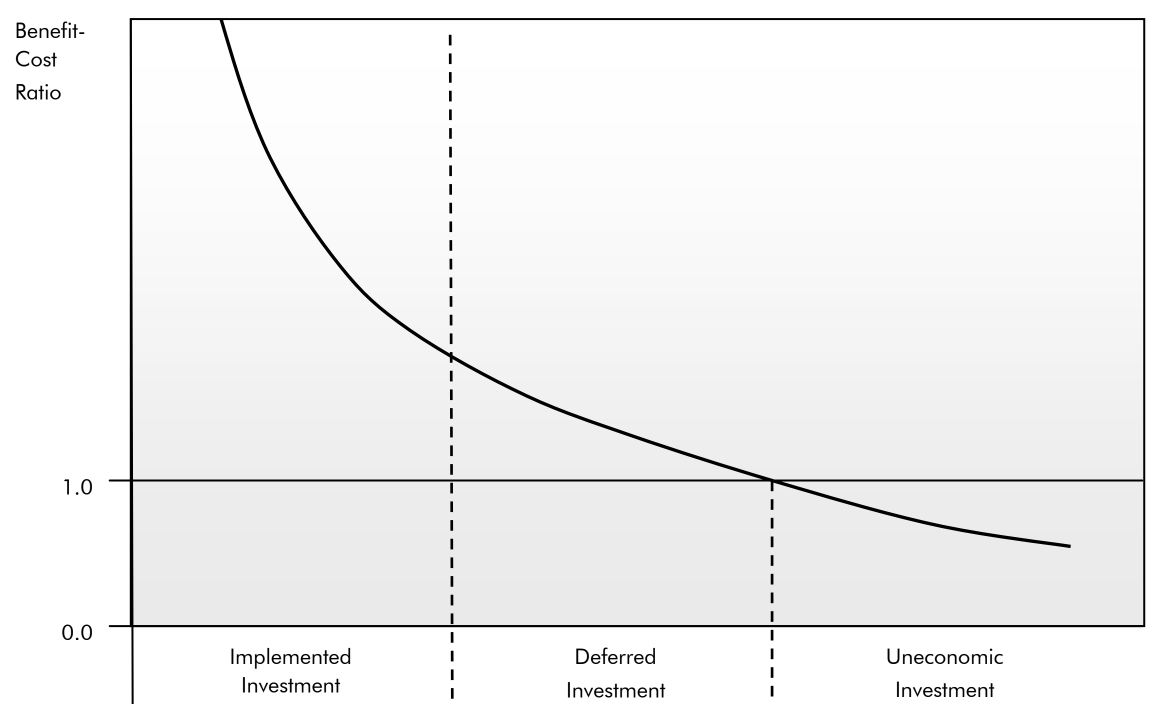
By expanding the scope of benefits considered in their analysis, these models are able to yield an improved understanding of existing and future investment needs for the Nation's surface transportation system.

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 in order of 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. If the funding level 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) would 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.

Given the current financing structure, it is thus reasonable to assume that any increases in future highway investment would be funded to a significant degree by increases in highway user charges. By raising the out-of-pocket costs of highway travel to users, these increased charges could also reduce the demand for use of the system, and thereby reduce the amount of additional investment that would be required to achieve a given level of condition and performance, or to exhaust all cost-beneficial investments. The impact would be larger for higher funding levels, which would require greater proportional increases in user charges.

Due to limitations in the modeling techniques used for investment analysis, previous editions of the C&P report did not explore this link between financing mechanisms and the investment scenario estimates. For this report, however, the HERS model has been adapted to allow for this type of feedback between revenues and investment. The analysis assumes that the funding to support any increases in highway and bridge investment above 2004 levels would be financed in a manner consistent with the current financing structure, which is primarily supported by user fees. One implication of this new approach is that total average highway user expenditures (which would include both user costs and the user surcharge) would actually be higher in future years under the "Maintain User Costs" scenario than in the base year since, as discussed earlier, taxes and tolls are excluded from the user cost target in this scenario. Chapter 10 includes a sensitivity analysis showing the impact that this new feature has on the investment scenario estimates.

While the assumption of user surcharges via the current general financing structure draws revenues, investment, and travel demand together, it still falls short of improving the efficiency of the current regime. Travel on uncongested facilities is charged at the same rate as those with significant congestion issues, and thus continues the distortionary effect that the current financing structure has on highway use and investment. This issue is explored in the next section.

Congestion Pricing and Investment Analysis

In addition to raising revenues to fund new infrastructure investments, user fees can be applied to reduce congestion on specific facilities. This type of targeted pricing is called congestion pricing, and may be intended for the principal purpose of congestion mitigation rather than revenue generation.

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 only 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.

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.

In the real world, a number of barriers exist to the implementation of a perfectly efficient congestion pricing system. Calculating and collecting tolls impose costs on both operators and users of a toll facility, and achieving the true optimum would require both a comprehensive knowledge of user demand and the ability to continuously adjust the fees that motorists are charged. However, as these barriers are being reduced, it is becoming increasingly possible to make the current system more efficient through variable road pricing. Significant advances in tolling technology have reduced both the operating costs of toll collection and the delays experienced by users from stopping or slowing down at collection points. Technology has also made it possible to charge different toll rates during different time periods, in some cases even varying the price dynamically with real-time traffic conditions. While many of these technologies require extensive roadway infrastructure (and would thus likely be deployed only on high-volume, limited access roads), other GPS-based, in-vehicle technologies are being developed that could make it possible to assess fees on virtually any roadway (though such technologies would have their own issues and limitations that could inhibit widespread adoption and use). To the extent that such charges reflect the underlying external costs, they can reduce the welfare loss due to the underpricing of road capacity. The economically efficient level of infrastructure investment under a regime of partial pricing could also be reduced accordingly.

For this report, the HERS model has been adapted to provide quantitative estimates of the theoretical impact that more efficient pricing could have on the future highway investment scenario estimates. This illustrative analysis, presented in Chapter 10, assumes that congestion pricing would be implemented universally on all congested roads. Importantly, it does not account for the considerable costs that could be associated with implementing such a comprehensive pricing system, which could vary widely depending on the type of technology adopted to collect them. It also does not fully address the network effects associated with drivers diverting to other roads. The methodology used for this analysis is presented in greater detail in Appendix A. The "Pricing Effects" section in Part IV of this report also provides a further discussion of other ongoing research activities in this area that will be reflected in future editions of this report.

While the above discussion focuses on highway pricing, the same considerations may apply to transit investments in some cases. 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.

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 only one part of the transportation system and addressing issues unique to each 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 would have on the transit investment scenarios (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.

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 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, "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.

CHAPTER 7

Capital Investment Scenarios

Summary

Exhibit 7-1 compares the 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 2003 to 2022, based on 2002 data shown in the 2004 C&P report and stated in 2002 dollars. The second column restates these highway and transit values in 2004 dollars, to offset the effect of inflation. The third column shows new average annual investment scenario projections for 2005 to 2024 based on 2004 data.

Exhibit 7-1

Highway, Bridge, and Transit Investment Scenario Projections Compared with Data from the 2004 C&P Report (Billions of Dollars)

Statistic	2003–2022 Projection (Based on 2002 Data)		2005–2024 Projection (Based on 2004 Data)
	2004 Report	Adjusted for Inflation	
Average Annual Investment Scenario Estimates*	**2002 $**	**2004 $**	**2004 $**
Cost to Maintain			
Highways and Bridges	$73.8	$77.1	$78.8
Transit	$15.6	$16.3	$15.8
Cost to Improve			
Highways and Bridges (Maximum Economic Investment Level)	$118.9	$124.1	$131.7
Transit	$24.0	$25.1	$21.8

* The investment scenario estimates are highly dependent on the underlying set of assumptions used in the analysis. Chapter 10 includes an assessment of the impact that changing some of these assumptions would have on the scenarios. One such alternative analysis, including a "universal congestion pricing" component, would reduce the average annual Cost to Maintain Highways and Bridges to $57.2 billion, and reduce the average annual Maximum Economic Investment Level to $110.8 billion. See Chapter 10 for details.

Results for highways, bridges, and transit are presented for two key scenarios: one in which the status of the current system is maintained and one in which it is improved. However, the exact specifications of the scenarios differ for each mode. Investment scenario estimates for highways and bridges are drawn from the Highway Economic Requirements System (HERS), which estimates the highway rehabilitation and highway and bridge capacity expansion component of investment; the National Bridge Investment Analysis System (NBIAS), which analyzes future bridge rehabilitation and replacement investment; and external adjustments to reflect functional classes and improvement types not directly modeled. The transit investment estimates for urbanized area operators that report to the National Transit Database (NTD) are calculated by the Transit Economic Requirements Model (TERM). Estimates for rural and special services are derived separately from the number of vehicles, the percentage of overage vehicles, vehicle replacement costs, and actual and industry-recommended replacement ages.

This chapter focuses on the "Maintain" and "Improve" investment scenarios noted in Exhibit 7-1. **The Introduction to Part II provides critical background information needed to properly interpret these figures.** That section also discusses the development of the future investment scenario estimates and the motivation for using economic analysis as the basis for the estimates, as well as the role of uncertainty in the investment analysis modeling process and the relationship between pricing and investment analysis.

Q&A

How would alternative assumptions affect the investment scenario estimates presented in this report?

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, including the impacts of aggressive congestion reduction strategies; alternative model parameters and assumptions; and recent model enhancements.

One of the key assumptions in these projections is the continuation of current tax and fee structures. As pointed out in the Introduction to Part II of this report, any shifts in financing mechanisms that significantly alter the out-of-pocket costs incurred by individual users would have an effect on the scenario results. Chapter 10 includes a hypothetical analysis of the impact that universal congestion pricing could have on these estimates. While that analysis is itself limited by its scope and attendant assumptions, the results indicate that universal congestion pricing could have a significant impact on the investment scenario estimates. The Maximum Economic Investment for Highways and Bridges level would be reduced by 15.9 percent, while the projected Cost to Maintain Highways and Bridges would be reduced by 27.5 percent. See Chapter 10 for more information on this analysis.

Chapter 9 includes an analysis of the projected impacts of these and other future investment levels on conditions and performance. Chapter 10 includes sensitivity analyses, showing how the investment scenario estimates would change under different assumptions about the values of key model parameters.

Both the highway and transit analyses depend heavily on forecasts of future demand. Chapter 10 explores the effects that varying assumptions about future travel demand would have on the projections identified in Exhibit 7-1. That chapter also includes a hypothetical analysis of the impact that the universal adoption of congestion pricing could have on the investment scenario estimates, by more efficiently aligning the costs borne by highway travelers with those that they impose on the transportation system. Highway travel growth forecasts are also discussed in Chapter 9.

More information on the methodology used to develop the investment projections, including recent changes to the methodology, is contained in Appendices A, B, and C. Part IV of this report examines some fundamental data and analytical issues relating to the types of investment/performance analysis reflected in this chapter.

Highways and Bridges

The average annual **Cost to Maintain Highways and Bridges** is projected to be $78.8 billion from all sources for 2005 to 2024. Accounting for inflation between 2002 and 2004 (using FHWA's Construction Bid Price Index), this estimate is 2.3 percent greater than the "Cost to Maintain" for 2003 to 2022 reported in the 2004 C&P report. At this level of investment, future conditions and performance of the Nation's highway system would be maintained at a level sufficient to keep average highway user costs from rising above their 2004 levels. The average annual **Maximum Economic Investment** for ("Cost to Improve") highways and bridges is projected to be $131.7 billion for 2005 to 2024, which is 6.2 percent higher than the estimate in the 2004 C&P report for 2003 to 2022, again

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.

accounting for inflation. This figure represents an "investment ceiling" above which it would not be cost beneficial to invest.

The changes in the projected investment scenario levels from the 2004 report are 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. Notable HERS methodological changes include updated estimates of highway improvement costs, particularly 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.

Q&A

What about inflation since 2004?

The investment scenario estimates in this chapter are stated in constant 2004 dollars. This matches up with both the financial data reported in Chapter 6 and the base year for the highway and bridge data that was used in generating the estimates. However, there are many indications that highway construction costs increased significantly in 2005, above the rate of general inflation. The "Improvement Costs" section in Chapter 10 includes a sensitivity analysis describing the impact that a 25 percent increase in highway and bridge improvement costs would have on the investment scenario estimates.

The other notable revision to the HERS methodology is the addition of a linkage between investment and the financing mechanisms used to pay for them. The model assumes that investment levels above current highway capital spending would be financed through increases in user charges. Such assumed increases have the effect of dampening travel demand growth, thereby limiting the amount of investment required to achieve a given level of performance. Further information on changes to HERS is found in Appendix A.

The increase in the Maximum Economic Investment for highways and bridges relative to the last report is also related to the fact that capital investment by all levels of government between 2002 and 2004 remained below the "Cost to Maintain" level. Consequently, the overall performance of the system declined, which increased the number of potentially cost-beneficial highway and bridge investments that would address these performance problems.

Transit

The estimated average annual **"Cost to Maintain"** transit asset conditions and operating performance is estimated to be $15.8 billion, compared with $15.6 billion in 2002 dollars presented in the last report. Eighty-seven percent of this transit investment is estimated to be in urban areas with populations of over 1 million, reflecting the fact that 92 percent of the Nation's passenger miles are currently in these areas. The average annual **"Cost to Improve"** both the physical condition of transit assets and transit operational performance to targeted levels by 2024 is estimated to be $21.8 billion, compared with $24.0 billion in 2000 dollars for the 2003 to 2022 period presented in the last report.

Fifty-eight percent of the total amount needed to maintain conditions and performance, or $9.0 billion dollars annually, and 60 percent of the total amount needed to improve conditions and performance, or $13.0 billion annually, are estimated to be for rail infrastructure. Guideway elements are estimated to require the largest amount of the total capital investment of all rail assets between 2005 and 2024, followed (in descending order of investment) by vehicles, systems, stations, and facilities.

Forty-three percent of the total amount needed to maintain conditions and performance, or $6.8 billion dollars annually, and 40 percent of the total amount needed to improve conditions and performance, or $8.8 billion annually, are estimated to be for nonrail infrastructure. Vehicles are estimated to require the largest amount of the total capital investment in nonrail assets between 2005 and 2024, followed (in descending order of investment) by facilities, guideway elements (dedicated lanes for buses), power systems, and stations.

Since the 2004 report, the asset inventory and asset deterioration information in TERM has been improved through special data collection efforts and engineering surveys. Ridership forecasts have been revised upward very slightly from 1.5 percent to 1.57 percent per year based on updated information collected from an expanded list of metropolitan planning organizations (MPOs). Changes in estimated investment reflect real changes in projected ridership, transit infrastructure size, and transit asset replacement costs. They also reflect improvements in the Federal Transit Administration's (FTA's) knowledge about the magnitude, deterioration, conditions, and replacement costs of these assets. The cost to improve conditions and performance declined largely due to a downward revision in congestion delay costs, which decreased the estimated amount required to improve performance.

Highway and Bridge Investment Scenarios

This section presents the projected investment scenario estimates for highways and bridges for two primary performance targets. The "Cost to Maintain Highways and Bridges" scenario represents the annual investment necessary to maintain the current level of highway system performance. The "Maximum Economic Investment" scenario (Cost to Improve Highways and Bridges) identifies a level of investment that would allow system performance to be significantly improved in an economically justifiable manner. **These investment levels illustrate two points on a continuum of alternative investment levels. Neither is endorsed as a target level of funding.** The impacts of a wider range of alternative investment levels on various measures of system performance are shown in Chapter 9. Chapter 9 also explores recent trends in highway expenditures compared with recent changes in system performance.

The combined highway and bridge investment scenarios are drawn from the separately estimated scenarios for highways and for bridges, and from external adjustments to the two models. These scenarios are defined differently, owing to the different natures of the data sources and models used to develop them. However, it is useful to combine them, particularly when comparing them to current or projected investment levels, since amounts commonly referred to as "total highway spending" or "total highway capital outlay" include expenditures for both highways and bridges. Chapter 8 compares current highway and bridge spending with the investment levels under the two scenarios outlined in this section.

The average annual **"Cost to Maintain Highways and Bridges"** over the 20-year period 2005 to 2024 is projected to be **$78.8 billion** from all sources in 2004 dollars. The average annual **"Maximum Economic Investment for Highways and Bridges"** is projected to be **$131.7 billion** (also in 2004 dollars). See the Introduction to Part II for a discussion of the implications of these scenarios and critical caveats that should be considered in interpreting them.

As described in the "Financing Mechanisms and Investment Analysis" section in the Introduction to Part II, a significant change that has been made for this report is the linkage of the analysis of highway investment to funding mechanisms that might be used to finance such investment levels. The scenarios assume that any increases in investment above base year levels would be financed through increases in user charges, one of the primary mechanisms currently used to fund highway investment in the United States. The analysis assumes that, by raising the out-of-pocket costs of highway travel to users, these increased charges would also reduce the demand for use of the system, thereby reducing the amount of additional investment that would be needed to achieve a given level of condition and performance, or to exhaust all cost-beneficial investments.

While the baseline scenarios presented in this chapter assume the continuation of current tax and fee structures, any shifts in financing mechanisms that significantly alter the out-of-pocket costs incurred by individual users would have an effect on these results. This concept is discussed in more detail in the "Congestion Pricing and Investment Analysis" section in the Introduction to Part II. Chapter 10 includes a hypothetical analysis of the impact that universal congestion pricing could have on these estimates, as well as a discussion of the impact that the linkage between financing and investment has on the results.

Finally, it should be noted that 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.

Cost to Maintain Highways and Bridges

Exhibit 7-2 shows the average annual "Cost to Maintain Highways and Bridges" by type of improvement and functional class. The component of investment on urban arterials and collectors under this scenario totals $49.7 billion, or 63.1 percent of the average annual "Cost to Maintain Highways and Bridges." Investment on rural arterials and collectors under this scenario totals $17.6 billion (22.4 percent), while the rural and urban local roads and streets component totals $11.5 billion (14.6 percent).

Exhibit 7-2

Cost to Maintain Highways and Bridges Scenario: Average Annual National Investment by Functional Class and Improvement Type (Billions of 2004 Dollars)

Functional Class	System Rehabilitation Highway	Bridge	Total	System Expansion	System Enhancement	Total
Rural Arterials & Collectors						
Interstate	$1.5	$0.6	$2.1	$1.6	$0.3	$4.0
Other Principal Arterial	1.8	0.7	2.5	0.9	0.7	4.1
Minor Arterial	1.6	0.7	2.3	0.4	0.4	3.0
Major Collector	3.0	1.0	4.1	0.4	0.4	4.9
Minor Collector	0.8	0.4	1.2	0.3	0.2	1.6
Subtotal	**$8.7**	**$3.4**	**$12.1**	**$3.6**	**$2.0**	**$17.6**
Urban Arterials & Collectors						
Interstate	$4.3	$1.6	$6.0	$11.3	$0.9	$18.2
Other Freeway & Expressway	2.0	0.6	2.6	5.3	0.7	8.7
Other Principal Arterial	4.4	0.9	5.3	3.9	1.0	10.2
Minor Arterial	4.5	0.6	5.1	3.0	0.7	8.9
Collector	1.9	0.3	2.1	1.2	0.5	3.8
Subtotal	**$17.2**	**$4.0**	**$21.1**	**$24.7**	**$3.9**	**$49.7**
Rural and Urban Local	$6.0	$1.4	$7.4	$2.8	$1.3	$11.5
Total	**$31.9**	**$8.7**	**$40.7**	**$31.0**	**$7.1**	**$78.8**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System

The "Cost to Maintain Highways and Bridges" scenario combines the "Maintain User Costs" scenario from HERS and the "Maintain Economic Backlog" scenario from NBIAS with external adjustments to the estimates produced by the two models.

Maximum Economic Investment for Highways and Bridges

The average annual "Maximum Economic Investment for Highways and Bridges" is broken down by functional class and type of improvement in *Exhibit 7-3.* The component of investment on urban arterials and collectors total $84.5 billion, or 64.1 percent of the total average annual "Maximum Economic Investment for Highways and Bridges." Investment on rural arterials and collectors under this scenario totals $28.2 billion (or 21.4 percent of the total), while the rural and urban local roads and streets component totals $19.0 billion (14.5 percent).

This scenario combines the "Maximum Economic Investment" scenarios from HERS and NBIAS with external adjustments to the two models.

Exhibit 7-3

Maximum Economic Investment for Highways and Bridges Scenario: Average Annual National Investment by Functional Class and Improvement Type (Billions of 2004 Dollars)

Functional Class	System Rehabilitation Highway	System Rehabilitation Bridge	System Rehabilitation Total	System Expansion	System Enhancement	Total
Rural Arterials & Collectors						
Interstate	$2.0	$0.8	$2.7	$2.2	$0.6	$5.5
Other Principal Arterial	3.0	1.1	4.0	1.2	1.1	6.4
Minor Arterial	3.3	1.0	4.2	0.8	0.7	5.7
Major Collector	5.0	1.6	6.5	0.8	0.6	7.9
Minor Collector	1.4	0.6	1.9	0.5	0.3	2.7
Subtotal	**$14.6**	**$4.9**	**$19.5**	**$5.5**	**$3.3**	**$28.2**
Urban Arterials & Collectors						
Interstate	$5.3	$2.1	$7.4	$20.8	$1.6	$29.8
Other Freeway & Expressway	2.6	0.7	3.3	10.7	1.2	15.2
Other Principal Arterial	7.4	1.3	8.6	8.4	1.6	18.7
Minor Arterial	5.8	0.9	6.7	6.4	1.2	14.4
Collector	2.8	0.4	3.2	2.4	0.8	6.4
Subtotal	**$24.0**	**$5.3**	**$29.3**	**$48.7**	**$6.5**	**$84.5**
Rural and Urban Local	$10.1	$2.2	$12.2	$4.6	$2.2	$19.0
Total	**$48.6**	**$12.4**	**$61.0**	**$58.8**	**$11.9**	**$131.7**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System

Investment Scenario Estimates by Improvement Type

Exhibits 7-2 and 7-3 also show the investment scenario estimates by type of improvement. The investment levels are classified into three categories (defined in Chapter 6): system rehabilitation, system expansion, and system enhancement. System rehabilitation, as defined in this report, consists of *capital* investment focused on preserving the condition of the pavement and bridge infrastructure. This includes the costs of resurfacing and reconstructing highways and repairing and replacing bridges, but does not include routine maintenance costs. Note that previous editions of the C&P report used the term "system preservation" for this type of investment. However, because, this term is increasingly being used for maintenance activities aimed at prolonging the life of the existing infrastructure, it has been replaced in this report by "rehabilitation," which is more directly indicative of the nature of these activities as capital investments.

System expansion includes the costs related to increasing system capacity by widening existing facilities or adding new roads and bridges. System enhancement includes targeted safety enhancements, traffic control improvements, and environmental improvements. Appendix A describes how the investment modeled by HERS and NBIAS was allocated among the three types of improvements.

Exhibit 7-4 displays the investment scenario estimates by improvement type for rural and urban areas for each scenario.

System Rehabilitation

Average annual investment in system rehabilitation is estimated to be $40.7 billion under the "Cost to Maintain" scenario and $61.0 billion under the "Maximum Economic Investment" scenario. These totals constitute 51.6 and 46.3 percent, respectively, of the totals for the two scenarios. Exhibits 7-2 and 7-3 also indicate that bridge repair and replacement investments represent roughly 20 percent of total system rehabilitation investment under each scenario. As shown in Exhibit 7-4, system rehabilitation makes up a much larger share of total investment in rural areas than in urban areas under each scenario.

System Expansion

The $31.0 billion in average annual investment for system expansion represents 39.4 percent of the total "Cost to Maintain Highways and Bridges" scenario. Comparable figures for the "Maximum Economic Investment" scenario are $58.8 billion and 44.6 percent. Exhibits 7-2 through 7-4 indicate that system expansion investment under each scenario is much larger in urban areas than in rural areas, both in the total amount and as a share of overall investment.

System Enhancement

Investment for system enhancement represents 9.0 percent of both the "Cost to Maintain Highways and Bridges" ($7.1 billion) and the "Maximum Economic Investment for Highways and Bridges" ($11.9 billion) scenarios. Investment in safety enhancements, traffic control facilities, and environmental enhancements are not directly modeled, so this amount was derived solely from the external adjustment procedures described below.

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 Exhibits 7-2 and 7-3 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 edition of the report consider the impact of some of the most significant operations strategies and deployments on highway system performance. The capital investment costs associated with these strategies are included in the estimates of highway capacity investment presented in this chapter. Operations strategies are further discussed in Chapter 15.

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. Such improvements constitute 9 percent of the total lane miles of additional capacity required under the "Maintain" scenario, but 38 percent of the total costs. Under the "Maximum Economic Investment" scenario, high-cost improvements represent 14 percent of added lane miles and 55 percent of total capacity investment. 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.

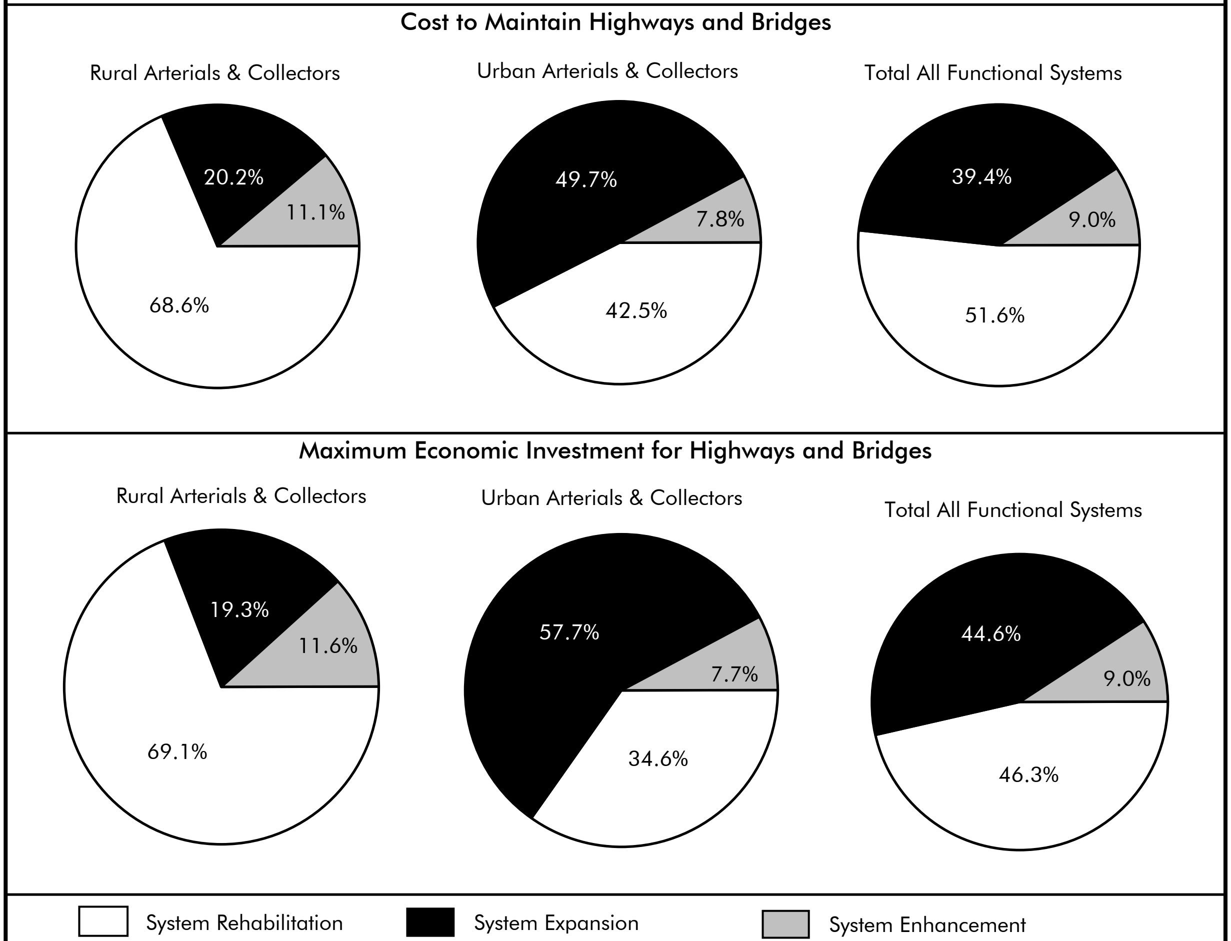
Sources of the Highway and Bridge Investment Scenario Estimates

The investment scenario estimates for highways and bridges under the "Maintain" and "Improve" scenarios were derived from three sources:

- Highway and bridge capacity expansion and highway resurfacing and reconstruction improvements were modeled using HERS.
- Bridge repair and replacement investments were modeled using NBIAS.
- The HERS and NBIAS results were supplemented by external adjustments made to account for functional classes not included in the data sources used by the models and types of capital investment that are not currently modeled.

Exhibit 7-4

Highway and Bridge Investment Scenario Estimates: Distribution by Improvement Type



Source: Highway Economic Requirements System and National Bridge Investment Analysis System.

The model scenarios used in HERS and NBIAS to construct the "Maintain" and "Improve" scenarios are discussed in greater detail below. *Exhibit 7-5* shows the sources of the highway and bridge investment scenario estimates.

External Adjustments

External adjustments were made to the directly modeled improvements generated by HERS and NBIAS in two areas:

Highway functional classes. Bridges on all functional classes are represented in the National Bridge Inventory (NBI) database used by NBIAS, so all of the investment scenario estimates related to bridge rehabilitation shown in this report are derived directly from NBIAS. However, the Highway Performance Monitoring System (HPMS) sample segment database used by HERS does not include rural minor collectors, rural local roads, or urban local roads. Consequently, HERS does not provide estimates for these systems, and separate estimates for highway resurfacing/reconstruction and system expansion were applied.

Improvement types. The improvement options that HERS and NBIAS consider primarily address pavement and capacity deficiencies on existing highway and bridge sections. Currently, HERS and NBIAS do not directly model investment in system enhancement. Estimates for this improvement type were applied across all functional classes.

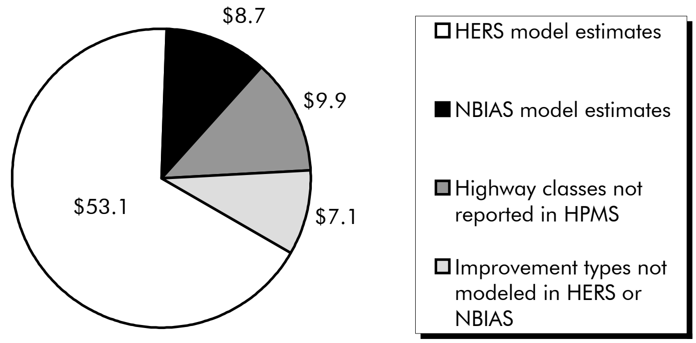
The adjustment procedures assume that the share of the highway investment scenario estimates represented by these functional classes and improvement types would be equivalent to their share of current highway capital spending. The amounts derived from these external adjustments are identified separately in this report because they would be expected to be less reliable than those derived from HERS and NBIAS.

The percentage of the total investment scenario estimates that are modeled in HERS and NBIAS in this report is approximately the same as it was in the 2004 C&P report.

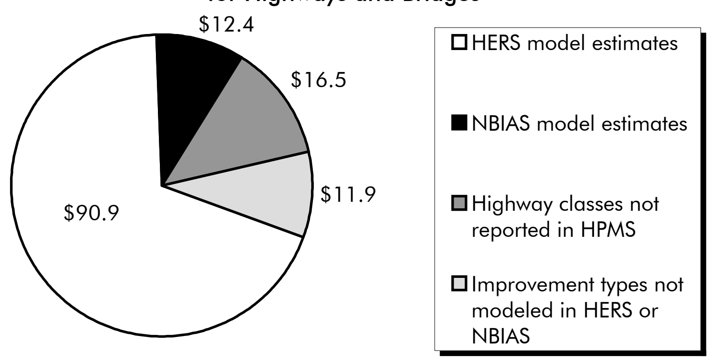
Exhibit 7-5

Sources of the Highway and Bridge Investment Scenario Estimates (Billions of 2004 Dollars)

Cost to Maintain Highways and Bridges



Maximum Economic Investment for Highways and Bridges



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.

Q&A

Do the adjustments for non-modeled items reflect highway-rail grade separation improvements?

Highway-rail grade separation improvements are at least partially captured in the adjustments made for non-modeled capital investments, which include safety enhancements. However, the analysis may not fully capture separation improvements that are aimed primarily at reducing highway user delay. The 2004 C&P report summarized the results of an analysis prepared by the Federal Railroad Administration which looked at the potential impacts of alternative future levels of investment in grade separation improvements. [See Chapter 19 of the 2004 C&P report for details.]

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 HPMS, which provides information on current roadway characteristics, conditions, and performance and anticipated future travel growth for a nationwide sample of more than 116,000 highway sections. While HERS analyzes these sample sections individually, the model is designed to provide results valid at the national level, and does not provide definitive improvement recommendations for individual highway segments.

Q&A

Does HERS identify a single "correct" level of highway investment?

No. The HERS model is a tool for estimating what the consequences may be of various levels of spending on highway conditions and performance. If funding were unlimited, it might make sense to implement all projects identified by HERS as cost beneficial. In reality, however, funding is constrained, and highways must compete for funding with other economic priorities. The investment scenarios in this chapter estimate the resources that would be required to attain certain levels of performance, but are not intended to endorse any specific level of funding as "correct" or "optimal."

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.

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

Q&A

How closely does the HERS model simulate the actual project selection processes of State and local highway agencies?

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 not selected solely 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 that shown in this report.

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.

While HERS was primarily designed to analyze highway segments, and the HERS outputs are described as "highway" investments in this report, the model also factors in the costs of expanding bridges and other structures when deciding whether to add lanes to a highway segment. All highway and bridge improvements related to capacity are modeled in HERS; the NBIAS model considers only investment related to bridge repair, rehabilitation, and replacement.

The HERS model also takes into account the impact that new investments in certain types of intelligent transportation systems (ITS) 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 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 monitoring, variable message signs, and traffic management centers), incident management (incident detection, verification, and response), and arterial management (upgraded signal control, electronic monitoring, and variable message signs).

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 baseline 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, their impacts on performance, and their implementation within HERS, as well as a further discussion of how travel demand elasticity is implemented in HERS.

Linking Investment Scenarios and Revenue Sources

A significant new feature in the version of HERS used for this report links the estimates of future investment scenario levels to the revenues that would be required to achieve this level of investment. The procedure assumes that increases in investment above current levels would be financed by levying additional charges on highway users. Through the HERS travel demand elasticity procedures, the increased cost of highway travel has a dampening effect on future travel growth, which in turn tends to reduce the future investment scenario estimates. Chapter 10 includes an analysis of the impact that this feature has on the HERS estimates. Appendix A includes more details on how this feature was implemented in HERS.

Q&A

What are the costs associated with the operations strategies and investments included in the HERS investment analyses?

The costs of the new or increased operations deployments 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 under the existing trends scenario used for these analyses is $94 million (in 2004 dollars). These costs are included in the investment scenario estimates included in this report.

Estimated average annual operating and maintenance costs for the operations strategies over the same 2005 to 2024 time period are $2.7 billion, including $260 million for new deployments and $2.5 billion for the existing infrastructure. These costs **are not** included in the "Cost to Maintain" or "Maximum Economic Investment" figures presented in this chapter, which are limited to capital investments only.

Note that the costs shown above only reflect the particular types of improvements currently modeled in HERS, and thus represent a subset of total operations deployments that are expected to occur. This analysis attempts to capture other capital costs relating to operations control facilities via the external adjustment procedure for nonmodeled improvement types discussed above.

HERS Investment Scenarios

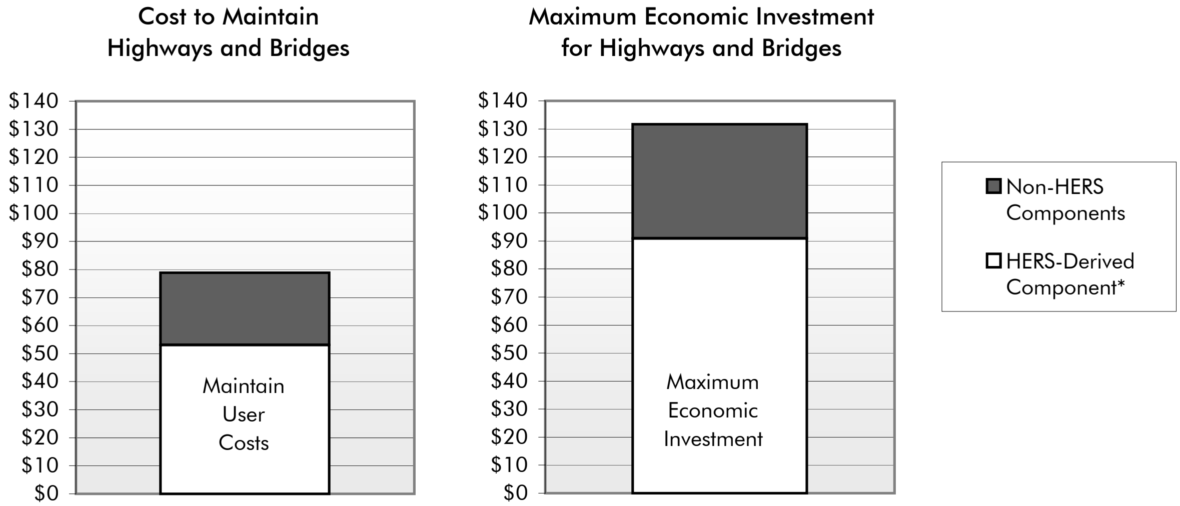
Two HERS investment scenarios were developed in order to generate the HERS-modeled portion of the two combined highway and bridge investment scenarios. The HERS portion of the "Cost to Maintain Highways and Bridges" was drawn from the HERS "Maintain User Costs" scenario, and the HERS "Maximum Economic Investment" scenario was fed into the "Maximum Economic Investment for Highways and Bridges (Cost to Improve)." *Exhibit 7-6* shows the estimated investment levels under the two HERS scenarios. The "Non-HERS Components" of the investment scenarios include NBIAS model estimates, highway classes not reported in HPMS, and improvement types not modeled in HERS or NBIAS.

The "Maintain User Costs" scenario in HERS was used to generate the highway resurfacing and reconstruction and system expansion components of the "Cost to Maintain Highways and Bridges." This scenario reflects the level of investment sufficient to allow highway conditions and performance at the end of the 20-year analysis period (as reflected in total highway user costs per vehicle mile traveled) to match the base year levels. It focuses on highway users, rather than the traditional engineering-based criteria, which are oriented more toward highway agencies. Highway user costs include travel time costs, vehicle operating costs, and crash costs. The average annual investment modeled by HERS under this scenario is estimated to be $53.1 billion.

The "Maximum Economic Investment" scenario is of interest mainly because it defines the highest level of annual highway investment that could be economically justified. It was used to generate the highway resurfacing and reconstruction and system capacity expansion components of the "Maximum Economic Investment for (Cost to Improve) Highways and Bridges." This scenario shows the highest funding level that could be justified while making investments that HERS deems to be cost-beneficial. While this scenario does not target any particular level of desired system performance, it would address the existing highway investment backlog and other deficiencies that will develop over the next 20 years because of pavement deterioration and travel growth. As shown in *Exhibit 7-6,* the average annual investment modeled by the

Exhibit 7-6

HERS Investment Scenarios, 2005–2024 (Billions of 2004 Dollars)



* The portion of the total investment for each scenario that would be used for types of capital improvements and types of roads that are modeled in HERS.

HERS "Maximum Economic Investment" scenario is $90.9 billion. See the Introduction to Part II for more details on the two scenarios.

The impact of these and other levels of investment on individual highway user cost components and other measures of conditions and performance is discussed in Chapter 9.

Highway 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 $430 billion of investment could be justified nationwide based solely on the current conditions and operational performance of the highway system. Approximately 81 percent of the backlog is in urban areas, with the remainder in rural areas. Capacity deficiencies on existing highways account for 58 percent of the backlog; the remainder results from pavement deficiencies.

Note that this figure does not include rural minor collectors or rural and urban local roads and streets because HPMS does not contain sample section data for these functional systems. The backlog figure also does not contain any estimate for system enhancement.

National Bridge Investment Analysis System

The scenario estimates of future capital investment relating to bridge repair and replacement shown in this report are derived primarily from NBIAS. While NBIAS incorporates analytical methods from the Pontis bridge management system, a tool first developed by FHWA in 1989 and now owned and licensed by the American Association of State Highway and Transportation Officials, it also builds certain economic criteria into its analytical procedures that are not included in Pontis.

While Pontis relies on detailed structural element-level data on bridges, NBIAS adds a capability to synthesize such data from general bridge condition ratings reported for all bridges in the 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.

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 model uses a probabilistic approach to modeling bridge deterioration for each synthesized bridge element, relying on a set of transition probabilities that project the likelihood that an element will deteriorate from one condition state to another over a given period of time. The model then applies the Markov modeling approach from Pontis to determine an optimal set of preservation 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 preservation work relative to completely replacing the bridge.

The NBIAS model is discussed in more detail in Appendix B.

Bridge Investment Scenarios

The "Maintain Economic Backlog" scenario is the bridge component of the "Cost to Maintain Highways and Bridges." This scenario identifies the estimated level of annual investment that would allow the cost of addressing all bridge deficiencies in 2024 to remain the same as in 2004. Under this scenario, existing deficiencies and newly accruing deficiencies would be selectively corrected, but the overall level of deficiencies measured in dollar terms would be maintained. As shown in *Exhibit 7-7,* t**he average annual investment under this scenario is estimated at $8.7 billion**, or 11.1 percent of the $78.8 billion average "Cost to Maintain Highways and Bridges" over a 20-year period. The "Non-NBIAS Components" of the investment scenarios include HERS model estimates, highway classes not reported in HPMS, and improvement types not modeled in HERS or NBIAS.

The "Maximum Economic Investment" scenario is the bridge repair and replacement component of the "Cost to Improve Highways and Bridges" described earlier in this chapter. Where it is cost beneficial to do so, this scenario would eliminate the existing bridge investment backlog and correct other deficiencies that are expected to develop over the next 20 years. **The average annual investment under this scenario is estimated to be $12.4 billion**, which is 9.4 percent of the $131.7 billion average annual investment level under the "Maximum Economic Investment for Highways and Bridges" scenario.

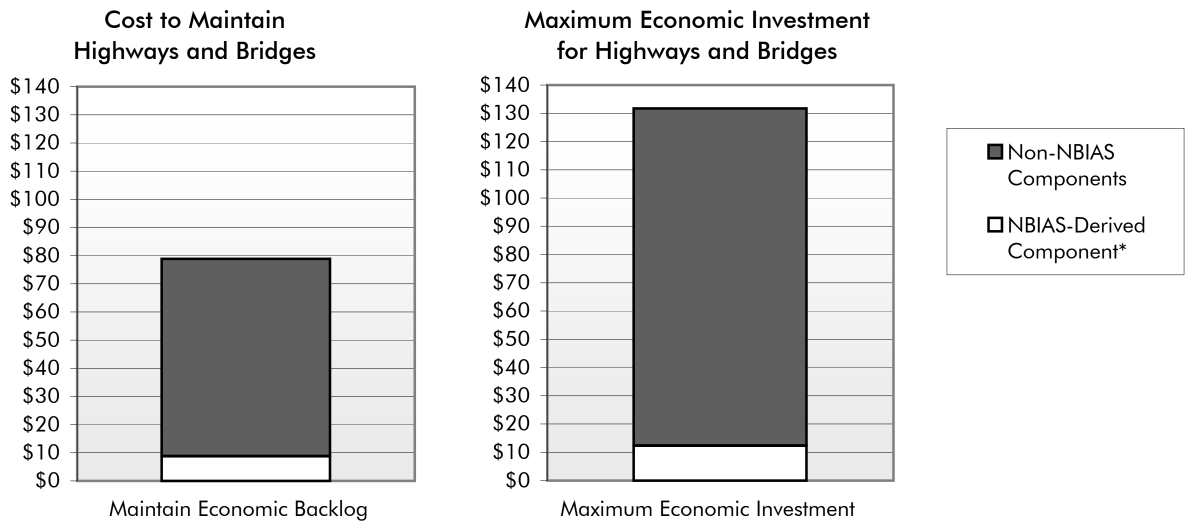
Q&A

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.

Exhibit 7-7

NBIAS Investment Scenarios, 2005–2024 (Billions of 2004 Dollars)



* The portion of the total investment for each scenario that would be used for types of capital improvements that are modeled in HERS.

Bridge Investment Backlog

As defined in this report, the bridge investment backlog represents the cost of improving all existing bridge deficiencies if the benefits of doing so exceed the costs. The NBIAS defines deficiencies broadly and covers more than the structurally deficient and functionally obsolete categories defined in Chapter 3. The NBIAS estimates that $65.2 billion could be invested immediately in a cost-beneficial fashion to replace or otherwise address currently existing bridge deficiencies.

Transit Investment Scenarios

FTA uses the Transit Economic Requirements Model (TERM), a model based on engineering and economic concepts, to prepare estimates of total capital investment projections for the U.S. transit industry. TERM was developed to improve the quality of these FTA estimates. This edition of the C&P report uses TERM to project the dollar amount of capital investment for the transit sector to meet various asset condition and operational performance scenarios by 2024. These capital investment scenario estimates are based on the asset condition estimation process and results provided in Chapter 3, ridership growth projections, and data from the National Transit Database (NTD) on the existing transit asset base (e.g., number of vehicles and stations) and operating statistics (e.g., operating speed). Since the last edition of the report, the accuracy of the asset inventory and asset deterioration in TERM has been improved through special data collection efforts and engineering surveys also discussed in Chapter 3. Ridership forecasts have been revised upward very slightly since the last report, by 0.07 percent per year, based on updated information collected from an expanded list of metropolitan planning organizations (MPOs).

TERM identifies potential investments using asset decay curves relating condition to age, and in some cases additionally to maintenance and use. TERM also identifies investments to achieve stated performance goals based on proxies of vehicle occupancies and passenger travel time. TERM uses benefit-cost analysis to limit the actual level of investment recommended by TERM to a subgroup of the total investments identified based on asset condition and performance targets which have benefit-cost ratios greater than one.

The benefit-cost component of TERM has been updated and refined since the 2004 report, refining values used by the benefit-cost analysis to be more agency-specific or region-specific. The investment estimates presented here have, therefore, been subjected to a much more rigorous benefit-cost test than investment estimates based on TERM provided in earlier report editions. [A technical description of TERM, including an explanation of changes made to the benefit-cost component of TERM since the last edition of this report, is provided in Appendix C.]

TERM projects estimated capital investment to achieve the following benchmarks which are then combined to form the different investment scenarios:

- **Maintain Asset 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. Ridership growth estimates are obtained from MPOs.

- **Improve Conditions**

  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 (2024). 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 targets a lower condition level. This condition level will be equal to the highest condition that can be achieved without replacing assets that are in operationally acceptable condition.

- **Improve Performance**

  The performance of the Nation's transit system is improved as additional investments in bus rapid transit (BRT), 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.

TERM has two benefit-cost tests. One benefit-cost test is applied to all proposed 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. This includes an assessment of the benefits and cost to riders of an agency-mode with the benefits and costs of using an alternative mode. A separate benefit-cost 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 improving investments exceed the costs of these investments over a 20-year period.

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 Condition absolutely reach a level 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 (2024) with the average asset condition in the base year (2004). The investment needs in this report to Maintain Conditions assume that in 2024 average conditions will be 3.6, compared with an average condition of 3.9 in 2004. To reach an average condition of 3.9 in 2024 would require TERM to replace assets below the condition replacement threshold, i.e., still in an operationally acceptable condition. The Improve Conditions scenario assumes that an average asset condition of 3.7 is reached in 2024; guideway and vehicles are replaced at very slightly lower conditions in the Improve Conditions scenario than in the Maintain Conditions scenario. To reach a condition of 4.0 in 2024 would require TERM to replace assets below the condition replacement threshold. (*See Appendix* C.)

Exhibit 7-8 provides estimates of the total annual capital investment to meet combinations the four investment scenarios. These estimates combine those calculated by TERM with rural and special service investment estimates prepared by FTA outside of the TERM framework. Annual transit investment is estimated to be $15.8 billion for the scenario to maintain the conditions and performance of the Nation's transit system at its 2004 level (compared with $15.6 billion in 2002 dollars and $16.3 billion in 2004 dollars in the last report). To reach the "Improve" scenario, which targets an average transit asset condition level of "good" by 2024 and which improves performance by increasing vehicle speeds as experienced by passengers and reduces occupancy rates to threshold levels, the amount of the "Maintain" scenario is increased by an additional $6.0 billion per year for a total average annual capital amount of $21.8 billion (compared with $24.0 billion in 2002 dollars and $25.1 billion in 2004 dollars in the last report). *These investment estimates assume a 1.57 percent average annual increase in ridership over the 20-year projection period compared with a 1.50 percent assumed in the 2004 report (and 1.60 percent average annual increase assumed in the 2002 report).* Note that the "Improve Conditions and Performance" scenario is an ideal target and defines an upper limit above which additional investment in transit is unlikely to be economically justifiable.

Exhibit 7-8

Average Annual Transit Investment by Scenario, 2005–2024 (Billions of 2004 Dollars)

Conditions	Performance	Average Annual Cost
Maintain	Maintain	$15.8
Improve	Maintain	$16.4
Maintain	Improve	$21.2
Improve	Improve	$21.8

Source: Transit Economic Requirements Model and FTA staff estimates.

The "Improve Conditions and Maintain Performance" and the "Maintain Conditions and Improve Performance" scenarios in Exhibit 7-8 represent intermediate points between the "Maintain Conditions and Performance Scenario" and the "Improve Conditions and Performance Scenario."

The level of investment estimated by the Maintain Conditions and Performance scenario increased marginally in current dollars from those in the 2004 C&P report, but declined in real terms. The level of investment estimated by the Improve Conditions and Performance scenario has declined, both in current- and real-dollar terms. The upward revision in projected ridership growth and improvements to the methodology used to generate asset records for transit capital assets not reported to FTA had upward effects on the estimated investment for both scenarios. In contrast, revisions to maintenance facility replacement costs, improvements to the benefit-cost analysis, revisions to the asset deterioration schedules for stations and rail systems, replacement and rehabilitation assumptions for subways structures and underground rail stations, and updated NTD data had downward effects on estimated investment, with the first two predominating. The asset inventory updates had a limited impact on estimated investment. The 2004 update increased estimated investment amounts slightly, and the 2005 update decreased them slightly. The estimated investment for the Improve Conditions and Performance scenario declined due to a decline in the estimate of the investment to improve performance, principally resulting from a reduction in estimated cost of congestion delay.

As shown in *Exhibit 7-9,* replacement and rehabilitation costs are $10.4 billion annually for the scenario to maintain conditions and performance (compared with $10.3 billion in the 2004 report), and $10.9 billion annually for the scenario to improve conditions and performance (compared with $11.7 billion in the 2004 report). The incremental $0.5 billion for asset rehabilitation and replacement under the "Improve Conditions" scenario results from the extra investment required to rehabilitate and replace additional assets to attain an overall physical condition of "good." Average asset condition levels are estimated to be closer to "good" than in the 2004 report, leading to a decline in the difference between the amount required to maintain conditions and the amount required to improve conditions. Asset expansion costs to meet the projected 1.57 percent average annual increase in ridership growth are $5.4 billion, similar to the last report. Investments to improve performance (increasing passenger speeds and reducing crowding in systems not operating at "good" performance threshold levels) are estimated to be $5.5 billion annually, compared with $6.6 billion annually in the 2004 report. This amount declined primarily due to a revision in the methodology used to calculate congestion delay costs, the latter being a key input to the benefit-cost evaluation of all investment proposed by TERM. The assumed cost of congestion delay used in determining

Exhibit 7-9

Annual Transit Investment by Scenario and Type of Improvement, 2005–2024 (Billions of 2004 Dollars)

Type of Improvement	Maintain Conditions & Performance	Improve Conditions & Maintain Performance	Maintain Conditions & Improve Performance	Improve Conditions & Performance
Replacement and Rehabilitation	$10.4	$10.9	$10.4	$10.9
Asset Expansion	$5.4	$5.4	$5.4	$5.4
Performance Improvements			$5.5	$5.5
Total	**$15.8**	**$16.4**	**$21.2**	**$21.8**

Source: Transit Economic Requirements Model and FTA staff estimates.

the investment estimates in this report are lower than in earlier reports and vary according to the average level of congestion in areas with similar levels of population. The amount to improve performance also declined very slightly due to the use of agency-specific maintenance expenditures, fares, and speeds in the benefit-cost analysis instead of national modal averages.

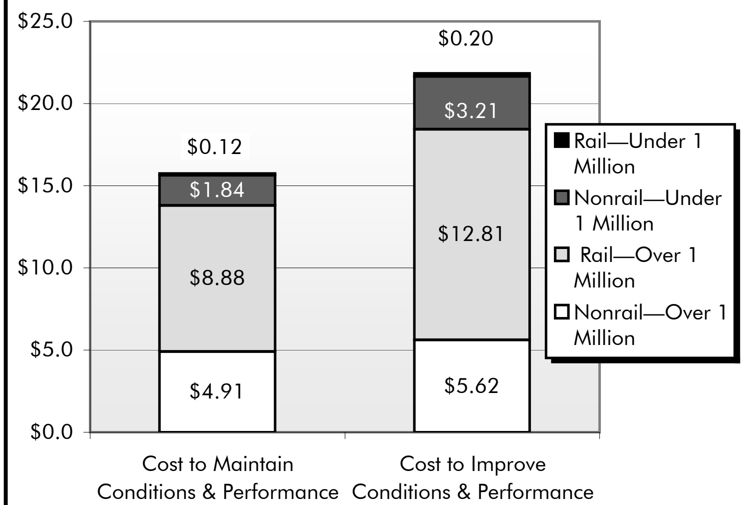
Costs to Maintain and Improve Conditions and Performance

Investment Estimates by Population Area Size

Exhibit 7-10 provides a summary of transit investment by TERM scenario, area population size, and broad asset type (rail or nonrail). This information is provided in more detail in *Exhibit 7-11*. Eighty-seven percent of transit investment estimates are concentrated in urban areas with populations of over 1 million, reflecting the fact that, in 2004, 92 percent of the Nation's passenger miles were in these areas.

Exhibit 7-10

Transit Average Annual Investment by Scenario and by Area Population Size and Mode, 2005–2024 (Billions of 2004 Dollars)



Source: Transit Economic Requirements Model and FTA staff estimates.

The "Maintain" scenario estimates an average annual investment of $13.8 billion to maintain the conditions and performance of transit assets in large urban areas (compared with $13.5 billion in the 2004 C&P report); the "Improve" scenario estimates an average annual investment of $18.4 billion annually to improve the conditions and performance of transit assets in large urban areas (compared with $20.5 billion in the 2004 C&P report). The investment in less-populated areas (i.e., those with populations under 1 million) is estimated to be considerably lower than the investment in more populous areas because the former has fewer transit assets. The Maintain Conditions and Performance scenario estimates an average investment of $2.0 billion annually in the transit infrastructure in these less-populated areas (compared with $2.1 billion in the 2004 C&P report), and the Improve Conditions and Performance scenario estimates an average investment of $3.4 billion annually in transit infrastructure in these less-populated areas (compared with $3.5 billion in the 2004 C&P report).

Nonrail Needs in Areas with Populations of Over 1 Million

The nonrail infrastructure (buses, vans, and ferryboats) component of the scenario to maintain conditions and performance in urban areas with populations over 1 million is considerably smaller than the rail component. The Maintain Conditions and Performance scenario estimates that 26 percent of the investment in larger urban areas, or about $4.9 billion annually, is for nonrail infrastructure (compared with $4.5 billion annually in the 2004 C&P report). Of this $4.9 billion, 74 percent, or $3.6 billion annually, is estimated for the rehabilitation and replacement of assets; and 25 percent, or $1.2 billion, is estimated for the purchase of new assets to maintain performance. It is estimated that 67 percent of rehabilitation and replacement expenditures and 61 percent of asset expansion expenditures would be for

Exhibit 7-11

Annual Average Cost to Maintain and Improve Transit Conditions and Performance, 2005–2024

Mode, Purpose & Asset Type (Millions of 2004 Dollars)		Cost to Maintain Conditions & Performance	Incremental Cost to Improve Conditions	Incremental Cost to Improve Performance	Cost to Improve Conditions & Performance
Areas Over 1 Million in Population					
Nonrail [1]					
Replacement & Rehabilitation	(Vehicles)	$2,437	$40		$2,477
	(Nonvehicles) [2]	1,205	-5		1,200
Asset Expansion	(Vehicles)	749	16		765
	(Nonvehicles)	489	0		489
Improve Performance	(Vehicles)			411	411
	(Nonvehicles) [2]			227	227
Special Service [3]	(Vehicles)	31	17		48
Subtotal Nonrail		**4,910**	**68**	**637**	**5,616**
Rail					
Replacement & Rehabilitation	(Vehicles)	1,636	246		1,882
	(Nonvehicles) [2]	3,517	0		3,517
Asset Expansion	(Vehicles)	930	0		930
	(Nonvehicles) [2]	2,798	0		2,798
Improve Performance	(Vehicles)			499	499
	(Nonvehicles) [2]			3,185	3,185
Subtotal Rail		**8,880**	**246**	**3,684**	**12,811**
Total Areas Over 1 Million		**13,790**	**315**	**4,321**	**18,426**
Areas Under 1 Million in Population					
Nonrail [1]					
Replacement & Rehabilitation	(Vehicles)	689	40		729
	(Nonvehicles) [2]	388	-2		386
Fleet Expansion	(Vehicles)	212	6		218
	(Nonvehicles) [2]	113	0		113
Improve Performance	(Vehicles)			203	203
	(Nonvehicles) [2]			564	564
Special Service [3]	(Vehicles)	174	94		268
Rural	(Vehicles)	264	147	294	705
	(Nonvehicles) [2]	5	10	13	28
Subtotal Nonrail		**1,844**	**295**	**1,074**	**3,213**
Rail					
Replacement & Rehabilitation	(Vehicles)	3	0		3
	(Nonvehicles) [2]	10	0		10
Fleet Expansion	(Vehicles)	16	0		16
	(Nonvehicles) [2]	92	0		93
Improve Performance	(Vehicles)		0	12	12
	(Nonvehicles) [2]		0	66	66
Subtotal Rail		**120**	**0**	**78**	**199**
Total Areas Under 1 Million		**1,964**	**295**	**1,152**	**3,412**
Total		**15,754**	**609**	**5,473**	**21,838**

[1] Buses, vans, and other (including ferryboats).

[2] Nonvehicles comprise guideway elements, facilities, systems, and stations.

[3] Vehicles to serve the elderly and disabled.

Source: Transit Economic Requirements Model and FTA staff estimates.

vehicles. The incremental costs to improve nonrail conditions are estimated to be $68 million annually, of which $40 million would be for vehicle rehabilitation and replacement. The incremental costs to improve performance are estimated to be $637 million annually, of which 64 percent ($411 million) would be spent on new vehicles (principally buses) and 36 percent ($227 million) on new nonvehicle assets. Expenditures on nonvehicle assets include investments for the purchase or construction of dedicated highway lanes for bus rapid transit (BRT). The Improve Conditions and Performance scenario estimates that, in total, $5.6 billion is estimated for investment in these more heavily populated areas (compared with $5.7 billion annually in the 2004 C&P report). Estimated investment in nonrail performance was not affected significantly by revisions to the benefit-cost analysis.

Rail Needs in Areas with Populations of Over 1 Million

The Maintain Conditions and Performance scenario estimates that 64 percent of the total transit investment in large urban areas, or $8.9 billion annually, is for rail infrastructure (compared with about $9.0 billion in the 2004 C&P report). Of this $8.9 billion, 58 percent, or $5.2 billion annually, is for the rehabilitation and replacement of rail assets to maintain conditions; and 42 percent, or $3.7 billion, is for the purchase of new assets to expand rail systems as ridership increases. The "Improve Conditions" scenario estimates an additional amount of $246 million annually for vehicles, but no additional amount for nonvehicle assets as the average condition of these assets is already "good." The "Improve Performance" scenario estimates an additional amount of $4.3 billion annually, including the cost of purchasing rights-of-way. (The amount estimated by the "Improve Performance" scenario in the 2004 C&P report was $5.1 billion annually. The amount declined due to revisions in the benefit-cost methodology.) Eighty-six percent of the $4.3 billion performance investments, or $3.2 billion, is for the expansion of the 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 $12.8 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 Under 1 Million

Based on the investment scenarios, 94 percent of the transit investment in areas with populations under 1 million is estimated to be for nonrail transit. The Maintain Conditions and Performance scenario estimates investment in the nonrail transit infrastructure in these less-populated areas to be $1.8 billion annually (compared with $2.0 billion annually in the 2004 C&P report); and the Improve Conditions and Performance scenario estimates it to be $3.2 billion annually (compared with $3.4 billion annually in the 2004 C&P report). The incremental investment estimated to improve conditions in these areas is $295 million annually, and the incremental investment to improve performance is $1.2 billion. Of the $1.2 billion incremental annual investment to improve performance, 46 percent, or $497 million, would be needed to acquire new vehicles; and 54 percent, or $577 million, would need to be invested in the new nonvehicle infrastructure. The current report assumes that

Q&A

What would be the effect of investing in light rail instead of BRT to improve performance in areas with populations of less than 1 million?

This change would increase the annual amount to improve performance by $302 million annually. The amount of rail investment in these areas would increase by $797 million and the amount of bus investment in these areas would decrease by $495 million. More light rail projects are economically viable (and pass the benefit-cost test) than was found in the analysis for the 2004 C&P report. This is mainly due to changes in agency-specific costs and ridership values as reported to the NTD.

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 2004 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. Twenty-nine percent of the expansion in investment to improve performance, or $307 million annually, is assumed to be necessary to improve service to rural areas, that now have limited or no service.

Rail Needs in Areas with Populations of Under 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 $120 million annually, compared with $40 million annually in the 2004 C&P report. This investment estimate increased due to an increase in the estimated size of the rail infrastructure in these areas because of enhancements in estimating unreported assets and extensions and the opening of new systems. Eighty-five percent of the $120 million, or $102 million annually, is for investment in nonvehicle rail infrastructure. The amount needed for the "Improve Performance" scenario is estimated to be $78 million annually (compared with $67 million in the 2004 C&P report).

Investment Estimates by Asset Type

Exhibit 7-12 provides disaggregated annual investment by scenario for rail and nonrail transportation modes by asset type for the following:

- Asset replacement and rehabilitation
- Asset expansion
- 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-eight percent of the total amount estimated by the Maintain Conditions and Performance scenario ($9.0 billion dollars annually) and 60 percent of the total amount estimated by the Improve Conditions and Performance scenario ($13.0 billion annually) are for rail infrastructure. As shown in *Exhibit 7-13*, vehicles and guideway elements are estimated to have the largest amounts of the total capital investment of all rail assets between 2005 and 2024, followed in descending order of investment by stations, systems, and facilities.

G*uideways* are estimated to account for 43 percent of the total value of the Nation's rail infrastructure. [See the "Value of U.S. Transit Assets" section in Chapter 3.] Just over a quarter of the total amount of the investment in the Nation's transit rail assets estimated by the Maintain and Improve Conditions and Performance scenarios is for guideway elements. Guideway elements are composed of 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 $3.6 billion. The "Maintain Conditions" scenario estimates annual rehabilitation and replacement to be $1.5 billion; the

Exhibit 7-12

Transit Infrastructure
Average Annual Investment by Scenario and by Asset Type, 2005–2024
(Millions of 2004 Dollars)

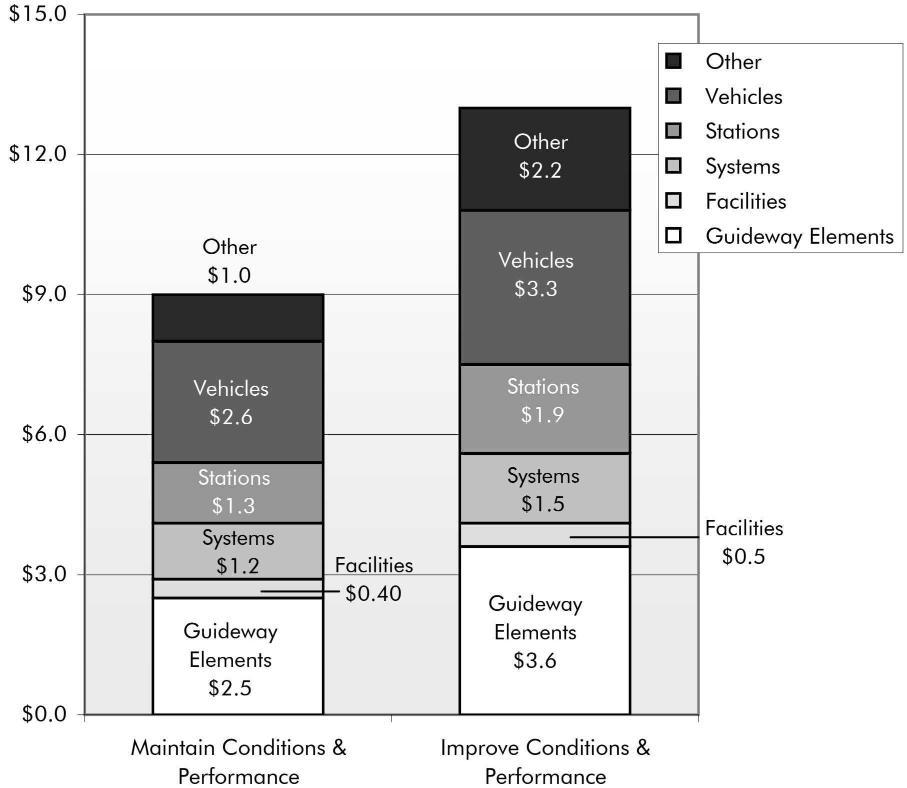
	Maintain Conditions and Performance			
Asset Type	**Rehabilitation and Replacement**	**Asset Expansion**	**Improve Performance**	**Total**
Rail				
Guideway Elements	$1,508	$1,035		$2,543
Facilities	$279	$101		$380
Systems	$1,030	$219		$1,249
Stations	$710	$587		$1,296
Vehicles	$1,638	$945		$2,583
Other Project Costs		$949		$949
Subtotal Rail	**$5,165**	**$3,836**	**$0**	**$9,000**
Nonrail				
Guideway Elements	$263	$137		$400
Facilities	$1,182	$353		$1,535
Systems	$80	$47		$127
Stations	$73	$40		$113
Vehicles	$3,594	$961		$4,555
Other Project Costs		$25		$25
Subtotal Nonrail	**$5,192**	**$1,562**	**$0**	**$6,754**
Total Maintain Conditions	**$10,357**	**$5,398**	**$0**	**$15,754**

	Improve Conditions and Performance			
Asset Type	**Rehabilitation and Replacement**	**Asset Expansion**	**Improve Performance**	**Total**
Rail				
Guideway Elements	$1,508	$1,035	$1,011	$3,554
Facilities	$279	$101	$92	$471
Systems	$1,030	$219	$270	$1,518
Stations	$710	$587	$641	$1,937
Vehicles	$1,884	$945	$511	$3,341
Other Project Costs		$949	$1,238	$2,187
Subtotal Rail	**$5,411**	**$3,836**	**$3,762**	**$13,008**
Nonrail				
Guideway Elements	$263	$137	$209	$609
Facilities	$1,186	$353	$356	$1,894
Systems	$79	$47	$11	$137
Stations	$72	$40	$75	$188
Vehicles	$3,932	$983	$909	$5,824
Other Project Costs		$25	$152	$177
Subtotal Nonrail	**$5,533**	**$1,584**	**$1,712**	**$8,829**
Total Improve Conditions	**$10,944**	**$5,420**	**$5,474**	**$21,838**

Source: Transit Economic Requirements Model and FTA staff estimates.

Exhibit 7-13

Annual Rail Investment by Scenario, 2005–2024 (Billions of 2004 Dollars)



Source: Transit Economic Requirements Model and FTA staff estimates.

"Maintain Performance" scenario estimates annual asset expansions to cost $1.0 billion and the "Improve Performance" scenario an incremental $1.0 billion annually. The estimated average condition of guideway improved slightly, from 4.25 in 2002 to 4.39 in 2004, primarily based on updated asset information. The amount estimated by the "Improve Conditions" scenario declined due to replacing the default assumption to replace tunnels after 100 years with the assumption not to replace them and to only undertake annual capital maintenance as reflected by NTD data for each agency's practices. The amount estimated by the "Improve Performance" scenario was also reduced by revisions to estimated cost of congestion delay used in the benefit-cost analysis. The impact of these declines outweighed increases resulting from a 3.9 percent increase in the value of rail guideway asset infrastructure between 2002 and 2004, and an increase in the TERM replacement threshold for all guideway except tunnels from a condition of 1.50 to a condition of 1.75. (For the 2004 C&P report, the Maintain Conditions and Performance scenario estimated investment of $3.5 billion annually for guideway; and the Improve Conditions and Performance scenario estimated investment of $3.8 billion annually for guideway.)

Vehicles are estimated to account for 19 percent of the total value of the Nation's rail infrastructure. Twenty-nine percent of the amount estimated to maintain rail asset conditions and performance, or $2.6 billion annually, and 26 percent of the amount estimated to improve rail asset conditions and performance, or $3.3 billion annually, are for vehicles. Annual vehicle rehabilitation and replacement costs are estimated to be $1.6 billion to maintain conditions and $1.9 billion to improve conditions. Annual asset expansion costs are estimated to be $945 million to maintain performance and $511 million to improve performance. These values are comparable to those in the 2004 C&P report, which estimated that $2.4 billion annually was needed to maintain rail vehicle conditions and performance and $3.3 billion annually to improve rail vehicle conditions and performance.

Rail systems, comprising train control, traction power, and communications, are estimated to account for 16 percent of the total value of the Nation's rail asset base. Fourteen percent of the amount estimated to maintain the conditions and performance of rail assets, or $1.2 billion annually, and 12 percent of the amount estimated to improve the conditions and performance of rail assets, or $1.5 billion annually, are for rail systems. Annual rehabilitation and replacement costs are estimated to be $1.0 billion both to maintain and to improve conditions. Annual asset expansion costs are estimated to be $219 million to maintain rail power system performance and an additional $270 million to improve performance. These values are comparable to the 2004 report, which estimated that $1.2 billion annually was needed to maintain rail power systems conditions and performance and $1.4 billion annually to improve rail power systems conditions and performance. Preliminary revisions to system decay curves had a very limited effect on estimated investment.

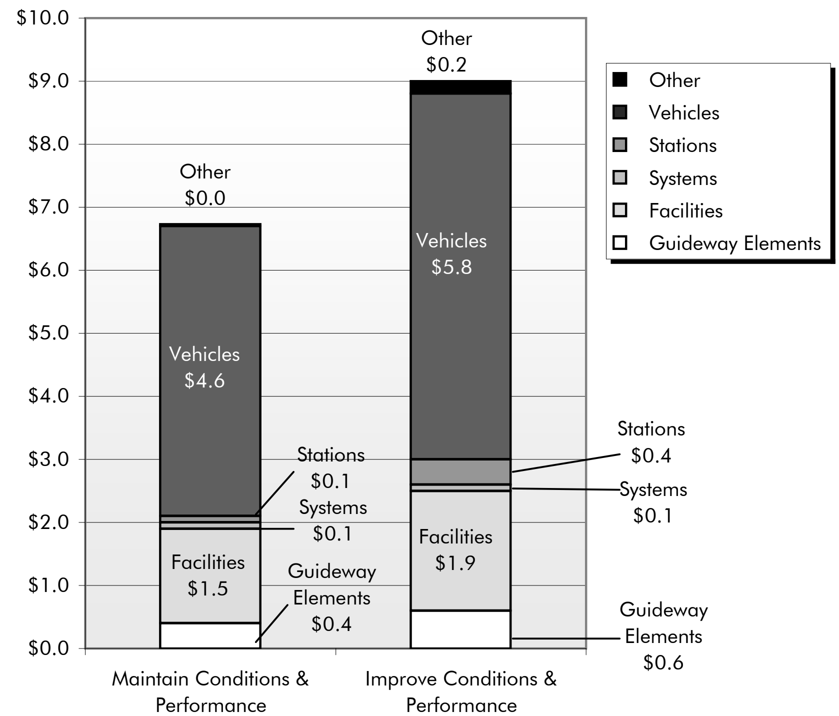
Stations are estimated to account for 17 percent of the total value of the Nation's rail infrastructure. Fourteen percent of the amount estimated to maintain the conditions and performance of rail assets, or $1.3 billion annually, and 15 percent of the annual amount estimated to improve the conditions 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 $710 million annually, about half the amounts indicated in the 2004 C&P report. The annual amount of station expansion to maintain performance is estimated to be $587 million, and the annual amount of station expansion to improve performance is estimated to be $641 million. Estimated investment for stations has declined since the 2004 report due to revisions to station deterioration curves (which led to an increase in average condition), a revision to the station replacement assumption in TERM, and revisions to the estimated cost of congestion delay. Investment estimates in this report assume that underground stations are rehabilitated only, and not replaced as assumed in earlier reports. The decrease in estimated station investment resulting from changes in station deterioration curves, the cost of congestion delay, and replacement assumptions outweighed increases in estimated station investment due to a 21 percent increase in the value of rail station assets as a result of revisions to the process of generating missing assets. (The 2004 C&P report estimated that $1.7 billion annually was needed to maintain station conditions and performance and $3.1 billion annually to improve station conditions and performance.)

Facilities for rail vehicles (maintenance facilities and yards) are estimated to account for 5 percent of the total value of the Nation's rail transit asset base. Four percent of the amount to maintain conditions, $380 million annually, and 3 percent of the amount to improve conditions and performance, $471 million annually, are estimated to be for facilities. Annual rehabilitation and replacement costs are estimated to be $279 million both to maintain and to improve conditions. Asset expansion costs are estimated to be $101 million annually to maintain performance and $92 million annually to improve performance. The estimated value of facilities in current dollars is 25 percent higher in 2004 than in 2002, as a result of updated asset information from agencies and revised facility replacement costs. The estimated average condition of facilities increased from 3.56 in 2002 to 3.82 in 2004. In summary, the somewhat higher asset valuation of maintenance facilities has led to higher estimates of future capital investment outweighing any reductions due to the increase in average condition. (The 2004 C&P report estimated $307 million annually to maintain rail facilities conditions and performance and $424 million annually to improve rail facilities conditions and performance.)

Nonrail Assets

Exhibit 7-14

Nonrail Annual Investment by Scenario, 2005–2024 (Billions of 2004 Dollars)



Source: Transit Economic Requirements Model and FTA staff estimates.

Forty-three percent of the total amount to maintain conditions and performance, or $6.8 billion dollars annually, and 40 percent of the total amount estimated to improve conditions and performance, or $8.8 billion annually, are for nonrail infrastructure. Vehicles are estimated to require the largest amount of the total capital investment in nonrail assets between 2005 and 2024, as shown in *Exhibit 7-14,* followed in descending order of estimated investment by facilities, guideway elements (dedicated lanes for buses), stations, and systems.

Vehicles are estimated to account for 34 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 $4.6 billion annually, and the investment in nonrail estimated by the Improve Conditions and Performance scenario is $5.8 billion annually. Seventy percent of estimated nonrail rehabilitation and replacement expenditures is for vehicles. Vehicles are also estimated to account for the largest proportion, about 60 percent, of nonrail asset expansion investments by the "Maintain Performance" scenario and 53 percent of the amount estimated by the "Improve Performance" scenario. (The 2004 C&P report estimated that $4.4 billion annually was needed to maintain the conditions and performance of nonrail vehicles and $6.0 billion annually to improve the conditions and performance of nonrail vehicles.)

Facilities are estimated to account for 52 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 20 percent of future nonrail investment because external structures and many of the facility components depreciate slowly. The Maintain Conditions and Performance scenario estimates investment in facilities to be $1.5 billion, and the Improve Conditions and Performance scenario estimates investment in facilities to be $1.9 billion. The conditions of bus maintenance facilities increased from 3.34 in 2002 to 3.41 in 2004. These results are comparable to those in the 2004 C&P report; the Maintain Conditions and Performance scenario in the 2004 report estimated investment of $1.6 billion annually for nonrail maintenance facilities, and the Improve Conditions and Performance scenario estimated investment of $1.9 billion annually for nonrail maintenance facilities. Although average condition increased, the amount needed to maintain facilities' condition declined due to revisions in facility replacement costs and revisions to the benefit-cost analysis.

Guideway elements account for 9 percent of the Nation's nonrail assets, *stations* account for 3 percent, and *power systems* account for 2 percent. The Maintain Conditions and Performance scenario estimates investment of $400 million annually for nonrail guideway, and the Improve Conditions and Performance scenario estimates investment of $609 million for nonrail guideway (compared with $212 million annually and $456 million annually in the 2004 report). These amounts increased principally due to an increase in the estimated value of the nonrail guideway infrastructure as a result of improvements to the process used to generate asset records for unreported assets. The Maintain Conditions and Performance scenario estimates investment of $133 million annually for nonrail stations, and the Improve Conditions and Performance scenario estimates investment of $188 million for nonrail stations (compared with $100 million annually and $350 million annually in the 2004 report). The increase in the amount to maintain conditions resulted from revisions to nonrail station deterioration curves and to a reduction in the assumed interval between rehabilitations from 40 to 35 years. The amount to improve performance declined as a result of the reduction in the assumed costs of congestion delay used in the benefit-cost analysis. The Maintain Conditions and Performance scenario estimates investment of $127 million annually in nonrail systems; and the Improve Conditions and Performance scenario estimates investment of $137 million in nonrail systems (compared with $180 million annually and $185 million annually in the 2004 C&P report). Nonrail systems are primarily comprised of communications systems. The decline in the amount needed to maintain conditions resulted from revised system decay curves for PBX systems. These systems were found to deteriorate much more slowly than previously estimated. The amount needed to improve performance declined as a result of the reduction in congestion costs by the benefit-cost analysis.

Q&A

What is a PBX system?

PBX stands for ***p****rivate* ***b****ranch* ***e****xchange,* a private telephone network used within an enterprise. Users of the PBX share a certain number of *outside lines* for making telephone calls external to the PBX.

Rural Transit Vehicles and Facilities

Investment for rural areas has been estimated using the same information and methodology as in the 2004 C&P Report [*see Appendix C*]. The most recent information on rural systems was published by the Community Transportation Association of America (CTAA) in 2000 and was also used to estimate investment for the 2002 edition of this report. The changes in estimated investment since the last report result from revisions in estimated vehicle and facility replacement costs. The estimated amount to maintain conditions and performance decreased by 2.9 percent in current dollars, from $277 million in 2002 to $269 million in 2004; the estimated amount to improve conditions and performance increased by 7.6 percent from $681 million in 2002 to $733 million in 2004. The estimate to maintain the conditions and performance of rural transit decreased as a result of reductions in the estimated replacement costs of automobiles and nonaccessible vans. Combined, these automobiles and vans are estimated to account for 63 percent of the rural fleet. The replacement cost of facilities (maintenance and administrative) was estimated to be the same. The estimate to improve conditions and performance increased by 3.4 percent due to a 9.2 percent increase in the cost of an ADA-accessible van. The "Improve Conditions and Performance" scenario assumes that all vans are replaced with models that are ADA accessible. Nonaccessible vans are estimated to account for 38 percent of the total rural fleet. As in the 2004 C&P report, the number of rural vehicles is assumed to increase at an average annual rate of 3.5 percent to improve performance.

Special Service Vehicles

The investment estimated for special service vehicles is 24 percent lower than in the 2004 C&P report as a result of a reduction in estimated vehicle replacement costs. The number of special service vehicles, as reported in the "FTA Trends Report FY2002 on the use of Section 5310 Elderly and Persons with Disabilities Program Funds" was estimated to be 37,720 in 2002, used as a proxy for 2004 in this report. Based on information reported to FTA by grantees, the average replacement price of a special service vehicle decreased from $46,985 in 2002 to $37,949 in 2004. Note that the estimated investment for vehicles funded by FTA accounts for 43 percent of the total amount estimated for the entire 37,720 special service vehicle fleet.

U.S. Federal Lands

Growth in public recreational use of Federal Lands has created a need for additional investment in alternative transportation systems (ATS), i.e., transit and transit enhancements, on Federal Lands. Transit investment on Federal Lands has been estimated outside the scope of the TERM framework and is discussed in more detail in Chapter 20 of the 2004 C&P report. In 2004, a joint FTA and FHWA study was completed, which estimated ATS on U.S. Forest Service (USFS) lands, which are part of the U.S. Department of Agriculture. This study identified 30 USFS sites that would benefit from new or supplemental ATS investments and estimated that approximately $698 million in 2003 dollars ($714 million in 2004 dollars or $60 million per year) would be needed in these areas between 2003 and 2022. An earlier joint FTA/FHWA study, undertaken in 2001, estimated ATS investment needs on National Park Service (NPS), Bureau of Land Management (BLM), and U.S. Fish and Wildlife Service (USFWS) lands, which are all part of the U.S. Department of the Interior (DOI). Total DOI needs for the period 2002 to 2020 were estimated to be $1.71 billion in 1999 dollars ($2.16 billion in 2004 dollars or $180 million per year). Ninety-one percent of these needs were estimated to be required by the NPS, 7 percent by the USFWS, and 2 percent by BLM.

Transit Investment Backlog

TERM estimates the amount of investment that would be required to replace the transit assets in not meeting certain replacement criteria. The "backlog" is the level of investment needed to replace all assets with conditions below the condition replacement thresholds specified by TERM necessary to improve conditions and is similar to the backlog requirement calculated by the HERS for highways. TERM assumes that the backlog is eliminated over a 20-year period, meaning that the average annual investment estimates calculated by TERM include one-twentieth of the backlog [*see Appendix C*]. TERM estimates that the Nation's transit infrastructure has an existing backlog of $27.66 billion (compared with $41.8 billion in the 2004 report).

Q&A

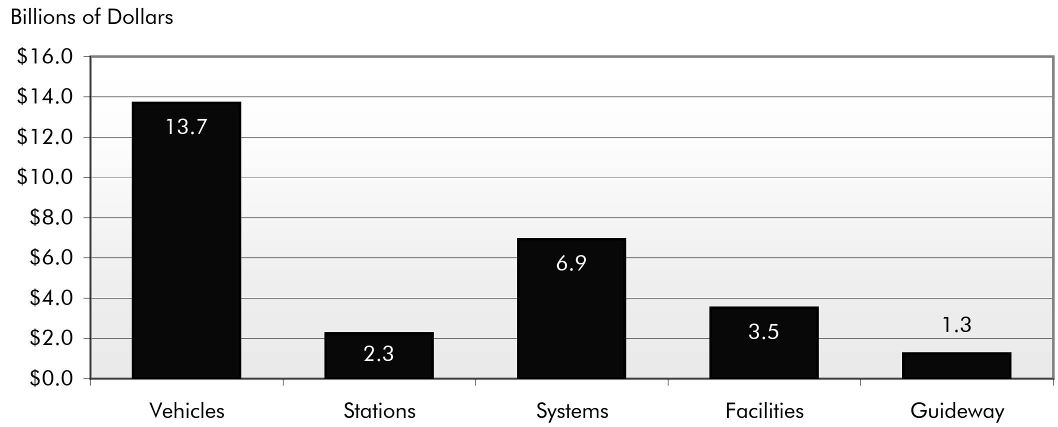
How much would be required to replace assets falling below thresholds to maintain conditions?

TERM estimates that $23.8 billion is needed to replace assets with conditions below the threshold levels specified by TERM to maintain conditions (compared with $27.0 billion in the 2004 C&P report). The investment estimated under the Maintain scenario in this chapter assume that these deferred needs are eliminated over a 20-year period, i.e., the average annual investment estimates include one-twentieth of this amount. Forty-one percent of the $23.8 billion, or $9.83 billion, is estimated to be needed to replace vehicles; 9 percent, or $2.3 billion, is estimated to be needed to replace stations; 29 percent, or $6.93 billion, is estimated to be needed to replace systems; 15 percent, or $3.5 billion, is estimated to be needed to replace facilities; and 5 percent, or $1.3 billion, is estimated to be needed to replace guideway. Fifty-four percent of the $23.8 billion, or $12.8 billion, is estimated to be for heavy rail assets, 33 percent, or $7.9 billion, is estimated to be for bus assets and 8 percent, or $2.2 billion, is estimated to be for commuter rail assets.

Exhibit 7-15 shows the backlog according to asset type. Forty-nine percent of the backlog, or $13.7 billion, is for vehicles; 25 percent, or $6.9 billion, is for systems; and 13 percent, or $3.5 billion, is for facilities. The backlogs for vehicles, stations, facilities, and guideway have decreased since the last report. The decrease in the backlog for vehicles resulted from vehicle replacements. The percentage of overage bus vehicles declined from 19 to 15 percent of the fleet, and the percentage of overage bus vehicles declined from 37 to 34 percent of the fleet. The station backlog decreased because underground stations were assumed to be rehabilitated only and never replaced. The facility backlog decreased due to a decline in the average facility replacement cost as a result of assigning lower replacement costs to smaller facilities. The only asset for which the estimated backlog increased was systems. The backlog by mode is provided in *Exhibit 7-16.* Eighty-seven percent of the backlog is estimated to be for heavy rail and bus assets, which is consistent with the strong backlog identified for both vehicles and stations. The backlog for heavy rail is estimated to be $16.2 billion and the backlog for buses is estimated to be $8.1 billion.

Exhibit 7-15

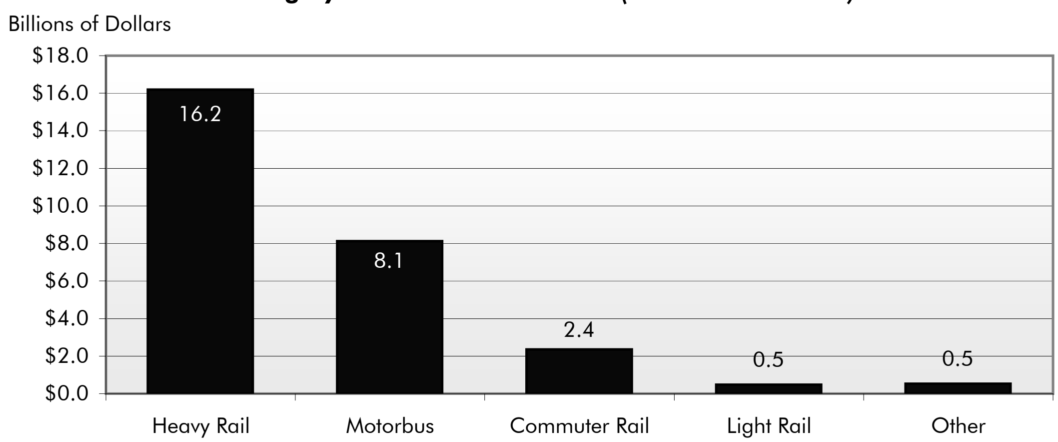
Estimated Backlog by Transit Asset Type in 2004 (Billions of Dollars)



Source: Transit Economic Requirements Model.

Exhibit 7-16

Estimated Backlog by Transit Mode in 2004 (Billions of Dollars)



Source: Transit Economic Requirements Model.

Summary of Revisions Since the 2004 C&P Report and Effects on Investment Estimates

The *asset deterioration schedules* for stations and systems were revised based on on-site engineering surveys conducted by FTA in 2005 and 2006, respectively. The revised deterioration schedule for stations led to a 1 percent decrease in station investment estimates. Preliminary revision to the systems deterioration schedule has been small, with a marginal effect on rail system investment estimates; on-site surveys of rail systems are continuing in 2006. A new deterioration curve for systems will be developed from the information collected in 2005 and 2006 and presented in the 2008 report.

The *benefit-cost* test in TERM for performance-enhancing investments was customized to provide a better reflection of the unique cost and ridership experience of each transit agency. The benefit-cost input parameters that are used to evaluate performance-enhancing investments (e.g., operating and maintenance costs, average fare and mode speed) are now specific to each agency mode. Prior to this change, the analysis used national modal averages for these parameters. These changes led to no changes in the Maintain Conditions and Performance scenario and led to a decline of roughly 10 percent in performance-enhancing investments. The congestion delay cost used by TERM was reduced to accord more closely with the 1997 Highway Cost Allocation Study and the level of congestion by population stratum. Prior to this revision, the benefit-cost analysis had assumed a single measure of congestion for all agencies. This change decreased rail investment estimates and increased nonrail investment estimates. Overall, this change led to a roughly 5 percent increase in the amount needed to maintain conditions and performance and a roughly 5 percent decrease in the amount needed to improve conditions and performance.

TERM's *asset inventories* for 25 of the Nation's large transit systems were updated in 2004 and 2005. These updates led to more comprehensive transit asset coverage. They follow substantial updates made for the last report with data collected by the NTD asset condition reporting modeling and from the New York Metropolitan Transportation Authority. These updates led to a very small decrease in the amount needed to maintain conditions and performance and a 0.2 percent decrease in the amount needed to improve conditions and performance. They also led to a revision in estimated replacement cost of smaller maintenance facilities.

The methodology used to estimate *generated assets*, i.e., assets for which no data exist in TERM, was revised to be dynamically based on NTD data for route miles, track miles, number of crossings, maintenance facilities, and stations for each agency mode. These revisions led to a small overall increase in investment estimates, primarily for rehabilitation and replacement, and increased FTA's estimate of bus guideway and number of bus and rail maintenance facilities, particularly in smaller urbanized areas.

Annual *projected PMT growth* was increased from an average annual rate of 1.50 percent to 1.57 percent, based on a survey of 92 agencies (compared with 76 agencies for the 2004 report). This slight increase in the projected demand for transit services exerted a very slight upward pressure on the amounts needed for asset expansion to maintain and improve performance. Projected PMT growth rates have increased slightly for six FTA regions and decreased slightly for four regions since the last survey of PMT forecasts was made for the 2004 report. Projected PMT growth rates varied according to region, ranging from 0.98 to 2.86 percent. The increase in projected PMT had a marginal positive effect on TERM's capital needs estimates.

Rehabilitation and replacement assumptions were revised for guideway and stations. The investment estimates in this report assume that underground tunnels are never replaced and receive annual capital maintenance. Investment estimates in earlier reports assumed that underground tunnels were replaced every 100 years.

The investment estimates in this report are based on the assumption that all stations are rehabilitated every 35 years; investment estimates in earlier reports were based on the assumption that subway stations were replaced every 70 years and that all other stations were rehabilitated every 40 years. These revisions resulted from a comparison of TERM's investment estimates with those of NYCT (New York City Transit), which revealed that TERM was overpredicting NYCT's investment by replacing large segments of NYCT tunnels and its subway stations. These revisions had significant downward effects on investment estimates for guideway and stations.

The *replacement life condition threshold* for guideway was increased. Investment estimates in the current report assume that guideway is replaced when it reaches a condition of 1.75. Investment estimates in earlier reports assumed that guideway would not be replaced until it reached a condition of 1.5. This is the lowest replacement threshold used by TERM and will be subject to further review.

CHAPTER 8

Comparison of Spending and Investment Scenario Estimates

Summary

This chapter compares the current spending for capital improvements described in Chapter 6 with the future investment scenarios outlined in Chapter 7. **These comparisons are intended to be illustrative, rather than to endorse a specific level of future investment.** While the analysis identifies gaps between the investment scenario estimates and current spending levels, it does not take a position as to whether or not these gaps should be closed. The impacts of different levels of investment are discussed in Chapter 9.

The size of the gap between an investment scenario and current spending is dependent on the investment analysis and the underlying assumptions used to develop that analysis. **See the Introduction to Part II for critical caveats concerning the interpretation of these results.** Chapter 10 explores the impacts that varying some assumptions would have on the investment scenario estimates.

Exhibit 8-1 compares the difference between the investment scenario estimates and spending in this report with the corresponding difference based on the data shown in the 2004 C&P report. The first column of figures contains values shown in the 2004 C&P report, which compared 2002 spending with the average annual investment scenario estimates for 2003 to 2022.

Exhibit 8-1

Highway, Bridge, and Transit Spending vs. Investment Scenario Estimates Compared with Data from the 2004 C&P Report

Percent by which Investment Scenario Estimates Exceed Current Spending	Based on 2002 Data	Based on 2004 Data
Cost to Maintain		
Highways and Bridges	8.3%	12.2%
Transit	26.8%	25.4%
Cost to Improve		
Highways and Bridges (Maximum Economic Investment Level)	74.3%	87.4%
Transit	95.1%	73.0%

Highways and Bridges

The average annual investment level under the "Cost to Maintain Highways and Bridges" scenario in the 2004 C&P report was 8.3 percent ($5.7 billion) higher than highway capital expenditures in 2002. The estimated gap increased to 12.2 percent ($8.5 billion) in 2004. The difference between the "Maximum Economic Investment Level for Highways and Bridges (Cost to Improve)" and 2004 spending is 87.4 percent ($61.4 billion). This represents an increase over the 74.3 percent gap estimated in the 2004 C&P report ($50.7 billion), based on the spending figures for 2002 presented in that report.

The changes in the size of the estimated gap between current spending and the investment scenarios are largely the result of improvements in the modeling of highway performance (most notably the linkage of investment levels to revenue sources) and the cost of capital improvements, particularly in large urbanized areas. The net impact of these changes is a small increase in the size of the estimated gap.

Transit

The estimated gap between current spending on transit capital investment and the investment estimates to maintain and improve conditions and performance has narrowed since the 2004 report. The estimated gap between actual spending and the amount to maintain conditions and performance narrowed very slightly from 26.8 to 25.4 percent; the estimated gap between actual spending and the amount to improve conditions and performance declined more markedly from 95.1 to 73.0 percent due to the decrease in the estimated amount to improve performance.

The Federal Transit Administration's (FTA's) estimate of the average annual investment to maintain transit asset conditions and performance between 2005 and 2024 is $15.8 billion annually, $3.2 billion (25.4 percent) more than actual spending in 2004; FTA's estimate to improve transit asset conditions and performance between 2005 and 2024 is $21.8 billion annually, $9.2 billion (73.0 percent) more than actual spending in 2004. FTA estimates to maintain conditions and performance from 2003 to 2022 provided in the 2004 report were 26.8 percent above actual capital spending in 2002; FTA estimates to improve conditions and performance were 95.1 percent above actual capital investment in 2002.

The portion of the "Maintain Conditions and Performance" scenario estimate for capital investment in vehicles is $7.1 billion annually, 109 percent more than actual expenditures of $3.4 billion in 2004; the portion of the "Improve Conditions and Performance" scenario estimate for capital investment in vehicles is $9.2 billion annually, or 171 percent more than actual expenditures in 2004. The nonvehicle transit infrastructure component of the "Maintain Conditions and Performance" scenario is estimated to be $8.6 billion annually, or 7 percent below actual expenditures of $9.2 billion in 2004; the capital investment in nonvehicle transit infrastructure component of the "Improve Conditions and Performance" scenario is estimated to be $12.7 annually, or 38 percent more than actual expenditures in 2004.

Highway and Bridge Spending Versus Investment Scenario Estimates

This section compares the average annual investment scenario estimates presented in Chapter 7 with the 2004 highway and bridge capital spending outlined in Chapter 6. As noted in Chapter 7, the investment scenario estimates presented here are based on the assumption that the current financing structure for highways in the United States will continue into the future. Changes in this structure toward a more efficient regime using congestion pricing would have an impact on the future investment scenario estimates and any gaps with current spending levels. Chapter 10 includes an analysis of the theoretical impact that an efficient pricing system could have on the estimates.

Q&A

Does this report recommend any specific level of investment?

No. The investment analysis in this report is intended to estimate what the consequences of various levels of spending might mean for highway system performance. The comparisons in this chapter between current spending and the highway and bridge investment scenarios are intended to be illustrative only. They are not intended to endorse any of the investment scenarios as the "correct" level of transportation investment.

Average Annual Investment Scenario Estimates Versus 2004 Spending

Exhibit 8-2 compares the average annual investment estimates under the "Cost to Maintain" and "Maximum Economic Investment" scenarios [*see Chapter 7*] with 2004 highway and bridge capital expenditures. The average annual "Cost to Maintain Highways and Bridges" projected for the 2005 to 2024 period is $8.5 billion (12.2 percent) higher than 2004 capital expenditures, while the estimated "Maximum Economic Investment for Highways and Bridges" exceeds current spending by $61.4 billion (87.4 percent). Expenditures for bridge rehabilitation in 2004 exceeded the corresponding component of the "Cost to Maintain" scenario, which is drawn from the "Maintain Economic Backlog" scenario in the National Bridge Investment Analysis System (NBIAS) [*see Chapter 7*].

Exhibit 8-2

Average Annual Investment Scenario Estimates vs. 2004 Capital Outlay

	2004 Capital Outlay ($Billions)	Investment Scenario Estimates (Billions of 2004 Dollars)			
		Cost to Maintain	Percent Above Current Spending	Maximum Economic Investment	Percent Above Current Spending
System Rehabilitation: Highways	$26.0	$31.9	23.0%	$48.6	87.1%
System Rehabilitation: Bridges	$10.5	$8.7	-16.6%	$12.4	18.6%
System Expansion	$27.5	$31.0	12.9%	$58.8	113.9%
System Enhancements	$6.4	$7.1	12.2%	$11.9	87.4%
Total	**$70.3**	**$78.8**	**12.2%**	**$131.7**	**87.4%**

While the percentage "gap" between 2004 highway resurfacing and reconstruction spending and the "Cost to Maintain" scenario is the largest among the subsets of highway and bridge spending shown in Exhibit 8-2, this does **not** indicate that current investment is inadequate to maintain pavement conditions. As noted in Chapter 7, the Highway Economic Requirements System (HERS)-derived component of the "Cost to Maintain" scenario is aimed at maintaining user costs rather than maintaining pavement conditions. The larger "gap" shown for the highway component of system preservation indicates that HERS has identified a large pool of potential pavement improvements that could yield significant benefits in terms of reducing user costs. While the ride quality on many functional systems has been improving in recent years (as reported in Chapter 3), the models indicate that many pavement improvements in both the near-term and longer-term future will continue to have high rates of return. The impact of investment on highway conditions and performance is discussed in more detail in Chapter 9.

Types of Improvements

Exhibit 8-3 compares the distribution of highway and bridge capital outlay by improvement type for the "Cost to Maintain Highways and Bridges" and the "Maximum Economic Investment for Highways and Bridges" with the actual pattern of capital expenditures in 2004. In that year, 39.1 percent of highway and bridge capital outlay went for system expansion.

The distribution of funding by investment type suggested by the investment scenarios developed using the HERS and NBIAS models depends on the level of available funding. For the "Cost to Maintain Highways and Bridges" scenario, 39.4 percent of the projected 20-year investment level is for system expansion, marginally higher than its share of current capital spending. If funding were to rise significantly above this level, the analysis suggests that even more cost-beneficial system expansion expenditures would be found, so that, for the "Maximum Economic Investment" scenario, 44.6 percent of the total investment is for system expansion, slightly below the share for system rehabilitation (46.3 percent).

Q&A

How does the improvement mix for the investment scenarios in this report compare with those in the 2004 C&P report?

The investment scenarios in this report are more heavily weighted toward capacity relative to system rehabilitation improvements than in the previous report. One factor in this shift is the lower percentage of total investment under the scenarios that are represented by bridge rehabilitation and replacement, which has not changed significantly since the previous report. Other factors are related to changes in the HERS methodology discussed in Chapters 7 and 10 and in Appendix A, including revised estimates of the unit costs of the different types of capital improvements (particularly in large urbanized areas) and to the use of lower values for travel demand elasticity.

Exhibit 8-3

Highways and Bridges Investment Scenario Estimates and 2004 Capital Outlay, Percentage by Improvement Type

	System Rehabilitation			System	System Enhance-	
	Highway	Bridge	Total	Expansion	ment	Total
2004 Capital Outlay	37.0%	14.9%	51.8%	39.1%	9.0%	100.0%
Cost to Maintain Highways and Bridges	40.5%	11.1%	51.6%	39.4%	9.0%	100.0%
Maximum Economic Investment for Highways and Bridges	36.9%	9.4%	46.3%	44.6%	9.0%	100.0%

Q&A

What options are available to reduce the "funding gaps" cited in this chapter?

As previously noted, this report does not endorse any of the investment scenarios as the "correct" level of transportation investment. If one were to explore options for closing these "gaps", then the discussions in Chapter 6 describing current highway financing mechanisms could serve as useful background material. Note, however, that while that chapter focuses on Federal, State, and local government investment in highway infrastructure, it is important not to overlook the private sector. While the financial data currently available are much more thorough in capturing public sector highway spending than that of the private sector, the private sector is playing an increasing role in highway finance. Mechanisms such as public-private partnerships are intended to foster increasing private investment in the future. Chapter 13 discusses public-private partnerships and other innovative finance programs in more detail.

The discussion of congestion pricing in the Introduction to Part II of this report focused on the potential impacts that this type of tolling might have on the future investment scenario estimates, and thus on reducing the funding gap. An analysis of the theoretical impact that this could have in reducing the level of investment under the Cost to Maintain and Maximum Economic Investment scenarios is presented in Chapter 10. However, it is also important to note that congestion tolling could also provide a substantial stream of additional revenue, assuming such revenues were dedicated to be used for highway purposes, and that these user charges would be additive to those currently imposed (such as fuel taxes and motor-vehicle taxes and fees), rather than replacing them. Congestion pricing could thus present a "two-pronged" approach to reducing the spending gap.

Note that the "Cost to Improve Highways and Bridges" is presented in this report as a maximum level of investment above which it would not be cost-beneficial to invest, even if available funding were unlimited. As highway investment increases above current levels, the marginal returns for each additional dollar invested would be expected to decline. Closing this larger "gap" entirely would also be desirable only if all other potential cost-beneficial spending opportunities across other government functions were similarly exhausted.

As discussed in Chapter 7, investment estimates for non-modeled items were determined by assuming that any future increase in this type of investment would be proportional to increases in total capital spending. For system enhancement, the percentages for the "Maximum Economic Investment for Highways and Bridges" and for the "Cost to Maintain Highways and Bridges" were set at 9.0 percent to match the percentage of expenditures in 2004.

Comparison with Previous Reports

Exhibit 8-4 compares the estimated differences between current spending and the average annual investment scenario estimates for this and the 1997, 1999, 2002, and 2004 C&P reports.

The percentage difference between current spending and the "Cost to Maintain Highways and Bridges" is somewhat higher than that in the 2004 report. As shown in Exhibit 8-4, the 2004 C&P report

Q&A

Why has the gap between current spending and the investment scenario estimates increased since the 2004 report?

While highway capital outlays increased by 3.1 percent between 2002 and 2004, the estimated "Cost to Maintain Highways" presented in this report also increased, by nearly 7 percent. As discussed in Chapter 7, this increase is due primarily to revised estimates of the cost of construction in large urbanized areas. Projects in these areas are becoming more complex, involving more environmental mitigation and construction strategies (such as night work) intended to reduce the impacts of work zones on users. Urban highway construction costs in general also increased between 2002 and 2004, by 11.2 percent (rural construction costs declined by 3.5 percent over the same period). Finally, traffic congestion has continued to increase, thereby increasing the number and severity of highway capacity deficiencies.

Exhibit 8-4

Average Annual Investment Scenario Estimates vs. Current Spending, 1997 to 2006 C&P Reports

		Percent Above Current Spending	
Report Year	**Relevant Comparison**	**Cost to Maintain Highways & Bridges (Low Scenario*)**	**Cost to Improve Highways & Bridges (High Scenario*)**
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%

* The investment scenarios are not fully consistent between reports. See Chapter 7 and Appendix A.

estimated that average annual investment under this scenario would be 8.3 percent above current spending. Estimates of the gap based on the 1997, 1999, and 2002 reports, however, were higher than the estimate in this edition.

Based on the information in the 1997 C&P report, the difference between the "Cost to Improve Highways and Bridges" would have been 108.9 percent. This difference was 92.9 percent in the 1999 C&P report and fell below 75 percent in the 2002 and 2004 reports. While it has risen in this report, it remains below the estimates from those earlier editions.

Transit Capital Spending Compared with Investment Scenario Estimates

This section compares the estimated average annual investment estimates for transit for the "Maintain" and "Improve" scenarios provided in Chapter 7 with actual 2004 capital spending on transit as discussed in Chapter 6. It is important to remember that the funding gaps between estimated investment under these scenarios and actual capital expenditures reflect passenger travel projections, the asset condition replacement thresholds chosen by the Transit Economic Requirements Model (TERM), and investment assumptions to improve performance by increasing passenger speed and reducing crowding as discussed in Chapter 7.

2004 Capital Spending and Estimated Average Annual Investment by Scenario

As indicated in Chapter 6, in 2004, total capital investment in transit by Federal, State, and local governments was $12.6 billion. The "Maintain" scenario estimate is $3.2 billion more annually or 25.4 percent above actual capital investment in 2004, and the "Improve" scenario estimate is $9.2 billion more annually or 73.0 percent above actual investment in 2004 [*Exhibit 8-5*]. These estimates are based on TERM. The gap between actual capital investment and the TERM estimate to maintain conditions and performance is similar to the 26.8 percent gap reported in the 2004 C&P report. Actual capital investment and the TERM estimate to maintain conditions and performance both are slightly higher than what was reported in 2004. However, the gap between actual capital investment and the TERM estimate to improve conditions and performance shrank considerably (from 95.1 percent in the 2004 C&P report) due to a decrease in the estimated amount needed to improve conditions and performance.

Exhibit 8-5

2004 Transit Capital Expenditures vs. Estimated Average Annual Investment by Scenario

(Billions of 2004 Dollars)		Average Annual Investments Minus Actual Expenditures in 2004	Average Annual Investments Percent Above Actual Expenditures in 2004
Actual 2004 Capital Expenditures	**$12.6**		
Estimated Annual Average Investments 2005–2024			
Costs to:			
Maintain Conditions & Performance	$15.8	$3.2	25.4%
Improve Conditions & Maintain Performance	$16.4	$3.8	30.2%
Maintain Conditions & Improve Performance	$21.2	$8.6	68.3%
Improve Conditions & Performance	$21.8	$9.2	73.0%

Source: National Transit Database (NTD), Transit Economic Requirements Model (TERM), and FTA staff estimates.

Comparisons by Asset Type

In 2004, $3.4 billion was invested in transit vehicles and $9.2 billion was invested in nonvehicle transit infrastructure, facilities, guideway elements, stations, and systems, compared with $4.1 billion and $8.2 billion in 2002 *[Exhibits 8-6* and *8-7]*. The gap between actual vehicle capital investment and the TERM estimate to maintain and improve the conditions of vehicle assets has widened since the last report and the gap between actual nonvehicle asset investment and the TERM estimate to maintain and improve the conditions of nonvehicle assets has declined, in part, due to a decrease in the share of capital spending on vehicles from 31 percent in 2002 to 27 percent in 2004, and an increase in the share of capital spending on nonvehicles from 69 to 73 percent.

Exhibit 8-6

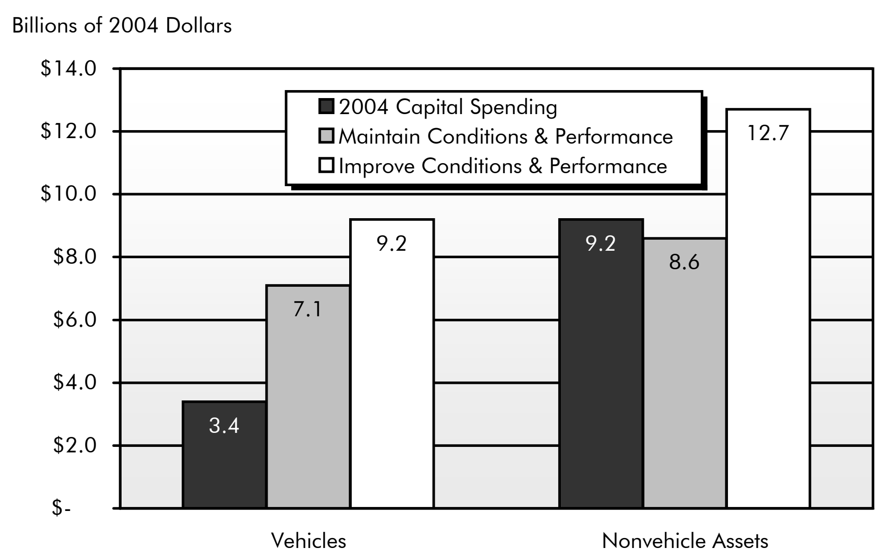
Average Annual Transit Investment by Scenario vs. 2004 Capital Spending by Asset Type

	Vehicles			Nonvehicle Assets		
	Billions of 2004 Dollars	Percent Above Actual Spending	Percent of Total Capital Investment	Billions of 2004 Dollars	Percent Above Actual Spending	Percent of Total Capital Investment
2004 Capital Spending	**$3.4**		**27%**	**$9.2**		**73%**
Costs to						
Maintain Conditions & Performance	$7.1	109%	45%	$8.6	-7%	55%
Improve Conditions & Performance	$9.2	171%	42%	$12.7	38%	58%

Source: Transit Economic Requirements Model and FTA staff estimates.

Exhibit 8-7

2004 Transit Capital Spending by Asset Type vs. Average Annual Investment by Scenario



Source: Transit Economic Requirements Model and FTA staff estimates.

Vehicles

The average annual amount estimated by TERM to maintain the conditions and performance of the Nation's transit vehicle assets between 2005 and 2024 is $7.1 billion annually, 109 percent above the actual spending of $3.4 billion in 2004. The average annual amount estimated by TERM to improve the conditions and performance of the Nation's transit vehicle assets is $9.2 billion annually, 171 percent above the actual 2004. [Note that in the 2004 report, the comparable gaps were 68 percent for the "Maintain" scenario and 127 percent for the "Improve" scenario.]

To maintain conditions, the entire bus fleet will need to be replaced at least once during the period 2005 to 2024, in spite of a reduction in the number of bus vehicles exceeding FTA's minimum replacement age. A large proportion of the existing rail fleet will also need to be replaced between 2005 and 2024. In addition to rehabilitating and replacing existing bus and rail vehicles, the annual investment under the "Maintain" scenario includes investment for expansion to accommodate projected transit ridership growth and improve operating performance. To serve projected growth in bus passengers would require expanding the existing bus fleet by roughly 46,000 vehicles from 2005 to 2024, approximately 42 percent. The investment to improve service performance would expand the 2004 bus fleet by an additional 26,000 vehicles, or 24 percent. Similarly, expansion to serve projected growth in rail passengers would require close to 5,500 additional vehicles for the period 2005 to 2024, an increase of roughly 21 percent. To improve rail service would require about 3,000 additional vehicles, an increase of 12 percent. Many of the buses purchased to expand services will also require funds for rehabilitation and replacement, and many rail vehicles will require investment for rehabilitation before 2024. Each of these capital investment needs is included in the overall vehicle needs estimates.

Nonvehicle Infrastructure

The annual amount estimated by TERM under the Maintain Conditions and Performance scenario for the Nation's nonvehicle transit infrastructure is $8.6 billion annually, 7 percent below the actual expenditures of $9.2 billion in 2004. The annual amount estimated by TERM under the Improve Conditions and Performance scenario for nonvehicle assets is $12.7 billion, 38 percent above actual expenditures in 2004. [Note that in the 2004 report, $8.7 billion was estimated to maintain the conditions and performance of nonvehicle assets, 6 percent above an actual capital investment of $8.2 billion.] As discussed in Chapter 3, 8 percent of all rail maintenance facilities, 35 percent of stations, 26 percent of train control systems, 1 percent of traction power systems, 3 percent of revenue collection equipment, 8 percent of track, 16 percent of elevated structures, and 13 percent of underground tunnels are estimated to be in poor or substandard condition. Non-vehicle infrastructure also needs to be expanded under the "Maintain Performance" scenario to meet projected passenger travel and, under the "Improve Performance" scenario, to reduce crowding and speed in systems operating at levels below the national average.

Historical Comparisons

Capital Investment and Rehabilitation and Replacement Needs

As shown in *Exhibit 8-8,* current capital spending in urban areas in 2004 reached its highest level relative to the rehabilitation and replacement amounts estimated by TERM ($12.6 billion in spending compared with $10.4 billion estimated for rehabilitation and replacement), or by 21 percent. Since 1993, capital investment in transit assets has been almost equal to or slightly higher than the estimated rehabilitation and replacement levels estimated by the "Maintain Conditions" scenario. Actual rehabilitation and replacement

Exhibit 8-8

Current Transit Capital Spending Levels vs. Rehabilitation and Replacement Investment, 1993–2004

(Billions of Current Dollars)		
Analysis Year	Current Capital Spending	Estimated Rehabilitation and Replacement Investment
1993	$5.7	$5.1
1995	$7.0	$7.0
1997	$7.6	$7.0
2000	$9.1	$9.2
2002	$12.3	$10.3
2004	$12.6	$10.4

expenditures are always lower than total capital investment because part of total capital investment in each year is for new system capacity. Based on FTA's budgetary history, about half of FTA's capital assistance has been for rehabilitation and replacement and about half for asset expansion. Investment in asset expansion contributes to higher average condition levels through the purchase of new assets.

Capital Spending and TERM Investment Estimates

Exhibit 8-9 compares the percentage difference between current capital spending levels and the level of transit investment estimated by TERM in 2004 with the percentage differences between capital spending levels and the projected investment estimates from TERM provided in the 1995, 1997, 1999, 2002, and 2004 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 2005 and 2024 is 25 percent higher than actual capital expenditures in 2004. In the 2004 report, the amount of annual investment estimated by TERM to maintain conditions and performance between 2003 and 2022 was 27 percent higher than actual capital expenditures in 2002. In earlier editions of the report, the annual investment estimates calculated by TERM ranged from 38 to 64 percent more than actual spending. A detailed account of the changes in investment estimates is provided in Chapter 7.

Exhibit 8-9

Average Annual Transit Investment by Scenario vs. Current Spending, 1995 to 2006 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%

Source: Transit Economic Requirements Model and FTA staff estimates.

CHAPTER 9

Impacts of Investment

Summary

This chapter serves two major purposes. The first is to discuss the impacts of historic investment, relating the condition and performance trends reported in Chapters 3 and 4 to the financial trends reported in Chapter 6. The second is to describe the impacts of future investment, exploring the impacts of investing at different levels of funding, building on the analysis in Chapters 7 and 8.

The highway portion of this chapter begins by examining the impacts that recent and historical funding patterns have had on highway conditions and performance. The section then discusses the impacts that different levels of future investment would be expected to have in five areas: pavement condition, operational performance, different types of highway user costs, future highway travel growth, and the bridge investment backlog. The impacts on conditions and performance in particular have been designed to project future values of some of the measures presented in Chapters 3 and 4.

The transit portion examines the historical relationship between funding levels and conditions and performance. Funding levels for transit between 2002 and 2004 have been sufficient to maintain conditions and performance. The chapter examines the impact of limiting rehabilitation and replacement expenditures to less than the amounts estimated to be sufficient to maintain transit asset conditions. The chapter also discusses the impact that transit investments have on transit ridership and provides estimates of ridership increases that will be generated by service improvements.

Impacts of Highway and Bridge Investment

The first part of this section compares recent trends in highway and bridge investments with the changes in conditions and operational performance described in Chapters 3 and 4. This includes an analysis of whether the gap identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges is consistent with recent condition and operational performance trends.

The subsequent parts explore some of the impacts that future levels of investment would be expected to have on highway conditions and performance, highway user costs, and future travel growth (derived solely from the Highway Economic Requirements System [HERS]) and the bridge investment backlog (derived from the National Bridge Investment Analysis System [NBIAS]). Impacts are presented for a variety of future investment levels, including the two key investment scenarios in Chapters 7 and 8 and other levels corresponding to certain condition and performance benchmarks. Total investment at the different levels was derived using the external adjustment procedures described in Chapter 7 for nonmodeled capital expenditures. Bridge rehabilitation and replacement investments from NBIAS were interpolated from the two NBIAS investment scenarios and current bridge spending levels. All future investment levels are stated in constant 2004 dollars, and the analysis of projected impacts for each particular investment level assumes that funding would be sustained at that level in constant dollar terms through the year 2024.

As in Chapters 7 and 8, the analyses presented in this section assume the continuation of the existing financing structure for highway improvements. Chapter 10 includes an analysis of the effects of moving toward more efficient congestion-based pricing.

Linkage Between Recent Condition and Performance Trends and Recent Spending Trends

As discussed in Chapter 6, capital spending by all levels of government has increased from 1997 to 2004 by 45.3 percent, from $48.4 billion to $70.3 billion. This equates to a 22.9 percent increase in constant dollar terms, as spending grew much faster than the rate of inflation. Over the same period, the percentage of total capital outlay used for system rehabilitation rose from 47.6 percent in 1997 to 51.8 percent in 2004. The combined result of this increase in total capital investment and the shift in the types of investments being made was a 58 percent increase in spending on system rehabilitation, from $23.0 billion to $36.4 billion. As indicated in Chapter 6, the term "system rehabilitation" is used in this report to describe capital improvement on existing roads and bridges intended to preserve or replace the existing pavement and bridge infrastructure.

The percentage of capital outlay used for system expansion fell from 44.4 percent in 1997 to 39.2 percent in 2004. Spending for system expansion grew more slowly than that for system rehabilitation over this period, rising 28 percent, from $21.5 billion dollars in 1997 to $27.5 billion in 2004.

Physical Conditions

The improved bridge conditions reported in Chapter 3 reflect the effects of the increased investment in system rehabilitation noted above. The percent of deficient bridges decreased from 1998 to 2004, falling from 29.6 percent to 26.7 percent. The impact on pavement conditions, however, has been more mixed. Ride quality has improved in some areas and on some functional classes, but has held steady or declined in other cases. Between 1997 and 2004, the share of vehicle miles traveled (VMT) on roads with good ride quality increased from 39.4 percent to 44.2 percent, but the share on roads with acceptable ride quality decreased from 86.4 percent to 84.9 percent. Both measures improved in rural areas (from 47.9 to 58.3 percent for good ride quality and 92.5 to 94.5 percent for acceptable ride quality), but the percentage of travel on roads in urbanized areas with acceptable ride quality declined from 82.6 to 79.2 percent. The share of travel on roads with acceptable ride quality essentially remained constant in small urban areas, increasing only slightly from 84.0 to 84.3 percent. The percentage of travel on roads with good ride quality increased in both small urban and urbanized areas over that period.

Operational Performance

While investment in system expansion has increased since 1997, it has declined as a share of total capital spending, as noted above. Based on the performance measures described in Chapter 4, congestion has continued to increase between 1997 and 2004. The Average Daily Percent of VMT Under Congested Conditions increased from 27.4 percent to 31.6 percent from 1997 to 2004, while the Average Length of Congested Conditions increased from 6.2 hours to 6.6 hours. The Travel Time Index increased from 1.30 in 1997 to 1.38 in 2004. The Annual Delay per Peak Period Traveler increased from 40.2 to 45.7 hours between 1997 and 2004, while Annual Delay per Capita in urbanized areas increased from 19.5 hours to 24.4 hours. However, the rate of change for each of these measures has decreased in recent years. In particular, smaller annual increases have been experienced since 1999 than was generally the case in the 5 years before 1999.

Q&A

Are the recent trends in conditions and performance consistent with the gaps identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges?

Yes. The operational performance measures described in this report show that congestion is getting worse in the Nation's urban areas. Increased investment would be necessary to maintain the overall conditions and performance of the highway system at a level at which user costs would stop rising in constant dollar terms.

As indicated in Chapter 8, spending on bridge rehabilitation has exceeded the estimated investment level for the bridge component of the "Cost to Maintain" scenario in recent years. This is consistent with the ongoing reduction in the percentage of deficient bridges.

While capital spending in general has been below the Cost to Maintain level in recent years, this has especially been true for spending in urban areas. Capital outlay on rural highways has actually been greater than the estimated Cost to Maintain in those areas. This is consistent with the trends shown in Chapter 3, which indicate that the percentage of travel on roads with good or acceptable ride quality has been improving significantly in rural areas, but has generally been steady or declined slightly in urban areas.

Impact of Future Investment on Highway Physical Conditions

Exhibit 9-1 shows how future measures of pavement conditions would vary at different investment levels. The second column shows the portion of the total investment at each level that is derived directly from HERS (only this portion of the total investment influences the pavement measures in the remaining columns). The third column, "Percent Change in Average IRI", is a measure of average pavement conditions (the International Roughness Index [IRI] is discussed in Chapter 3). The other two measures show the percentage of VMT on pavement having an IRI value below 95 and an IRI value below 170. These two IRI values were defined in Chapter 3 as the thresholds for rating pavement ride quality as good and acceptable, respectively.

At the funding level estimated in Chapter 7 as the Maximum Economic Investment for Highways and Bridges ($131.7 billion annually), the average pavement quality would improve by 21.1 percent, while the percentage of VMT on pavement rated as adequate or better would rise from 84.8 percent to 92.5 percent. At the Maintain User Costs level (labeled "Cost to Maintain" scenario in Exhibits 9-1 through 9-4 and 9-7), average IRI would decrease by 2.5 percent, and the VMT percentage on good pavement would increase from 45.2 percent to 57.7 percent.

Exhibit 9-1 also shows projections of pavement quality at other funding levels. The results indicate that an average annual expenditure level of $75.8 billion would be sufficient to maintain average IRI over the 20-year analysis period. If highway spending were to be held at 2004 levels (in constant dollars) through the year 2024, increasing only with inflation, average IRI would be projected to increase by 5.4 percent if improvements were implemented in the manner recommended by HERS. The percentage of VMT on roads with good ride quality would increase to 52.6 percent, while the percentage on adequate ride quality pavement would decrease to 80.0 percent.

Exhibit 9-1

Projected Changes in 2024 Highway Physical Conditions Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in Average IRI	Percent of VMT on Roads with		
Total	HERS-Derived Component*		IRI<95	IRI<170	Funding Level Description
			45.2%	**84.8%**	**2004 Values**
$131.7	$90.9	-21.1%	68.3%	92.5%	Maximum Economic Investment scenario
$123.6	$85.1	-19.3%	67.3%	91.7%	
$116.6	$80.1	-17.9%	66.6%	90.9%	
$102.6	$70.1	-13.3%	64.0%	88.6%	
$89.7	$60.9	-8.6%	61.3%	86.4%	
$78.8	$53.1	-2.5%	57.7%	83.6%	Cost to Maintain scenario
$75.8	$50.1	**0.0%**	56.1%	82.5%	**Average IRI Maintained**
$70.3	$44.7	5.4%	52.6%	80.0%	Actual 2004 Capital Outlay

* 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.

Source: Highway Economic Requirements System.

Impact of Future Investment on Highway Operational Performance

Exhibits 9-2 and *9-3* show how several indicators of highway operational performance would be affected at various levels of spending. The first of these is average speed of highway vehicles, a simple measure of average traffic flow, which also corresponds to one of the two transit performance measures used in the Transit Economic Requirements Model (TERM). Exhibit 9-2 indicates that an average annual investment of $89.7 billion would be sufficient to maintain average highway speeds at their 2004 level of 43.0 miles per hour. This dollar amount is higher than the amount identified as the Cost to Maintain Highways and Bridges, at which investment level the average speed would drop by 0.3 mile per hour. At the Maximum Economic Investment level of spending, average speeds would increase to 44.0 miles per hour.

The next two indicators show the estimated percentage of VMT occurring on roads with peak volume-to-service-flow (capacity) ratios above 0.80 and above 0.95. As indicated in Chapter 4, these levels are generally used to describe congested and severely congested operating conditions on highways, respectively. If 2004 highway spending levels were maintained in constant dollar terms through 2024, the percentage of VMT on congested roads would be projected to increase from 23.7 percent to 36.4 percent, while the percentage on severely congested roads would increase from 13.3 percent to 19.1 percent. The percentage of VMT on congested roads would be projected to increase (to 29.5 percent) even at the Maximum Economic Investment level, while the percentage of VMT on severely congested roads would decline (to 10.4 percent).

For a potential capacity improvement to be included in a particular HERS scenario, the improvement must meet the minimum benefit-cost ratio (BCR) test associated with that scenario. 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 which do not merit capacity expansion in HERS. The results in Exhibit 9-2 indicate that HERS is generally finding capacity improvements on severely congested roads to be more cost-beneficial than those on moderately congested routes, and is targeting investment accordingly.

Exhibit 9-2

Projected Changes in 2024 Highway Operational Performance Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Average Speed (mph)	Impact of HERS-Derived Investment on Roads Modeled in HERS		
			Percent of VMT on Roads with		
Total	HERS-Derived Component *		V/SF>.80	V/SF>.95	Funding Level Description
		43.0	23.7%	13.3%	**2004 Values**
$131.7	$90.9	44.0	29.5%	10.4%	Maximum Economic Investment scenario
$123.6	$85.1	43.9	29.9%	11.3%	
$116.6	$80.1	43.7	30.6%	12.3%	
$102.6	$70.1	43.4	32.4%	13.9%	
$89.7	$60.9	**43.0**	33.9%	15.9%	**Average Speed Maintained**
$78.8	$53.1	42.7	35.3%	17.7%	Cost to Maintain scenario
$75.8	$50.1	42.5	35.5%	18.1%	
$70.3	$44.7	42.3	36.4%	19.1%	Actual 2004 Capital Outlay

* 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.
V/SF = volume/service flow ratio

Source: Highway Economic Requirements System.

Exhibit 9-3 shows how the HERS projections of average delay per VMT would change at different funding levels, including separate projections for congestion delay and incident delay. HERS calculates these values as part of its determination of average speed and travel time costs. HERS estimates that an average annual expenditure level of $89.7 billion would be sufficient to maintain average total delay per VMT at 2004 levels. At current spending levels, average total delay would be projected to increase by 7.9 percent, while spending at the Maximum Economic Investment level would result in a decrease of 10.6 percent.

The impacts on congestion delay and incident delay at various funding levels differ somewhat. Congestion delay would be projected to decrease at higher funding levels, but would increase at lower investment levels, reaching 20.8 percent if spending remains at the 2004 level of $70.3 billion in constant dollar terms. Incident delay, however, would be projected to decrease at all funding levels, with significant reductions of over 30 percent at the Maximum Economic Investment level, and would increase slightly only at current spending levels. At the Maintain User Costs level, congestion delay would be projected to increase 14.2 percent, while incident delay would decrease by 7.8 percent. The level of future investments in operations and intelligent transportation systems assumed in these scenarios is expected to have a greater impact on reducing delay caused by incidents, making it possible to reduce average incident delay per VMT even at lower levels of funding.

It should be noted that these estimates are for average delay per VMT. Since highway travel is projected to increase over time under all of these scenarios, total hours of delay would likewise be expected to increase.

Exhibit 9-3

Projected Changes in 2024 Highway Travel Delay Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component *	Total Delay per VMT	Congestion Delay per VMT	Incident Delay per VMT	Funding Level Description
$131.7	$90.9	-10.6%	-6.4%	-30.4%	Maximum Economic Investment scenario
$123.6	$85.1	-9.2%	-4.3%	-28.4%	
$116.6	$80.1	-7.3%	-1.5%	-25.1%	
$102.6	$70.1	-4.4%	2.8%	-20.4%	
$89.7	$60.9	0.0%	9.1%	-13.3%	
$78.8	$53.1	3.4%	14.2%	-7.8%	Cost to Maintain scenario
$75.8	$50.1	4.8%	16.2%	-5.7%	
$70.3	$44.7	7.9%	20.8%	-0.6%	Actual 2004 Capital Outlay

* 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.

Source: Highway Economic Requirements System.

Impact of Future Investment on Highway User Costs

The HERS model defines benefits as reductions in highway user costs, agency costs, and societal costs. Highway user costs are composed of travel time costs, vehicle operating costs, and crash costs. The HERS-derived portion of the "Cost to Maintain Highways and Bridges" scenario in Chapter 7 was based on maintaining average total user costs at 2004 levels. The analysis presented there estimates that an average annual investment of $78.8 billion in constant 2004 dollars for the period 2005 through 2024 would be sufficient to maintain highway user costs at their baseline 2004 levels.

Exhibit 9-4 describes how average total user costs, travel time costs, and vehicle operating costs are influenced by the total amount invested in highways. The overall average crash costs calculated by HERS do not vary significantly at different investment levels.

While an average annual highway investment of $78.8 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would rise by 0.7 percent, while average vehicle operating costs would fall by the same percentage. Average vehicle operating costs would increase at current funding levels, while travel time costs would decrease at annual average funding levels of $89.7 billion or higher.

Estimates of total user costs vary at different levels of future investment, rising by 1.1 percent at the current spending level and falling 2.8 percent at the Maximum Economic Investment level. Travel time costs show slightly greater variation, ranging from a 2.0 percent increase at current funding levels to a 3.1 percent decrease at the Maximum Economic Investment level.

Exhibit 9-4

Projected Changes in 2024 Highway User Costs Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component *	Total User Costs	Travel Time Costs	Vehicle Operating Costs	Funding Level Description
$131.7	$90.9	-2.8%	-3.1%	-3.1%	Maximum Economic Investment scenario
$123.6	$85.1	-2.5%	-2.7%	-2.9%	
$116.6	$80.1	-2.2%	-2.3%	-2.7%	
$102.6	$70.1	-1.6%	-1.4%	-2.1%	
$89.7	$60.9	-0.8%	-0.3%	-1.5%	
$78.8	$53.1	**0.0%**	0.7%	-0.7%	**Cost to Maintain scenario**
$75.8	$50.1	0.4%	1.1%	-0.3%	
$70.3	$44.7	1.1%	2.0%	0.4%	Actual 2004 Capital Outlay

* 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.

Source: Highway Economic Requirements System.

Q&A

What is the significance of the relatively small changes in user costs presented in Exhibit 9-4?

While the projected changes in user costs at different investment levels are small in percentage terms, it is important to note that they are being applied to all travel on functional classes analyzed by HERS. While the 2.8 percent reduction in average user costs per VMT under the "Maximum Economic Investment" scenario appears relatively low, by the year 2024 it would translate into annual user costs savings of approximately $116 billion, based on projected future VMT under that scenario.

If spending were maintained at 2004 levels in constant dollar terms, and average user costs per VMT rose by 1.1 percent, by 2024 this would translate into additional user costs of approximately $45 billion per year, based on the projected future VMT at this level of investment.

To understand the significance of the relative size of these percentage changes, it is important to recognize that the total user costs and total travel time costs presented in this report include all travel time, not just the additional travel time that results from congestion. Most 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 thus a limit on the ability of highway investment to cause dramatic reductions in this key component of user costs.

The percent change in user costs shown in Exhibit 9-4 is 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, 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.

Another important consideration is that the values reported in Exhibit 9-4 are for the economic costs associated with highway conditions and performance, and do not include user charges such as fuel taxes, motor-vehicle fees or tolls. As discussed in the "Introduction" to Part II and in Chapter 7, a key addition to the HERS analysis for this edition of the report is to connect increases in investment above base year 2004 levels with increases in user revenues to pay for them. As a result, actual user expenditures (including both user costs and user charges) would be higher in 2024 at the Maintain User Cost level than in 2004.

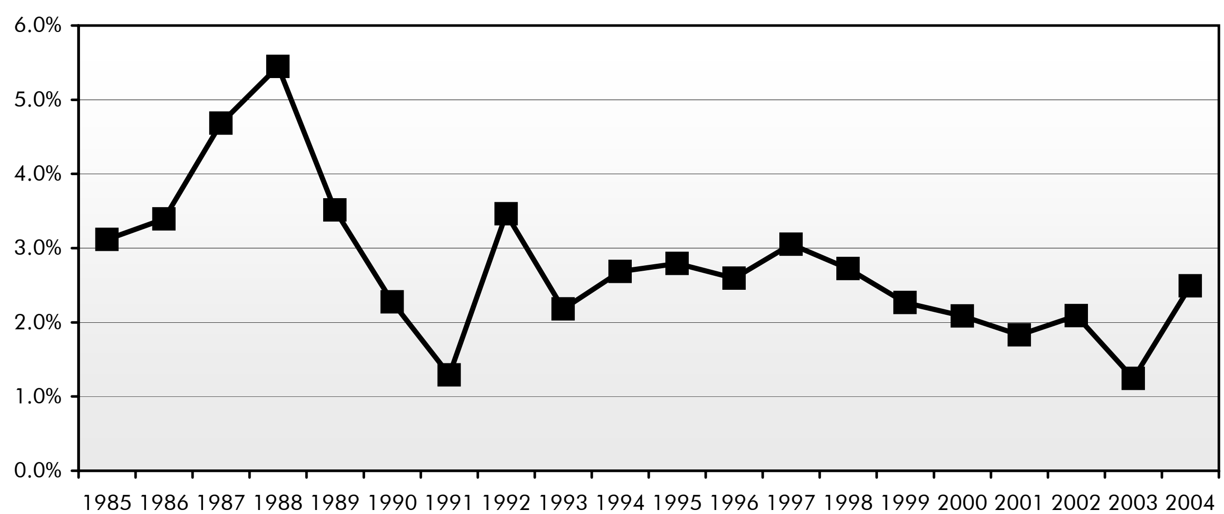
Impact of Future Investment on Travel Growth

Historic Travel Growth

From 1984 to 2004, annual highway VMT grew from 1.73 trillion to 2.98 trillion, an average annual growth rate of 2.76 percent. As shown in *Exhibit 9-5*, however, travel growth has varied somewhat from year to year, ranging from a high of 5.45 percent in 1988 to a low of 1.24 percent in 2003. 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. VMT growth was below average during recessions in the early 1990s and early 2000s, while annual VMT growth was higher than 3 percent in every year from 1985 through 1989. Exhibit 9-5 shows that travel grew more slowly during the economic expansion of the 1990s than in the 1980s, reflecting a long-term trend toward lower VMT growth rates.

Exhibit 9-5

Annual VMT Growth Rates, 1984 to 2004



Source: Highway Performance Monitoring System.

Travel Growth Forecasts

The Highway Performance Monitoring System (HPMS) data supplied by the States and used as the primary input in HERS include 20-year forecasts of future highway travel. The weighted average annual growth rate for all sample sections based on these forecasts in the 2004 data is 1.92 percent, which is significantly lower than the average growth rate over the prior 20 years. Projected growth in rural areas (2.15 percent average annual) is somewhat higher than in urban areas (1.79 percent). *Exhibit 9-6* shows projected year-by-year VMT for the period 2004 to 2024 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.

Exhibit 9-6

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)
2004 (actual)	**2,982**	**2,982**
2005	3,051	3,039
2006	3,120	3,098
2007	3,189	3,157
2008	3,258	3,218
2009	3,327	3,279
2010	3,396	3,342
2011	3,465	3,406
2012	3,533	3,472
2013	3,602	3,538
2014	3,671	3,606
2015	3,740	3,675
2016	3,809	3,746
2017	3,878	3,818
2018	3,947	3,891
2019	4,016	3,965
2020	4,085	4,042
2021	4,154	4,119
2022	4,223	4,198
2023	4,292	4,279
2024	**4,361**	**4,361**

Source: Highway Performance Monitoring System.

As discussed in Chapter 7, HERS predicts that the level of investment in highways will affect future VMT growth. 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

Q&A

Do the travel demand elasticity features in HERS differentiate between the components of user costs based on how accurately highway users perceive them?

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 cost.

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.

transportation, or forgoing some trips entirely. The model also assumes that reducing user costs (see above) 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.

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 [*see Exhibit 9-4*], they will 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. The HERS assumes that the HPMS forecasts represent the level of travel that would occur if a constant level of service were maintained. As indicated in Chapter 7, 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.

The assumption that the HPMS travel forecasts implicitly represent a constant price is supported by recent research done on behalf of the Federal Highway Administration (FHWA), which created a year-by-year forecast for future VMT at the national level based on forecasts of demographic and economic variables. The forecasts made by this model, which does not incorporate any information on future levels of service, imply an average annual VMT growth rate that is generally similar to the baseline growth rate implicit in the HPMS data.

Another feature of HERS, newly introduced for this report, links investment levels to highway user revenues. Specifically, the model assumes that increases in highway capital expenditures above base year levels will be accompanied by increases in highway user fees to cover them. This "surcharge," operating through the HERS travel demand elasticity procedures, will thus tend to limit future travel growth at higher levels of investment. See Chapter 7 and Appendix A for more on this feature of HERS.

Travel Growth and Investment

Exhibit 9-7 shows how the effective VMT growth rates in HERS are influenced by the total amount invested in highways, and the location of highway improvements in urban and rural areas.

If average annual highway and bridge capital outlay were to rise to $78.8 billion in constant 2004 dollars, HERS predicts that overall highway user costs in 2024 would remain at 2004 levels. The "Maintain User Costs" scenario derived from HERS attempts to maintain the average user costs at the end of the 20-year analysis period for the entire highway system, but user costs can vary on individual functional classes and on individual highway sections and in intermediate years. Importantly, the estimated user costs targeted in this scenario also do not include fuel taxes and other highway user fees. Since these fees automatically rise as funding levels in the HERS analysis are increased above base-year expenditures, they will tend to suppress some travel that might otherwise have occurred. This effect largely accounts for the fact that projected average annual VMT growth rates at this level of investment are slightly lower than those derived from the baseline HPMS data.

Exhibit 9-7

Projected Average Annual VMT Growth Rates, 2005–2024, for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Average Annual VMT Growth			
Total	HERS-Derived Component *	Total	Rural	Urban	Funding Level Description
		1.92%	**2.15%**	**1.79%**	**HPMS Baseline VMT Projection**
$131.7	$90.9	1.94%	2.08%	1.86%	Maximum Economic Investment scenario
$123.6	$85.1	1.91%	2.07%	1.83%	
$116.6	$80.1	1.91%	2.06%	1.82%	
$102.6	$70.1	1.90%	2.07%	1.81%	
$89.7	$60.9	1.89%	2.08%	1.78%	
$78.8	$53.1	1.88%	2.10%	1.77%	Cost to Maintain scenario
$75.8	$50.1	1.87%	2.09%	1.75%	
$70.3	$44.7	1.86%	2.09%	1.73%	Actual 2004 Capital Outlay

* 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.

Source: Highway Economic Requirements System

Implementing all of the cost-beneficial highway investments in the $131.7 billion "Maximum Economic Investment" scenario would reduce user costs overall, but these would again be offset to some degree by the increases in user fees that HERS assumes would be levied to fund this higher level of investment. In urban areas, the net impact of this is lower user expenditures (user costs plus user fees), resulting in higher travel growth rates in urban areas than are currently projected in HPMS. In rural areas, the net impact is an increase in user expenditures, leading to lower travel growth rates relative to the HPMS baseline.

In 2004, all levels of government spent $70.3 billion for highway capital outlay, corresponding to the "Actual 2004 Capital Outlay" row in Exhibit 9-7. At this level of investment, there are no increased user fees levied by HERS, so the only impact on travel growth is through user costs. If average annual investment remains at this level in constant dollar terms over the next 20 years, HERS projects that the increase in user costs would limit average annual VMT growth to 1.86 percent, somewhat below the baseline forecasts in HPMS.

While there is some variation in forecast future travel growth rates at different levels of investment, this range is relatively narrow, from 1.86 percent to 1.94 percent on an average annual basis. This again is largely a function of the procedures in HERS for assessing user fees to fund increased investment levels, in concert with the HERS travel demand elasticity procedures. VMT is projected to grow to between 4.3 trillion and 4.4 trillion by 2024 under all the investment scenarios (as well as under the HPMS baseline).

Impact of Investment on the Bridge Investment Backlog

Chapter 7 projects that funding bridge investments at approximately $12.4 billion annually over a 20-year period would eliminate the existing backlog and correct other deficiencies that are expected to develop by 2024, where it is cost-beneficial to do so. This is the "Maximum Economic Investment" scenario. Chapter 7 also projects that funding bridge investments at approximately $8.7 billion annually would ensure that the cost of addressing all bridge deficiencies in 2024 would remain the same as in 2004. This is the "Maintain Economic Backlog" scenario.

Exhibit 9-8 shows projected changes in the bridge backlog for different funding levels. The existing backlog is estimated at approximately $65.3 billion. If investment over the 20-year period were limited to $5.9 billion per year, the backlog would rise to $120.7 billion. If bridge investment were maintained at the 2004 funding level in constant dollars ($10.5 billion), the bridge backlog would be projected to decrease by 47 percent, to approximately $34.5 billion.

Exhibit 9-8

Projected Changes in 2024 Bridge Investment Backlog Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)	Backlog	Percent Change from 2004	Funding Level Description
12.4	0.0	-100.0%	Maximum Economic Investment scenario
11.1	21.4	-67.2%	
10.5	34.5	-47.2%	2004 Spending on Existing Bridges*
9.4	53.6	-17.8%	
8.7	65.3	**0.0%**	**Maintain Economic Backlog**
8.2	75.2	15.2%	
7.0	97.8	49.8%	
5.9	120.7	84.9%	

* Includes spending on rehabilitation and reconstruction of existing bridges. Excludes construction of new bridges.

Source: National Bridge Investment Analysis System.

Transit Investment Impacts

This section first summarizes the effects of historical transit spending on current transit physical conditions and operating performance as experienced by passengers. It then examines the impact on transit asset conditions at the end of the forecast period in 2024, if future rehabilitation and replacement spending were to be lower than the maintain condition investment levels estimated by TERM. The section concludes with estimates of the effect of transit investment to improve performance on ridership.

Current Impacts

Physical Conditions

Funding levels between 2002 and 2004 have been adequate to maintain conditions. Total capital investment increased from $12.3 billion in 2002 to $12.6 in 2004. Bus vehicle conditions were about the same, declining marginally from an average of 3.09 in 2002 to 3.08 in 2004 within the adequate condition category. Over the same time period, the average age of a bus vehicle declined from 6.2 to 6.1 years. Average rail vehicle conditions improved from 3.47 in 2002 to 3.50 in 2004, and the average vehicle age declined from 20.4 to 19.7 years. Facility conditions have improved. The average bus facility condition increased from 3.34 in 2002 to 3.41 in 2004, and the average rail facility condition increased from 3.56 to 3.82. The average condition of stations (bus and rail) also increased from 2.99 in 2002 to 3.43 in 2004. The average condition of elevated structures increased from 4.27 in 2002 to 4.31 in 2004, the average condition of underground tunnels increased from 4.09 to 4.23, the average condition of track increased from 4.17 to 4.27, and the condition of yards increased from 3.64 to 3.80.

Operating Performance

Funding levels between 2002 and 2004 have been sufficient to maintain performance. There was a slight increase in the average speed of passengers traveling on transit between 2002 and 2004 from 19.9 to 20.1 miles per hour. The average speed of passenger travel on rail modes decreased from 25.3 miles per hour in 2002 to 25.0 miles per hour in 2004, and the average speed as experienced by passengers on bus modes increased from 13.7 to 14.0 miles per hour.

Future Impacts

Constrained Rehabilitation and Replacement Expenditures

Exhibit 9-9 shows the effect on transit asset conditions of reducing rehabilitation and replacement expenditures below the level estimated by the Transit Economic Requirements Model (TERM) under the "Maintain Conditions" scenario. This TERM analysis pertains to agencies covered by the National Transit Database (NTD) and therefore excludes rural and special service needs and the effect of spending constraints on asset conditions for these public transportation providers. Note that under the "Maintain Conditions" scenario TERM estimates the amount of investment that will make the average asset condition in 2024 the same as the average asset condition that existed in 2004 for all assets combined. The condition of each asset category, however, may be slightly different in 2024 than in 2004. As discussed in Chapter 7, the investment estimated by TERM to maintain conditions, which is provided in this report, assumes that an average condition of 3.6 will be reached in 2024, compared with an average condition of 3.9 in 2004. To reach an average condition of 3.9 in 2024 would require including replacement expenditures in the

Exhibit 9-9

Effect of Capital Spending Constraints on Transit Condition Estimates

	2004 Condition	Percent of TERM Estimates of Rehabilitation and Replacement Expenditures to Maintain Conditions			
Asset Type		**100%**	**90%**	**80%**	**70%**
Guideway Elements	4.4	4.1	4.0	4.0	3.9
Facilities	3.6	3.2	2.9	2.9	2.9
Systems	3.9	3.7	3.7	3.5	3.4
Stations	3.4	3.1	3.1	3.1	3.1
Vehicles	3.4	3.4	3.3	3.3	3.1
All Assets	**3.9**	**3.6**	**3.5**	**3.5**	**3.4**
Rehabilitation and Replacement Expenditure Scenarios*		$9.36	$8.89	$7.91	$6.92

*Excludes rural vehicles and facilities.

investment estimate total for some assets that will not need replacement, i.e., their conditions will not fall below their estimated replacement thresholds during the 20-year forecast period.

If the amount estimated by TERM under the "Maintain Conditions" scenario for the rehabilitation and replacement of transit assets in urban areas is reduced by 10 percent, from $9.88 billion annually to $8.89 annually, the average condition of transit assets is estimated by TERM to fall from 3.9 in 2004 to 3.5 in 2024. If the amount estimated by TERM (for the rehabilitation and replacement of transit assets in urban areas) is reduced by 30 percent, to $6.92 billion, TERM estimates that average asset conditions would fall to 3.4 in 2024.

Ridership Response to Investment

TERM considers, in its benefit-cost analysis, the effect of transit capital investment on user costs and the effect of the change in these costs on transit ridership. Transit user costs are composed of out-of-pocket costs and travel-time costs. Travel time-savings are realized in two ways, by adding new or expanding existing rail or bus rapid transit (BRT) service, or by adding vehicles to reduce crowding. Out-of-pocket savings occur when passengers switch from automobiles to transit.

The TERM estimates for improving performance in urban areas are $5.17 billion annually (compared with $6.52 billion annually in the 2004 report). Of this amount, $2.01 billion annually would be for asset expansion in new rail or BRT service to increase speed and $3.16 billion annually would be for asset expansion in new vehicles to reduce occupancy levels. The average increase in ridership estimated to result from speed improvements achieved by expanding or building new rail or BRT system capacity is 22.9 million passengers annually; the average increase in ridership estimated to result from decreasing occupancy levels by adding new vehicles is 51.6 million passengers annually. [Note the total amount estimated by TERM to improve performance is $5.2 billion annually. The additional investment to improve performance represents the cost of increasing the rural transit fleet by 3.5 percent per year.]

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 less than 1 percent decrease or increase, respectively, in the number of transit riders. The percentage change in ridership resulting by 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).

CHAPTER 10

Sensitivity Analysis

Summary

This chapter explores the effects of varying some of the assumptions that were used to develop the investment scenario projections in Chapter 7. In any modeling effort, evaluating the validity of the underlying assumptions is critical. The results produced by the Highway Economic Requirements System (HERS) and the Transit Economic Requirements Model (TERM) are strongly affected by the values they are supplied for certain key variables. 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.

The first part of this chapter addresses the impacts that aggressive congestion reduction strategies could have on the future investment scenario estimates. Two alternatives involving intelligent transportation systems (ITS) and operations strategies are developed. The first assumes a more aggressive deployment schedule than the one assumed in the baseline scenarios, which was based on existing trends. The second is a hypothetical scenario that assumes full, immediate deployment, illustrating the maximum impact that the technologies and strategies modeled in HERS would be expected to have. The third illustrative scenario assumes the universal application of efficient pricing on all congested roads. By aligning the costs borne by highway users with the costs they impose on other users, such policies can encourage the more efficient use of the transportation system.

One of the major enhancements to the HERS modeling process in this report is to account for the amount of additional revenue that would be required to support higher levels of investment. The chapter shows the impact of this new feature, as well as the impact of accounting for work zone delay, a new type of user impact in HERS that was introduced in the 2004 edition.

There is some uncertainty about the 20-year travel growth forecasts on which HERS and TERM rely. The highway and transit sections both show the impact of changing assumptions about growth rates on the investment scenario projections. Highway investment scenario estimates are shown for an alternative in which baseline constant-price future highway travel growth rates match those observed over the last 20 years. The sensitivity of the transit investment scenario estimates to the growth rate forecast is analyzed by allowing three alternative growth rate inputs: 50 percent higher than the forecast, 50 percent below the forecast, and 100 percent below the forecast (i.e., zero transit passenger-mile growth). Transit investment scenarios are also calculated using the 1.5 percent passenger miles traveled (PMT) forecast in the 2004 C&P report.

The chapter also includes other sensitivity analyses that show the impact of using alternative values for certain key model parameters (whose estimated values may be subject to some uncertainty). Both the highway and transit sections analyze the impact of increasing the unit improvement costs in the three investment models by 25 percent, as well as the effects of variations in the value of time and travel demand elasticity. The highway section also considers alternative values for additional parameters, including the value of a statistical life and the value of reducing incident delay. The transit section looks at the effect of making performance-enhancing investments in light rail instead of in bus rapid transit (BRT), and at changing the replacement threshold for guideway (a revision made for this report).

Highway Sensitivity Analysis

The accuracy of the investment scenario estimates reported in Chapter 7 depends on the validity of the underlying assumptions used to develop the analysis. This section explores the effects that varying several key assumptions in the highway investment analysis process would have on the Maximum Economic Investment (Cost to Improve Highways and Bridges) and the Cost to Maintain Highways and Bridges. While not discussed directly in this chapter, any changes in the projected investment scenarios would also affect the gaps identified in Chapter 8 between projected spending and the investment scenario levels.

Aggressive Congestion Reduction Strategies

As described in Chapter 7, the HERS analysis considers the impact of current and future ITS deployments and operations strategies on highway conditions and performance, with resulting implications for the projected investment scenario levels. The analyses of Chapters 7, 8, and 9 used a baseline scenario for future deployments based on existing trends. Chapter 7 and Appendix A include more information on the types of strategies and investments reflected in the existing trends deployment scenario, which include those targeted at freeway management (ramp metering, electronic monitoring, variable message signs, and traffic management centers), incident management (incident detection, verification, and response), and arterial management (upgraded signal control, electronic monitoring, variable message signs, and emergency vehicle signal preemption).

The baseline scenarios assume the continuation of existing financing structures. As a result, the inherent economic inefficiencies of the current structure would remain, whereby travel on uncongested facilities is charged at the same rate as those with significant congestion issues. In an ideal (from an economic point of view) world, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another, thereby reducing peak traffic volumes and increasing net benefits to all users combined.

The analyses in this section explore the impact that alternative assumptions about future ITS deployments and more efficient pricing could have on the baseline investment analysis results.

Operations/ITS Deployment

Exhibit 10-1 shows the impact of two alternative operations and ITS deployment scenarios: one with more aggressive assumptions about future deployments, 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.

The aggressive operations/ITS deployment scenario assumes that existing trends in the adoption of ITS infrastructure and strategies would accelerate in the future. The impact of increasing the rate at which such technologies are adopted in the future would be to decrease the estimated infrastructure investment necessary to maintain conditions and performance at current levels by approximately $1.9 billion per year under this particular scenario. While this reduction is small in overall percentage terms (2.4 percent of the total Cost to Maintain Highways and Bridges), it should be considered that the impacts are concentrated on capacity investments in urbanized areas. In 2004, such investments accounted for just one-fifth of total highway capital outlay.

Exhibit 10-1

Impact of Aggressive Congestion Reduction Strategies on Investment Scenario Estimates

	Cost to Maintain Highways & Bridges		Maximum Economic Investment for Highways & Bridges	
	($Billions)	Percent Change	($Billions)	Percent Change
Chapter 7 Baseline	**$78.8**		**$131.7**	
Aggressive Operations Deployments	$76.9	-2.4%	$131.1	-0.5%
"Full" Operations Deployments	$73.6	-6.6%	$131.9	0.1%
"Universal" Congestion Pricing	$57.2	-27.5%	$110.8	-15.9%

Source: Highway Economic Requirements System (HERS).

Q&A

What are the costs associated with the aggressive deployment strategy analyzed here, relative to those for the baseline existing trends deployment strategy?

As described in Chapter 7, the costs of the new or increased operations deployments 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 under the aggressive deployment strategy used for these analyses is $590 million (in 2004 dollars). These costs are included in the capital investment scenario estimates based on the aggressive deployment strategy shown in Exhibit 10-1 for both the "Cost to Maintain" and "Maximum Economic Investment" scenarios. As described in Chapter 7, the comparable figure for the baseline existing trends deployment strategy was $94 million per year.

Estimated average annual operating and maintenance costs for the aggressive deployment strategy over the same 2005 to 2024 time period are $3.2 billion (in 2004 dollars), including $890 million for new deployments and $2.3 billion for the existing infrastructure. These costs **are not** included in the Cost to Maintain or the Maximum Economic Investment figures in Exhibit 10-1. As described in Chapter 7, the comparable figure associated with the baseline existing trends strategy was $2.7 billion, including $260 million for new deployments and $2.5 billion for the existing infrastructure.

Note also that the costs shown above reflect only the particular types of improvements currently modeled in HERS, and thus represent a subset of total operations deployments that are expected to occur. This analysis attempts to capture other capital costs relating to operations control facilities via the external adjustment procedure for non-modeled improvement types discussed in Chapter 7.

The average annual capital cost of new deployments under the hypothetical full deployment scenario would be $1.2 billion. However, as this scenario assumes the immediate and complete deployment of all ITS technologies and operations strategies, these costs would be entirely front loaded at the beginning of the analysis period.

The aggressive scenario does not have as significant an impact on the Maximum Economic Investment relative to that based on existing trends, reducing that level by less than 1 percent. While ITS deployments would in some cases reduce the benefit-cost ratio (BCR) of certain potential widening projects below the 1.0 threshold imposed by this scenario, in other cases, both an ITS deployment and a widening project would be cost-beneficial. Consequently, the level of performance that HERS finds cost-beneficial to achieve would be significantly better under the aggressive scenario than under the baseline trends scenario. Average highway user costs would be lower than under the existing trends scenario, representing additional annual savings of $10 billion by 2024 ($126 billion in annual savings relative to 2004, compared with $116 billion under the existing trends scenario). Incident delay costs on urban arterials and collectors would be reduced by another 2.9 percent (and by 5.4 percent on urban Interstates) relative to the baseline scenario, even though the overall level of investment is lower.

The "full deployment" scenario illustrates the maximum impact that the types of strategies and technologies modeled in HERS could have on the future investment scenario estimates. Deploying ITS to the fullest extent would have a strong impact on the Cost to Maintain Highways and Bridges, reducing it by $5.2 billion (6.6 percent). While the Maximum Economic Investment level with full deployment is essentially the same as for the baseline scenario, the impact on highway conditions and performance is even greater than under the aggressive deployment scenario. Annual highway user cost savings in 2024 would be $27 billion more than under the baseline scenario ($144 billion in annual savings compared with 2004), and incident delay costs on all arterials and collectors in urban areas would be reduced by 4.1 percent (6.9 percent on urban Interstates).

Congestion Pricing

As referenced throughout this report, the baseline investment scenarios assume the continuation of existing financing structures, under which user fees are typically assessed on a per-mile (or per-gallon) basis. As a result, highway users are typically charged the same amount, regardless of where or at what time of day they travel. As discussed in the Introduction to Part II, this can contribute to overuse of the transportation system, since users of congested roads are paying the same rate as those on uncongested routes. The efficiency of the system could be improved by imposing congestion-based tolls, which could 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 HERS model has recently been modified to simulate the imposition of optimal congestion pricing on congested roadways. Preliminary results from these new procedures are shown in Exhibit 10-1. There are numerous caveats that should be understood when interpreting these results. The scenario should be considered to show the impact that optimal, universal congestion pricing could have on the investment scenario estimates. **This theoretical scenario does not constitute a comprehensive policy proposal.** The analysis does not account for the substantial startup and administrative costs that could be associated with deploying congestion pricing on a universal basis, which could vary widely depending on the type of technology adopted to collect them. The congestion tolls applied in the analysis would be

Q&A

What are the limitations of the preliminary HERS pricing analysis presented in this section?

The primary limitation of the analysis is that it assumes that efficient prices could be charged universally, on all functional classes, during the entire analysis period. As discussed in the Introduction to Part II, a number of barriers exist to the implementation of a perfectly efficient congestion pricing system in the real world. Calculating and collecting tolls impose costs on both operators and users of a toll facility, and achieving the true optimum would require both a comprehensive knowledge of user demand and the ability to continuously monitor congestion and dynamically adjust the fees that motorists are charged.

The current state and extent of pricing technology and infrastructure are also limited. Variable tolling systems are much more practical at bridges, tunnels, or on freeways; deploying such systems on surface arterials and collectors, with numerous access points and intersecting traffic, would be much more challenging, depending on the type of technology used. However, new technologies are being developed and considered that could make more widespread adoption of such approaches more practical in the future.

The analysis is also limited by the current HERS modeling framework. The model treats highway segments independently and does not account for the full general-equilibrium impacts of pricing on interconnected roadways. Additional refinements would also be required to more completely model the shifting of demand between time periods.

Q&A

How high are the congestion tolls being imposed by HERS in the analysis described in this section, and what would be the associated revenues?

The average congestion toll calculated by HERS on highway sections where it is applied is 20.5 cents per mile for the "Maintain" scenario and 17.4 cents per mile for the "Maximum Economic Investment" scenario. On some extremely congested sections, the optimal congestion tolls can be considerably higher, while the optimal congestion tolls would be lower on less congested sections. No congestion tolls were applied to uncongested highway sections. The estimated annual revenues produced by the congestion tolls are approximately $34 billion for the "Maintain" scenario and $24 billion for the "Maximum Economic Investment" scenario. Average toll rates and annual revenues would be higher in the latter portions of the 20-year analysis period, as baseline traffic levels increase and contribute to congestion.

The larger average tolls and revenues under the "Maintain User Cost" scenario reflect the fact that higher tolls are required at lower levels of highway investment to suppress travel to the point that user costs would be maintained. Congestion would be higher under this scenario, so that drivers have larger negative impact on each other. For the "Maximum Economic Investment" scenario, the additional capacity expansion at the higher investment levels result in reduced congestion, so that drivers' impact on each other is not as severe, and thus the efficient congestion toll rates are lower.

As is noted in the text, the investment analysis with congestion pricing applied were not revenue constrained, as in the baseline analysis. However, this analysis suggests an important dichotomy between the revenues that would be produced under congestion pricing and revenues that would be generated from user fees to fund increased investment levels; in fact, the two are in some sense counter to one another. Lower levels of investment would require smaller user fee charges, but would result in more congestion and thus higher efficient congestion tolls and revenues. Higher levels of investment would require larger user fee charges, but congestion levels, toll rates, and revenues would be lower. While revenues from congestion pricing would be available to finance capital investment, they are not explicitly intended for that purpose, and this is reflected in the efficient toll rates that would be applied in this analysis.

in addition to any current user taxes and fees; they do not substitute for existing fees. This analysis represents an initial attempt at quantifying some of the impacts of congestion pricing; future research is planned to refine this analysis to more explicitly consider time of day demand shifts and to better account for some of the network effects among parallel or intersecting routes. However, there will always be limits on how well a segment-based model such as HERS can model these effects (see the discussion of this topic in the Part IV Afterword).

The results of this hypothetical HERS analysis shown in Exhibit 10-1 indicate that **universal congestion pricing would have a very significant impact** on the investment scenario estimates. The Maximum Economic Investment level would decrease by almost 16 percent, to $110.8 billion. The estimated "gap" between this scenario and 2004 highway capital outlay would be reduced to 57.7 percent. The Cost to Maintain Highways and Bridges would decline even more proportionally, by over 27 percent, to $57.2 billion. This level of investment is well below 2004 capital spending.

While this analysis uses a theoretical, idealized construct (universal pricing at economically efficient levels) and may thus potentially overstate the impact to some degree, it nevertheless indicates that pricing, in conjunction with operations strategies and other highway investment, has a very important and potentially substantial role to play in addressing highway congestion. Future refinements planned for this line of analysis could result in either higher or lower estimates of the impacts shown in this initial attempt at modeling congestion pricing in the C&P report.

Impact of Recent Model Enhancements

As new capabilities and enhancements are made to the C&P analytical tools in each report, it is useful to document the impact that these new features have on the investment scenario estimates. A new HERS feature introduced in this report links highway revenues with highway investment. The investment scenario estimates in the 2004 C&P report included the effects of work zone delay in the estimates of user benefits. However, since that report did not document the impact of this feature, such an analysis is included here.

Linking Revenue and Investment

One of the primary changes to the highway investment methodology is to link the investment analyses to the revenues that would be required to support such a level of investment. Chapter 7, Appendix A, and the Introduction to Part II have more extensive discussions of this feature, which assumes that increases in annual highway capital investment above base year 2004 levels would be financed through increases in highway user charges. By raising the cost of highway travel, such surcharges have the effect of reducing future travel growth and the level of investment required to support it.

Exhibit 10-2 shows the impact that this new feature has on the future investment estimates under the two scenarios presented in Chapter 7. "Turning off" the revenue option feature in HERS (thereby ignoring the link between revenue and investment) would increase the estimated Cost to Maintain Highways and Bridges by 2.6 percent ($2.1 billion). The impact on the "Maximum Economic Investment" scenario would be even larger, at 3.7 percent ($4.9 billion higher than the baseline scenario). As the "gap" between current spending and the level of investment under the scenarios increases, so does the level of the required user surcharge to align revenues and investment. As a result, the impact of this feature is proportionally greater at the Maximum Economic Investment level than at the Cost to Maintain level.

More information on this HERS feature is found in the Chapter 7, Appendix A, and the Introduction to Part II.

Exhibit 10-2

Impact of Recent Model Enhancements on Investment Scenario Estimates

	Cost to Maintain Highways & Bridges		Maximum Economic Investment for Highways & Bridges	
	($Billions)	Percent Change	($Billions)	Percent Change
Chapter 7 Baseline	**$78.8**		**$131.7**	
No Link between Revenue and Investment	$80.9	2.6%	$136.6	3.7%
No Work Zone Delay	$78.3	-0.6%	$133.5	1.4%

Source: Highway Economic Requirements System (HERS).

Work Zone Delay

For the 2004 C&P report, HERS was modified to consider the negative impact that work zones would have on existing users of the road, modeled as the delay (due to reduced capacity) associated with highway improvements. The work zone delay estimates are included as a negative user benefit in the HERS benefit-cost analysis. Appendix A of the 2004 C&P report contains more information on this feature.

"Turning off" this feature by removing it from the HERS BCR calculations has a modest impact on the scenario estimates. Exhibit 10-2 indicates that ignoring work zone delay impacts would increase the

Maximum Economic Investment level by 1.4 percent ($1.8 billion). Some marginal projects that are not cost-beneficial when accounting for work zone delay would become so if these effects were not included.

The estimated Cost to Maintain Highways and Bridges would decrease by 0.6 percent ($0.5 billion). Since all projects at this level of investment are well above the BCR threshold, turning work zone delay off does not result in any new projects being considered; instead, it affects only the relative ranking of potential improvements. The net impact of this is a slight shift toward capacity investment, which reduces the investment necessary to maintain user costs.

Alternative Model Assumptions

Using the HERS and National Bridge Investment Analysis System (NBIAS) models to produce the investment analyses for this report requires certain assumptions to be made concerning the nature of the data that are used and the way in which the analyses are structured internally in the models. Some of these key assumptions include the interpretation of the future travel forecasts in the data, the method used to "grow" traffic between the base year and the travel forecast year, and the temporal pattern of investment under the "Maximum Economic Investment" scenario.

Travel Growth and Price Forecasts

States provide forecasts of future vehicle miles traveled (VMT) for each individual Highway Performance Monitoring System (HPMS) sample highway section. As indicated in Chapter 7, 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 (exclusive of taxes and tolls) at 2004 levels. If HERS predicts that highway-user costs will deviate from baseline 2004 levels on a given highway segment, the model's travel demand elasticity features will modify the baseline VMT growth projections from HPMS. Appendix A includes more discussion of the travel demand elasticity features in HERS.

The HERS model utilizes VMT growth projections to predict future conditions and performance of individual highway segments and to analyze future investment. If the HPMS VMT forecasts *as modified by the HERS travel demand elasticity features* are overstated, the investment scenario projections may be too high. If travel growth is underestimated, the investment scenario estimates may be too low.

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 demand elasticity procedures in HERS don't accurately predict how highway users will respond to changes in costs. The latter effect is addressed in the next section by varying the values of the elasticity parameters used in the model. This section explores the impacts of the former case by modifying the estimates of future travel found in the HPMS sample data.

As indicated in Chapter 9, the State-supplied VMT growth projections in HPMS for 2004 to 2024 average 1.92 percent per year, well below the 2.76 percent average annual VMT growth rate observed from 1984 to 2004. The HERS model assumes that the 1.92 percent composite VMT growth projection in HPMS represents the growth that will occur at a constant level of service. As noted in Chapter 4, however, the level of service on highways in the United States 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 represent a declining level of service as well, and would thus understate future *constant price* growth, causing HERS to likewise underestimate the level of investment that would be needed to achieve a given level of performance.

It is thus prudent to consider the impact of such a circumstance on the Chapter 7 projections, and the historic growth rate provides a useful benchmark for comparison.

Exhibit 9-7 shows the impact of different levels of future investment on the average annual VMT growth rate, if one assumes that the baseline travel growth forecasts in HPMS represent a constant level of service. *Exhibit 10-3* shows the impact on the investment scenario estimates of assuming that the 20-year future growth in VMT that would occur at a constant level of service matches the growth over the previous 20 years, rather than using the baseline assumption that the constant-price growth would be in line with the HPMS forecasts. Modifying the travel growth projections in this fashion would increase the Cost to Maintain Highway and Bridges by 56.6 percent. Increased VMT would increase the rate of pavement deterioration, as well as increase the share of resources that HERS would recommend using for capacity expansion, to nearly 50 percent of total highway investment under this scenario. Both of these factors would tend to increase the investment that would be necessary to maintain user costs at 2004 levels.

The Maximum Economic Investment for Highways and Bridges would increase by 33.9 percent based on this change in assumptions. The increased travel would increase the number of pavement and capacity projects that HERS would find cost-beneficial.

Q&A

Can Exhibit 10-3 be used to analyze the impact that travel demand management policies (such as pricing) have on the investment scenario estimates?

No. Travel demand management (TDM) policies are intended to actively reduce the amount of highway usage in congested periods. Such policies accomplish this goal by directly or indirectly raising the cost of highway travel to users in order to alleviate excess demand and are often used as a means of addressing inefficiencies in the pricing of highway use (see the discussion in the Introduction to Part II). As discussed in Chapter 7, the travel demand elasticity feature of HERS is intended to capture the effect of increases or decreases in the price of travel on travel demand. This is not what the figures shown in Exhibit 10-3 represent, however. Rather, they simply convey the impact that different assumptions about future constant-price travel growth would have on the investment estimates and should thus not be used to make inferences about changes in VMT growth rates induced by TDM strategies.

More generally, Exhibit 10-3 should not be used to infer a direct linear relationship between a certain level of future VMT and future highway investment. This relationship is not linear, and the overall level of future travel nationwide is less critical than the spatial distribution of future travel growth. For example, large increases in VMT on uncongested highway sections would not impact the future investment scenario estimates as much as smaller increases in VMT on severely congested highway sections.

Another assumption concerning future travel growth that is made in the HERS analysis concerns the pattern of growth between the base year of the analysis and the future year of the travel forecasts in HPMS. The assumption used in the baseline scenarios is that growth

Exhibit 10-3

Impact of Alternate Model Assumptions on Investment Scenario Estimates

	Cost to Maintain Highways & Bridges		Maximum Economic Investment for Highways & Bridges	
	($Billions)	Percent Change	($Billions)	Percent Change
Chapter 7 Baseline	**$78.8**		**$131.7**	
Historic VMT Growth Rates	$123.5	56.6%	$176.4	33.9%
Geometric VMT Growth	$87.5	11.0%	$132.7	0.8%
Minimum BCR			$129.1	-2.0%

Source: Highway Economic Requirements System (HERS).

will occur at a constant annual level. This is sometimes referred to as *linear growth*. An alternative assumption would be that travel growth occurs at a constant annual rate, often referred to as *geometric growth*. Linear growth implies a declining annual growth rate over time. The "Travel Growth Forecasts" section in Chapter 9 discusses these two different assumptions about future growth patterns.

The impact of assuming a geometric growth pattern in the HERS travel forecasts is shown in Exhibit 10-3. The estimated Cost to Maintain Highways and Bridges level would be higher under this assumption, increasing 11 percent relative to the baseline scenario. VMT levels in earlier funding periods are lower under the geometric growth assumption than under the linear growth assumption. However, in later years, this situation is reversed, as VMT under geometric growth continues to rise exponentially and greatly exceed the levels under constant annual growth through 2024 and beyond. Since the potential highway improvements identified by HERS consider future travel growth for the lifetime of the improvement, the higher VMT growth beyond 2024 would affect the pattern of investments recommended by the model. The share of investment devoted to capacity expansion under this alternative assumption would rise to over 42 percent of total capital spending, and the cost of attaining any fixed level of system performance in 2024 (such as the Cost to Maintain level) would be more expensive. The impact of assuming a geometric growth pattern in the HERS travel forecasts on the Maximum Economic Investment level would be smaller, since this scenario does not target a specific level of system performance. Under this assumption, the Maximum Economic Investment level would increase by 0.8 percent relative to the baseline scenario.

Timing of Investment

In previous editions of the C&P report using the HERS model for the highway investment analysis, the Maximum Economic Investment for Highways and Bridges (Cost to Improve) was defined by setting the minimum BCR threshold in the model at 1.0 and implementing all improvements with BCR's exceeding this threshold. The effect of this model setting was to front-load the investment projected in HERS, as the entire backlog of cost-beneficial investments was addressed in the first 5-year funding period, followed by lower levels of expenditures meeting the benefit-cost test in subsequent funding periods. The total investment over all the periods was then converted to an average annual figure for use in the report.

For this edition of the report, the structure of this HERS scenario has been modified. The Maximum Economic Investment level is now defined as the highest constant level of annual investment that can be attained while continuing to only implement improvements in each funding period that are cost-beneficial. This change was made to facilitate the use of the new revenue options feature in HERS described above, in which user charges are linked to annual investment levels.

The impact of this change is to increase the estimated level of investment under this scenario. Defining the Maximum Level of Investment under the old BCR test would result in an average annual investment estimate of $129.1 billion, which is $2.6 billion (or 2.0 percent) lower than the baseline amount reported in Chapter 7. The significance of this difference is that, by aggressively investing in highways over the first 5 years, the total amount of cost-beneficial investment (in constant 2004 dollars) over 20 years would be reduced. This $2.6 billion annual difference could be interpreted as a "cost" of deferred investment in highways.

Alternative Model Parameters

The HERS model uses several key input parameters whose values may be subject to considerable uncertainty or debate, but whose values can affect the costs and benefits of investment strategies estimated within the model. To assess the importance of such uncertainty, the future investment scenario estimates were recomputed using different values for some of these parameters, including the unit costs of highway and bridge capital improvements and HERS values for a statistical life, ordinary travel time, reductions in incident delay, and travel demand elasticity. *Exhibit 10-4* shows the impacts of the alternative parameter values on the Maximum Economic Investment level for Highways and Bridges.

Exhibit 10-4

Impact of Alternate Model Parameters on Investment Scenario Estimates

Maximum Economic Investment for Highways & Bridges	($Billions)	Percent Change
Chapter 7 Baseline	**$131.7**	
HERS and NBIAS Improvement Costs		
Increase 25 percent	$146.4	11.2%
Value of a Statistical Life		
Reduce 50 percent	$130.7	-0.8%
Increase 100 percent	$133.5	1.4%
Value of Ordinary Travel Time		
Increase 25 percent	$139.1	5.6%
Reduce 25 percent	$122.3	-7.2%
Value of Incident Delay Reduction		
3 times value of ordinary travel time	$139.4	5.8%
Equal to value of ordinary travel time	$122.0	-7.4%
Elasticity Values		
Use 2004 C&P values	$123.0	-6.6%

Source: Highway Economic Requirements System.

Improvement Costs

The unit improvement costs used in HERS and NBIAS to calculate total investment costs, though recently updated, may themselves be subject to uncertainty. For example, currently unforeseen circumstances may cause highway construction costs to increase faster than the general rate of inflation in the future. It is therefore prudent to consider the impact of higher-than-expected capital improvement costs on the estimated investment levels under the C&P scenarios.

While this particular sensitivity analysis has been routinely included in each of the previous three editions of the C&P report, it has taken on even more meaning in light of recent trends in highway construction costs, which rose sharply in 2005. As discussed in Chapter 8, trends through the first three quarters of that year showed an increase of 24 percent above 2004 levels. While the quarterly volatility in the Federal Highway Administration Bid Price Index makes it impossible to predict what final 2005 or 2006 values for that index are likely to be, anecdotal evidence suggests that these cost increases have not abated. As a result, this analysis may be viewed as reflecting actual recent trends rather than hypothetical future ones.

Exhibit 10-4 shows the impact of inflating all the improvement costs used by HERS and NBIAS by 25 percent on the Maximum Economic Investment level (note that this is a departure from the comparable scenarios in earlier C&P reports, which reflected only changes to the HERS cost inputs). The increase in the investment scenario estimates due to higher unit values for the improvement costs is partially offset by the elimination of some projects that would no longer be considered cost-beneficial by HERS or NBIAS. The net result is an increase of 11.2 percent in the scenario estimate. The impact is greater on the NBIAS results (increasing scenario costs by 18.8 percent) than in HERS (increasing scenario costs by 10.1 percent). As discussed in the Part IV Afterword, the benefit-cost tests applied in HERS are more robust than those in NBIAS, which results in relatively more potential investments being “screened out” at the higher construction cost levels.

Increasing the unit improvement costs by a given percentage has a straightforward (if less conceptually meaningful) impact on the “Cost to Maintain” scenario estimates from the two models. Since the investments included in the “Maintain User Cost” scenario all have BCRs well above 1.0, raising the improvement cost estimates does not cause HERS to forego any improvements on benefit-cost grounds. Similar effects would result in the “Maintain Economic Backlog” scenario in NBIAS. The increase in the Cost to Maintain Highways and Bridges will thus be roughly proportional to the change in improvement costs.

Value of a Statistical Life

HERS uses $3.0 million for the value of a statistical life, which is the U.S. Department of Transportation's (DOT's) standard value for use in benefit-cost analyses. As with the value of time, there is a great deal of debate about the appropriate value, and no single dollar figure has been uniformly accepted by the academic community or within the Federal government.

Doubling the value would increase the Maximum Economic Investment for Highways and Bridges by 1.4 percent. HERS would find a few more projects to implement on the basis of their increased safety benefits if the value of life were increased. Reducing the value of a statistical life by 50 percent would reduce the Maximum Economic Investment level by 0.8 percent. A few marginal projects that were justified based on potential reductions in crash rates would not be implemented if the value of life used in the analysis were reduced.

Changing the value of a statistical life in HERS does not have a significant impact on the investment scenario estimates. The model is not currently equipped to consider all the safety benefits of highway improvements, nor does it model safety-oriented enhancement projects (such as improved crash barriers or protected turning lanes). The Afterword in Part IV of this report includes a discussion of future research options for improving the HERS model's capabilities in this area.

Value of Ordinary Travel Time

The value of time in HERS was developed using a standard methodology adopted by DOT. This methodology provides consistency among different analyses performed within the Department. However, some debate remains about the appropriate way to value time, and no single methodology has been uniformly accepted either by the transportation community or within the Federal government.

Increasing the value of ordinary travel time in HERS by 25 percent would increase the Maximum Economic Investment level by 5.6 percent. Increasing the value of time causes HERS to consider more widening projects (which reduce travel time costs) to be cost-beneficial. The share of investment devoted to capacity expansion would thus increase slightly, to over 46 percent of total improvement costs (versus 44.6 percent in the baseline). Reducing the value of time by 25 percent would have the opposite effect, resulting in a 7.4 percent reduction in the Maximum Economic Investment level.

Value of Incident Delay Reduction

As noted in Appendix A and elsewhere in this report, HERS calculates the delay associated with traffic incidents in addition to that caused by recurring congestion and traffic signals. Research has indicated that such unpredictable delay may be perceived by highway users as more onerous (and thus more "costly" on a per-hour basis) than is 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.

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 10-4 shows the impact of setting this premium at a higher level (3.0 times the ordinary travel time) or eliminating it by setting the value of incident delay equal to ordinary travel time.

Changing the reliability premium associated with incident delay reductions has an effect similar to changing the value of ordinary travel time. Increasing the reliability premium to 3.0 makes incident delay-reducing improvements relatively more valuable, thereby raising the Maximum Economic Investment level by 5.8 percent. Eliminating the premium results in a reduction of 7.2 percent in the investment estimate.

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 and the reasons for using a lower value in this report.

Using the former parameter values would reduce the Maximum Economic Investment level for Highways and Bridges by 6.6 percent. Reducing the assumed amount of travel induced by reductions in user costs at higher investment levels serves to reduce the number of projects that would be cost-beneficial.

Q&A

What impacts do alternate parameter assumptions have on the Cost to Maintain Highways and Bridges?

The impacts of alternative model parameters and procedures on the investment scenario estimates are much more ambiguous and difficult to interpret for the "Cost to Maintain Highways and Bridges" than is the case for the "Maximum Economic Investment" scenario. This generally results from the definition of the Cost to Maintain Highways and Bridges used in this report [*see Chapter 7*]. The HERS-modeled portion of this cost is based on the "Maintain User Cost" scenario, in which investment is sufficient to allow average highway user costs for 2024 as calculated by HERS to match the initial levels in 2004. The initial calculation of user costs, however, is directly affected by many of the parameters shown in Exhibit 10-4, including the values of time, incident delay, and statistical life. As a result, the target average user cost that is maintained will be different for alternative values of these parameters, leaving the baseline and the alternatives less comparable to one another and making any such comparisons less meaningful. The impacts of alternative values on the Maximum Economic Investment level, however, are based on implementing only cost-beneficial projects and are thus not subject to this same caveat.

In the case of the ordinary travel time and reliability premium parameters, increasing their value also increases the initial calculated value of user costs. Less investment would then generally be necessary to maintain user costs at this higher, less "ambitious" level in the future. In both cases, the change is somewhat artificial and due solely to differences in the specification of the baseline and alternative scenarios. Changing the value of the statistical life parameter does not affect the estimate of the "Cost to Maintain" scenario to any significant degree.

Conceptually, the values of the elasticity parameters should not affect the investment if user costs are maintained at their current levels, since there would be no price response under such circumstances. However, this would only apply to the "Maintain User Cost" scenario if this were true for every section in every time period. In fact, the scenario definition is based on system-wide averages, in which user costs will rise on some sections and decline on others. The net effect of changing elasticity parameters thus depends on how such effects play out on individual sections, making it impossible to predict the net outcome. Also, if user costs are higher or lower than the baseline in the intermediate years between the base year and the end of the 20-year analysis period, then elasticity will have stronger or lesser impacts on overall travel growth and thus investment levels under the "Maintain User Cost" scenario, but this is not directly related to elasticity and the investment level required to reach the original user cost level in the final year.

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
- Type of performance enhancing investment
- Replacement condition thresholds
- Value of time
- User travel cost elasticities.

These alternative projections illustrate how the baseline investment estimates for transit presented in Chapter 7 will vary in response to changes in the assumed values of input variables.

Changes in PMT

TERM relies heavily on forecasts of PMTs 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, i.e., current levels of 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 1.57 percent used in this report is a weighted average of the most recent, primarily 2000 to 2005, MPO forecasts available from 92 of the Nation's largest metropolitan areas. TERM investment estimates in the 2004 C&P report were based on a projected PMT growth rate of 1.5 percent, based on a weighted average of the forecasts available from 76 of the Nation's largest metropolitan areas. PMT increased at an average annual rate of 2.23 percent between 1995 and 2004 and at an average annual rate of 0.65 percent between 2002 and 2004.

Future transit investment levels have been estimated by TERM based on four alternative projected PMT scenarios to examine the sensitivity of transit investment needs to variations in PMT *[Exhibit 10-5].* 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).

(4) PMT growth is 1.5 percent, the rate used in the 2004 C&P report

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

Exhibit 10-5

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 2004 Dollars)**	**Percent Change**	**(Billions of 2004 Dollars)**	**Percent Change**
Baseline (1.57%)	$15.75	–	$21.84	–
Increased 50% (to 2.36%)	$18.72	18.8%	$24.82	13.7%
Decreased 50% (to 0.79%)	$12.95	-17.8%	$19.03	-12.9%
Decreased 100% (to 0%)	$10.33	-34.4%	$16.40	-24.9%
Baseline 2004 Report (1.50%)	$15.55	-1.4%	$21.63	-1.0%

*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.

Improve Conditions and Performance scenario because PMT growth rates affect primarily 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. A 50 percent increase/decrease in PMT growth will increase/decrease the cost to maintain conditions and performance by 18 to19 percent and the cost to improve conditions and performance by 13 to 14 percent. TERM estimates of future investment to maintain conditions and performance would decrease by 34 percent if PMT ceases to grow, although this is not a likely scenario.

If PMT growth were assumed to be 1.5 percent, as was assumed in the 2004 C&P report, instead of 1.57 percent as assumed in this report, the investment estimated by TERM for the Maintain Conditions and Performance scenario would be 1.4 percent lower and the investment estimated to improve conditions and performance would be 1.0 percent lower than the baseline estimates in this report.

Changes in Capital Costs

The capital costs used in TERM are based on actual prices paid by agencies for asset purchases as reported to FTA in TEAM (Transit Electronic Award and Management System) and in special surveys. Asset prices in the current version of TERM have been converted to 2004 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 10-6,* a 25 percent increase in capital costs increases the costs to maintain conditions and performance by 18 percent and the costs to improve conditions and performance by 15 percent.

Exhibit 10-6

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	$15.75	–	$21.84	–
Increase Costs 25%	$18.62	18.2%	$25.02	14.6%

*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.

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.

Change Performance-Enhancing Investment from BRT to Light Rail

Starting with the 2004 C&P report, TERM has assumed that investment to improve performance by increasing the speed of passenger travel in urbanized areas with populations of less than 1 million and no rail system are made in BRT. The 2002 C&P report assumed that these performance improving investments were made in light rail. As shown in *Exhibit 10-7,* the estimated investment to improve conditions and performance would be 1.4 percent higher if performance improving investments were assumed to be made in light rail instead of BRT.

Exhibit 10-7

Impact of Replacing BRT with Light Rail to Improve Estimates by Scenario*

	Annual Cost to Improve Conditions & Performance	
	(Billions of 2004 Dollars)	Percent Change
Baseline	$21.84	–
Light Rail Performance Enhancing Investment	$22.14	1.4%

*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 Replacement Condition Thresholds

Asset condition thresholds set the condition that an asset must fall to in order for TERM to make the decision to invest money to replace it. These condition thresholds are provided in Appendix C. The replacement threshold used to determine replacement investments for guideway was raised from 1.5 for the 2004 C&P investment scenarios to 1.75 for the results in this report. As shown in *Exhibit 10-8*, the estimated investment to maintain conditions would be 3.9 percent lower and the estimated investment to improve conditions would be 2.8 percent lower if guideways were allowed to deteriorate to the lower 1.5 condition.

Exhibit 10-8

Impact of Using 2004 C&P Condition Replacement Thresholds*

	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	$15.75	–	$21.84	–
2004 C&P Thresholds	$15.15	-3.9%	$21.25	-2.8%

*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 10-9 shows the effect of varying the value of time. The baseline value of time is assumed to be $11.20, as recommended by the DOT 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 report, which also used these values.)

Overall, variations in the value of time have a very limited effect on projected investment estimates. 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 10-9

Impact of Change in the Value of Time on Transit Investment Estimates by Scenario*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
Value of Time	**(Billions of 2004 Dollars)**	**Percent Change**	**(Billions of 2004 Dollars)**	**Percent Change**
Baseline	$15.75	–	$21.84	–
Increase 100%	$15.79	0.2%	$22.69	3.9%
Decrease by 50%	$15.81	0.4%	$21.69	-0.6%

*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 1 percent change in user costs. TERM uses user cost elasticities to estimate the changes in ridership that will result from changes in fare and travel time costs, 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 10-10*, a doubling or halving of these elasticities has almost no effect on projected investment scenarios.

Exhibit 10-10

Impact of Change in the Value of User Cost Elasticities on Transit Investment Estimates by Scenario*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
User Cost Elasticities	**(Billions of 2004 Dollars)**	**Percent Change**	**(Billions of 2004 Dollars)**	**Percent Change**
Baseline	$15.75	–	$21.84	–
Increase 100%	$15.75	0.0%	$22.80	4.4%
Decrease by 100%	$15.75	0.0%	$21.01	-3.8%

*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.

PART III

Special Topics

Introduction

Chapters 11 and 12 provide a more in-depth look at specific components of the Nation's transportation system, presenting information to provide additional insight into these components. Chapters 13 through 15 provide a more extensive discussion of several topics that were touched upon in the core analytical portion of the report, Chapters 2 through 10. These chapters are intended to provide additional insights into these issues and to highlight some related activities currently underway within the Department of Transportation.

Chapter 11, **Interstate System,** highlights the system characteristics, system conditions, operational performance, and financing of the Interstate System. The chapter also presents analyses of future investment and performance for the Interstate System. While the rural and urban Interstates are identified in the functional class tables in earlier portions of the report, this chapter provides additional details and brings all Interstate-related information into a single location.

Chapter 12, **National Highway System (NHS),** is similar in scope and coverage to Chapter 11, but focuses on the entire NHS rather than simply its Interstate System component. While some of the earlier chapters in the report include some NHS-related data, most information pertaining to the NHS in this report is located in this chapter. A detailed look at the conditions of the components of the Nation's Strategic Highway System (STRAHNET) is also presented in this chapter.

Chapter 13, **Innovative Finance,** highlights several of the techniques and strategies that are specifically designed to supplement the traditional methods used as part of the Federal-aid Highway Program. Credit assistance, debt financing, and public-private partnerships are explored in detail.

Chapter 14, **Freight Transportation,** supplies information related to various aspects of the trucking industry, including its impact on the Nation's highway system and the impact that the condition and performance of the Nation's highways have on trucking. Topics presented are the growth of freight transportation, congestion, safety, and special investment needs relating to trucking.

Chapter 15, **Operations Strategies,** presents a more detailed insight into the solutions to the problems of maintaining an acceptable degree of mobility on the Nation's highway system, while meeting the need for increased traffic volume. Several potential solutions are presented to address some of the operational performance issues raised in Chapter 4.

CHAPTER 11

Interstate System

Interstate System

In 2006, the Dwight D. Eisenhower National System of Interstate and Defense Highways, commonly known as the Interstate System, turns 50 years old. On June 29, 1956, President Eisenhower signed the Federal-Aid Highway Act of 1956, which launched the Interstate construction program. The safety and operational benefits of the Interstate System were felt as each segment opened and the miles began to stretch across the country. The Interstate System has become the backbone of transportation and commerce in the United States over the last half-century.

The Interstate System has become such an integral element of the American way of life that most people never knew or have forgotten what highway travel was like in the pre-Interstate era. As a result, they take it for granted. The 50th anniversary is a time to remind people of what is possibly the greatest public works project in history and to honor the men and women who made it possible. More important, it is an opportunity to examine what the country will have to do to keep the Interstates an evolving and flexible network that will continue to meet the changing needs—economic, social, and military—of the 21st century.

Along with a brief history, this chapter provides a snapshot of the current physical conditions, operational performance, and finance of the Interstate System, and projects the potential impacts of future investment on the Interstates. This chapter represents a supplementary analysis to those of the larger, national road network presented in Chapters 2 through 9 of the report.

Background

The Interstate System dates to the period in the late 1930s when the United States was completing its first "Interstate System," a two-lane paved network of highways generally carrying 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 BPR (then called 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 for urban circumferential and distributing routes that would be designated at a later date (in 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 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).

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. The Highway Trust Fund has allowed massive investment in infrastructure projects—generating $182 billion starting in FY 1957 for the Interstates alone (for construction and improvement) through apportionments to the States.

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, and accelerated metropolitan development throughout the United States. At the same time, it facilitated military transportation from the Cold War to the War on Terrorism.

The National Highway System Designation Act of 1995 included the Interstate System as the core of a National Highway System (NHS), described in Chapter 12.

Characteristics, Conditions, and Performance

Expectations of the Interstate System have changed dramatically since the start of the construction program in 1956. The year before, the BPR had submitted a report to Congress on *Needs of the Highway Systems, 1955-84* (the Interstate portion of the report covered only the 37,681 miles designated in 1947). The report assumed that the Interstate System would be completed by 1966. Much of the construction would take place on the alignment of the existing road in the designated Interstate corridor. A substantial portion of the Interstate System, nearly 7,000 miles, would need only two lanes through the mid-1960s, while

28,000 miles would require four lanes. Only about 2,300 miles would require six or more lanes and that only in the more heavily populated areas. Minimum design standards assumed that, in less populated areas, particularly in the West, two-lane Interstates could retain at-grade intersections with lower-volume highways and railroads.

The 1956 Act and subsequent legislation changed these assumptions. Higher design standards would be adopted; all routes were required to have a minimum of four lanes with no at-grade crossings. The features needed for full access control and safe, efficient operation required construction on new alignment for much of the Interstate System. More mileage was authorized (including 1,000 miles in 1956 and another 1,500 miles in 1968), bringing the total covered by the 1956 Act, as amended, to 42,794 miles. Moreover, construction of the Interstates evolved from an engineering feat, as it was perceived at the start, to a challenge of blending engineering necessity with environmental sensitivity and serving traffic needs while eliminating or reducing adverse impacts. As traffic volumes increased substantially, the pressure to improve performance far exceeded the high expectations common at the start of the program.

This evolution of assumptions and expectations highlights the importance of understanding the conditions and performance of the Interstate System today. As officials explore the future of the Interstate System, an accurate assessment of network and use characteristics will provide a baseline for the discussion. It can be, however, only a baseline, for as the history of the Interstate System demonstrates, many unforeseeable factors will affect its performance in coming decades.

Interstate System Characteristics

Exhibit 11-1 describes the total public road length of the Interstate System (comparable data for all roads can be found in the "Highways by Purpose" section in Chapter 2). The route miles of the Interstate System in the United States increased from 46,747 in 2004 to 46,835 in 2004. About 67.1 percent (31,447 route miles) were in rural areas, slightly less than 4.5 percent (2,088 route miles) were in small urban areas, and 28.3 percent (13,270 route miles) were in urbanized areas**.** By comparison, of the total 3,997,462 route miles for all roads in the United States, slightly more than 75.1 percent were in rural areas, slightly less than 4.7 percent were in small urban areas, and the remaining approximately 20.2 percent were in urbanized areas.

Exhibit 11-1

Interstate Route Miles and Lane Miles, 1995–2004

	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Route Miles						
Rural	32,703	32,919	33,152	33,107	31,477	-0.4%
Small Urban	1,731	1,744	1,794	1,808	2,088	2.1%
Urbanized	11,569	11,651	11,729	11,832	13,270	1.5%
Total	**46,003**	**46,314**	**46,675**	**46,747**	**46,835**	**0.2%**
Lane Miles						
Rural	132,346	133,573	135,000	135,032	128,012	-0.4%
Small Urban	7,269	7,365	7,626	7,776	8,890	2.3%
Urbanized	64,865	65,603	67,020	68,088	75,127	1.6%
Total	**204,480**	**206,541**	**209,647**	**210,896**	**212,029**	**0.4%**

Source: Highway Performance Monitoring System.

The number of Interstate route miles in rural areas declined from 33,107 in 2002 to 31,477 in 2004. During the same period, the number of Interstate System miles in small urban areas increased from 1,808 in 2002 to 2,088 in 2004 and the number of route miles in urbanized areas increased from 11,832 in 2002 to 13,270 in 2004. **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 the Highway Performance Monitoring System (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 1995 and 2004, rural Interstate route miles decreased by approximately 0.4 percent annually, small urban Interstate route miles increased at an average annual rate of 2.1 percent, and Interstate route miles in urbanized areas increased 1.5 percent annually. The 0.2 percent overall annual growth rate for Interstates roughly matches that for all roads during that time period.

Exhibit 11-1 also describes the number of Interstate lane miles between 1995 and 2004 (comparable data for all roads can be found in the "Highways by Purpose" section in Chapter 2). In 2004, there were 212,029 lane miles of Interstates in the United States. Slightly less than 60.4 percent were in rural communities, just less than 4.2 percent were in small urban areas, and 35.4 percent were in urbanized areas. By comparison, about 73.4 percent of all highway lane miles in the United States were in rural areas, 4.8 percent of lane miles were in small urban areas, and 21.8 percent of lane miles were in urbanized areas.

Between 1995 and 2004, rural Interstate lane miles decreased by 0.4 percent annually, small urban Interstate lane miles grew at 2.3 percent annually, and urbanized Interstate lane miles increased by 1.6 percent annually. The annual growth rate of lane miles from 1995 to 2004 for the total Interstate System was 0.5 percent annually or almost double the annual growth rate of lane miles for all roads in the United States over the same period. This growth in Interstate lane miles has occurred due to both new construction and the reclassification of some arterials to Interstate status.

Exhibit 11-2 describes the number of Interstate bridges in 1996, 1998, 2000, 2002, and 2004 (comparable data for all bridges can be found in the "Bridges by Functional Classification" section in Chapter 2). Between 1996 and 2004, the number of rural Interstate bridges decreased from 28,638 to 27,648 bridges, while during the same period, the number of urban Interstate bridges increased from 26,596 to 27,667. The reduction in rural bridges is caused in part by the reclassification of some rural Interstates to urban status as communities have grown in size.

Exhibit 11-2

Number of Interstate Bridges, 1996–2004

	1996	1998	2000	2002	2004
Rural	28,683	27,530	27,797	27,316	27,648
Urban	26,596	27,480	27,882	27,929	27,667
Total	**55,234**	**55,010**	**55,679**	**55,245**	**55,315**

Source: National Bridge Inventory.

Interstate Use Characteristics

Exhibit 11-3 describes vehicle miles traveled (VMT) on Interstate highways between 1995 and 2004 (comparable data for all roads can be found in the "Highways Travel" section in Chapter 2). In 2004, Americans traveled more than 267 billion vehicle miles on rural Interstates, 25.7 billion vehicle miles on small urban Interstates, and in excess of 433.9 billion vehicle miles on urban Interstates. Interstate travel continued to represent the fastest-growing portion of VMT between 1995 and 2004. Interstate VMT grew at an average annual rate of approximately 2.8 percent during this period, while VMT on all roads grew by about 2.3 percent annually.

Exhibit 11-3

Interstate Vehicle Miles Traveled, 1995–2004 (Millions of VMT)

	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural	224,705	241,451	269,533	281,461	267,397	2.0%
Small Urban	17,310	18,393	21,059	22,578	25,784	4.5%
Urbanized	327,329	346,376	375,088	389,903	433,982	3.2%
Total	**569,345**	**606,220**	**665,681**	**693,941**	**727,163**	**2.8%**

Source: Highway Performance Monitoring System.

Many of the operational performance measures discussed in Chapter 4 are not computed separately by functional class, so no specific information is available for the Interstate System. However, data for the Daily Vehicle Miles Traveled (DVMT) per Lane Mile metric are available on a functional class basis, and demonstrates the increasing demands being placed on the Interstate System. From 1995 to 2004, DVMT per lane mile increased from 4,329 to 5,707 on rural Interstate highways, from 6,254 to 7,925 on small urban Interstate highways, and from 13,826 to 15,783 on Interstate highways in urbanized areas (comparable data for all roads can be found in the "DVMT per Lane Mile" section in Chapter 4).

Exhibit 11-4 describes Interstate highway travel by vehicle type between 1995 and 2004. In 2004, 81.3 percent of travel on rural Interstates was by passenger vehicle; 2.9 percent was by single-unit truck; and 15.9 percent was by combination truck. About 92.8 percent of urban Interstate travel was by passenger vehicle; 2.1 percent was by single-unit truck; and 5.1 percent was by combination truck. By contrast, passenger vehicle travel represented approximately 92.3 percent of travel on all roads in 2004. Single-unit truck travel was just above 2.7 percent of travel, and combination truck travel represented slightly more than 4.9 percent.

Travel on rural and urban Interstates grew faster than on any other functional system. Between 1995 and 2004, for example, combination truck travel grew by 3.9 percent annually on urban Interstates and by 4.1 percent on rural Interstates. By comparison, combination truck travel on all roads increased by 2.6 percent annually during the same period.

Pavement Ride Quality

The Federal Highway Administration (FHWA) has adopted a performance measure for the NHS based on the percentage of VMT that occurs on roadways meeting the standard for "good" ride quality, defined as having an International Roughness Index (IRI) value of less than 95 inches per mile. Another measure still in use is based on "acceptable" ride quality, defined as having an IRI value of less than or equal to 170 inches per mile. Note that, based on the way the measures are defined, "good" is a subset of "acceptable."

Exhibit 11-4

Interstate Highway Travel by Vehicle Type, 1995–2004 (Millions of VMT)

	1995	1997	2000	2002	2004	Annual Rate of Change 2004/1995
Rural						
PV	180,031	188,969	214,175	224,375	270,816	4.6%
SU	6,708	7,667	8,260	8,745	9,627	4.1%
Combo	36,644	41,642	44,377	45,633	52,828	4.1%
Urban						
PV	315,888	330,668	358,906	373,957	471,597	4.6%
SU	7,148	7,906	8,719	9,106	10,482	4.3%
Combo	18,492	20,641	23,472	23,887	26,044	3.9%

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

SU = Single Unit Trucks (6 tires or more)

Combo = Combination Trucks (trailers and semi-trailers)

Note: Table does not include VMT for Puerto Rico

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

Exhibit 11-5 shows the percentage of total Interstate VMT on pavements with good and/or acceptable ride quality broken down by population area subsets (comparable data for other functional systems can be found in the "Overall Pavement Ride Quality" section in Chapter 3). Since 1995, the percentage of VMT on pavements with good ride quality has increased in rural areas, small urban areas, and urbanized areas.

Exhibit 11-5

Percent of Interstate VMT on Pavements With Good and Acceptable Ride Quality, by Population Area, 1995–2004

Quality	1995	1997	1999	2000	2002	2004
Good (IRI<95)						
Rural Areas	53.3%	56.5%	66.8%	69.6%	72.2%	73.7%
Small Urban Areas	51.4%	52.9%	59.8%	62.5%	65.1%	65.6%
Urbanized Areas	39.1%	35.4%	39.7%	42.5%	43.8%	48.5%
Acceptable (IRI≤170)						
Rural Areas	94.5%	95.7%	97.4%	97.4%	97.3%	97.8%
Small Urban Areas	94.9%	96.1%	95.9%	95.3%	94.6%	95.0%
Urbanized Areas	88.8%	88.1%	90.4%	91.0%	89.3%	89.9%

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 2004, at 73.7 percent. A total of 97.8 percent of all VMT on the rural Interstate System occurred on pavements with acceptable ride quality.

On small urban Interstates, the percentage of VMT occurring on pavements with good ride quality was 65.6 percent in 2004. VMT on small urban Interstate pavements classified as having acceptable ride quality was 95.0 percent. For urbanized Interstates, the percentage of VMT on pavements with good ride quality was 48.5 percent in 2004, while the percentage of VMT on acceptable ride quality pavements was 89.9 percent.

Lane Width, Alignment, and Access Control

As described in Chapter 3, roadway alignment affects the level of service and safety of the highway system. Inadequate alignment may result in speed reductions as well as impaired sight distance. In particular, trucks are affected by inadequate roadway alignment with regard to speed.

There are two types of alignment: horizontal (curvature) and vertical (gradient). Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst). *Exhibit 11-6* summarizes alignment for rural Interstates (alignment is normally not an issue in urban areas). More than 92.6 percent of rural Interstate miles are classified as Code 1 for vertical alignment and 95.4 percent as Code 1 for horizontal alignment (comparable data for other functional systems can be found in the "Roadway Alignment" section in Chapter 3).

Exhibit 11-6

Rural Interstate Vertical/Horizontal Alignment Status, 2004 (Percent of Miles)

		Vertical	Horizontal
Code 1:	All curves and grades meet appropriate design standards.	92.6%	95.3%
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.	6.3%	1.3%
Code 3:	Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits.	0.4%	0.8%
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.	0.7%	2.6%

Source: Highway Performance Monitoring System.

Lane width can have an impact on highway safety and operational performance. Currently, higher functional systems such as Interstates are expected to have 12-foot lanes. As shown in *Exhibit 11-7,* approximately 99.7 percent of rural Interstate miles and 98.3 percent of urban Interstate miles have minimum 12-foot lane widths (comparable data for other functional systems can be found in the "Lane Width" section in Chapter 3).

Exhibit 11-7

Interstate Lane Width, 2004

	>=12 ft	11 ft	10 ft	9 ft	<9 ft
Rural	99.66%	0.32%	0.00%	0.00%	0.02%
Urban	98.31%	1.55%	0.10%	0.00%	0.03%

Source: Highway Performance Monitoring System.

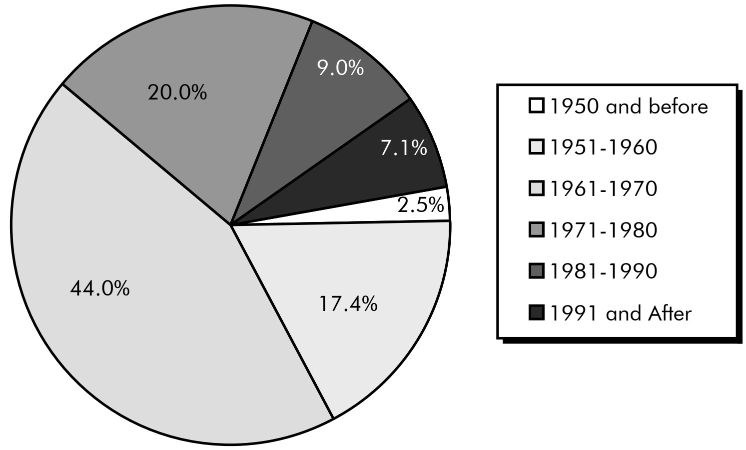
The vast majority of the Interstate mileage consists of divided highways with a minimum of four lanes and full access control. The Interstate Systems for Alaska and Puerto Rico are not required to meet this standard. For Alaska and Puerto Rico, the requirement is that construction is adequate for current and probable future traffic demands and the needs of the locality. In Alaska, 1,034 miles of rural Interstate are not required to have a minimum of four lanes and full access control. For urban Interstates, 104 miles do not meet the specified criteria for access control; 53 of these miles are in Puerto Rico and the remaining miles are in Alaska.

Bridge Age and Conditions

Exhibit 11-8 shows that, of the bridges currently on the Interstate highway system, approximately 17.4 percent were constructed during the 1950s, 44.0 percent were constructed during the 1960s and 20.0 percent were constructed during the 1970s. Since such a large percentage of these bridges are in approximately the same period in their service lives, this poses a challenge for long-term strategies relating to the rehabilitation or replacement of Interstate bridges. Future spending may be more variable over time than would be the case for bridges on other functional classes, which were constructed more evenly over time.

Exhibit 11-8

Age Composition of Interstate Bridges, 2004

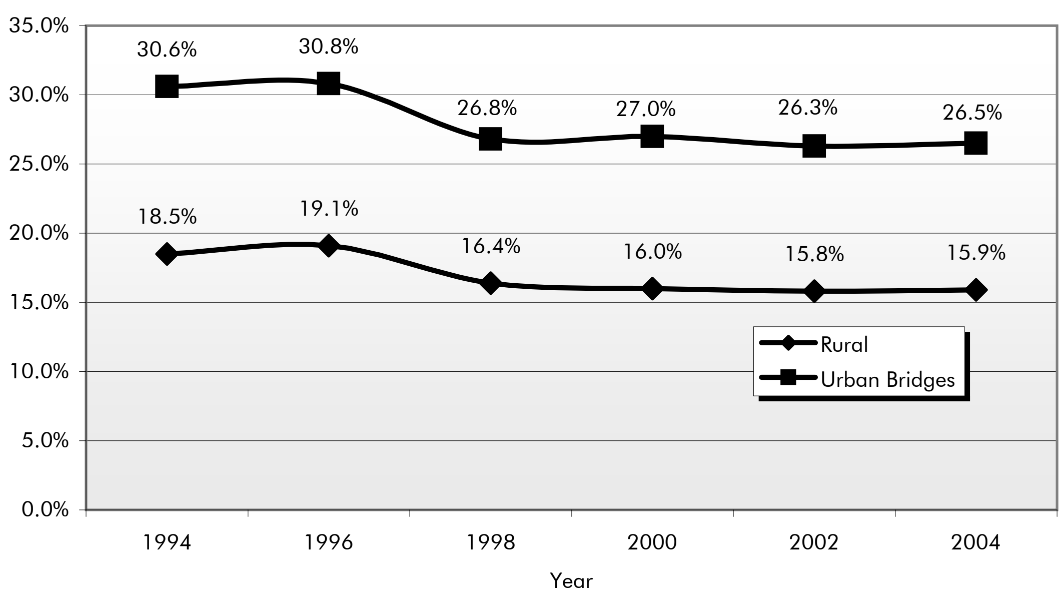


Source: National Bridge Inventory.

Exhibit 11-9 shows that approximately 15.9 percent of all rural Interstate bridges were deficient in 2004, including 1,163 that were structurally deficient (about 4.2 percent of the total number) and 3,224 that were functionally obsolete (11.7 percent of the total number). Among rural functional systems, the rural Interstate System had the lowest percentage of structurally deficient bridges and the lowest number of functionally obsolete bridges and deficient bridges (comparable data for other functional systems can be found in the "Rural and Urban Deficient Bridges by Functional Classification" section in Chapter 3).

Exhibit 11-9

Interstate Bridge Deficiency Percentages, by Population Area, 1994 –2004



Source: National Bridge Inventory.

Approximately 26.5 percent of all urban Interstate bridges were deficient in 2004. This included 1,667 structurally deficient bridges (6.0 percent of total urban Interstate bridges) and 5,617 functionally obsolete bridges (20.5 percent of the total). Among urban functional systems, the Interstate System had the lowest percentage of deficient bridges.

The percentage of deficient bridges has steadily declined in recent years. In 1994, for example, 18.5 percent of rural Interstate bridges were deficient. That percentage had declined to 15.9 percent by 2004. The percentage of deficient urban Interstate bridges also declined, from 30.6 percent in 1994 to 26.5 percent in 2004.

The FHWA also looks at bridge deficiencies by the percentage of deficient deck area. Approximately 17.9 percent of the rural Interstate bridge deck area was deficient in 1996. This has decreased to 15.7 percent in 2004. The percentage of deficient deck area on urban Interstate bridges decreased from 34.2 percent in 1996 to 31.8 percent in 2004.

Exhibit 11-10 shows the number of Interstate bridges built by time period and the percentage of such bridges that are structurally deficient or functionally obsolete. Among the time periods shown, the highest percentage of deficiencies is on bridges constructed between 1911 and 1920; of the five Interstate bridges, one is structurally deficient and two are functionally obsolete; thus, the total percentage of deficient bridges is 60.0 percent. Of the bridges built between 1951 and 1960, 33.0 percent are either structurally deficient or functionally obsolete. This percentage falls to 24.0 percent for bridges built from 1961 to 1970, to 13.0 percent for bridges built from 1971 to 1980, to 12.7 percent for bridges built from 1981 to 1990, to 7.2 percent for bridges built from 1991 to 2000. None of the 886 bridges constructed from 2001 to 2004 are currently structurally deficient or functionally obsolete.

Exhibit 11-10

Interstate Bridge Deficiency Percentages, by Period Built

Time Period	Number of Interstate Bridges Built	Percent Structurally Deficient	Percent Functionally Obsolete	Total Percent Deficient
<= 1900	6	0.0%	16.7%	16.7%
1901-1910	3	0.0%	33.3%	33.3%
1911-1920	5	20.0%	40.0%	60.0%
1921-1930	114	12.3%	25.4%	37.7%
1931-1940	524	6.3%	18.3%	24.6%
1941-1950	754	6.6%	24.0%	30.6%
1951-1960	9,597	8.0%	25.1%	33.0%
1961-1970	24,314	6.1%	17.9%	24.0%
1971-1980	11,084	3.7%	9.3%	13.0%
1981-1990	5,001	1.1%	11.5%	12.7%
1991-2000	3,013	0.4%	7.2%	7.7%
2001-2004	886	0.0%	0.0%	0.0%
Not Reported	14	7.1%	28.6%	35.7%
Total	**55,315**	**5.1%**	**16.1%**	**21.2%**

Source: National Bridge Inventory.

Safety Performance

Exhibits 11-11 and *11-12* describe the number of fatalities and the fatality rate for Interstates between 1995 and 2004. While the number of fatalities has increased on both rural and urban Interstates, these roads are still safer on average than those in other functional

Exhibit 11-11

Fatalities on the Interstate System, 1995–2004

	1995	1997	2000	2002	2004
Rural Interstates	2,658	3,040	3,254	3,298	3,246
Urban Interstates	2,177	2,292	2,419	2,482	2,516

Source: Fatality Analysis Reporting System.

classes. The fatality rate on rural Interstates has remained lower than any other rural functional class, and the fatality rate on the urban Interstate System has remained the lowest of any functional class. More detailed information about highway safety can be found in Chapter 5.

Exhibit 11-12

Interstate System Fatality Rates, 1994–2004 (Fatalities per 100 Million VMT)

	1995	1997	2000	2002	2004
Rural Interstates	1.18	1.28	1.21	1.17	1.21
Urban Interstates	0.63	0.63	0.61	0.60	0.55

Source: Fatality Analysis Reporting System.

For the period from 1995 to 2004, the rural Interstate fatality rate has been almost double that of the urban Interstate System. This is consistent with the statistics presented in Chapter 5, which showed that fatality rates are generally higher in rural areas.

Finance

All levels of government spent $15.5 billion for capital improvements on Interstate highways and bridges in 2004, which constituted 22.0 percent of the $70.3 billion of capital outlay on all functional classes. *Exhibit 11-13* categorizes this total by type of improvement. System rehabilitation expenditures constituted 51.3 percent of total capital spending on Interstates, system expansion 41.4 percent, and system enhancement 7.3 percent. (See the “Capital Outlay by Improvement Type” section in Chapter 6 for definitions of these three broad categories of improvement types).

Exhibit 11-13

Interstate Capital Expenditures, 2004

	Total Invested (Billions of Dollars)			Percent of Total	Percent of Total for all Functional Classes		
	Rural	Urban	Total	Interstate	Rural	Urban	Total
System Rehabilitation							
Highway	$2.1	$2.9	$5.0	32.2%	8.0%	11.2%	19.2%
Bridge	$0.5	$2.5	$3.0	19.2%	4.6%	23.9%	28.5%
Subtotal	**$2.6**	**$5.4**	**$8.0**	**51.3%**	**7.0%**	**14.9%**	**21.9%**
System Expansion							
Additions to Existing Roadways	$0.9	$2.1	$3.1	19.8%	7.2%	16.7%	24.0%
New Routes	$0.6	$2.5	$3.1	20.1%	4.9%	19.0%	23.9%
New Bridges	$0.1	$0.2	$0.2	1.5%	3.8%	10.9%	14.6%
Subtotal	**$1.6**	**$4.8**	**$6.4**	**41.4%**	**5.9%**	**17.5%**	**23.4%**
System Enhancements	**$0.3**	**$0.8**	**$1.1**	**7.3%**	**4.8%**	**13.0%**	**17.8%**
Total Investment	**$4.5**	**$11.0**	**$15.5**	**100.0%**	**6.4%**	**15.7%**	**22.1%**

Sources: Highway Statistics 2004, Table SF-12A and unpublished FHWA data.

Capital investment on Interstate highways decreased slightly between 2002 and 2004, falling 9.2 percent; total capital investment on all functional classes rose by only 3.1 percent. *Exhibit 11-14* shows that rural Interstate spending fell by 32.1 percent between these 2 years, driven by decreases of 60.9 percent in rural Interstate bridge system rehabilitation and 43.0 percent in system expansion involving rural Interstate widening.

Exhibit 11-14

Interstate Capital Expenditures, 2004 versus 2002

	2002 (Billions of Dollars)			2004 (Billions of Dollars)			Percent Change 2004 Versus 2002		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
System Rehabilitation									
Highway	$2.8	$3.1	$5.9	$2.1	$2.9	$5.0	-25.6%	-6.2%	-15.4%
Bridge	$1.2	$1.9	$3.2	$0.5	$2.5	$3.0	-60.9%	28.4%	-6.1%
Subtotal	**$4.0**	**$5.1**	**$9.1**	**$2.6**	**$5.4**	**$8.0**	**-36.3%**	**7.1%**	**-12.1%**
System Expansion									
Additions to Existing Roadways	$1.6	$2.0	$3.7	$0.9	$2.1	$3.1	-43.0%	6.1%	-15.8%
New Routes	$0.5	$2.2	$2.7	$0.6	$2.5	$3.1	18.0%	14.7%	15.3%
New Bridges	$0.0	$0.2	$0.2	$0.1	$0.2	$0.2	195.0%	8.9%	30.2%
Subtotal	**$2.2**	**$4.3**	**$6.5**	**$1.6**	**$4.8**	**$6.4**	**-25.8%**	**10.5%**	**-1.7%**
System Enhancements	**$0.4**	**$1.1**	**$1.5**	**$0.3**	**$0.8**	**$1.1**	**-22.8%**	**-25.4%**	**-24.7%**
Total Investment	**$6.6**	**$10.5**	**$17.1**	**$4.5**	**$11.0**	**$15.5**	**-32.1%**	**5.1%**	**-9.2%**

Sources: Highway Statistics 2004, Table SF-12A and unpublished FHWA data.

It is important to note that, for a particular functional class (such as rural Interstates) and a 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 and can be more easily affected by large individual projects that happen to have a high level of cash outlays in a given year. It would be premature to suggest that the changes in expenditure patterns observed between 2002 and 2004 represent a long-term trend. This comparison is included primarily to help put into perspective the comparisons of 2004 spending with the future capital investment scenarios discussed later in this chapter.

Future Capital Investment and Performance

Exhibits 7-2 and 7-3 in Chapter 7 show the estimated average annual Maximum Economic Investment for Highways and Bridges (Cost to Improve) and the Cost to Maintain Highways and Bridges for 2005–2024, categorized by functional class and improvement type. For the "Cost to Maintain" scenario, the portion of the estimated investment on Interstates totals $4.0 billion for rural and $18.2 billion for urban. These amounts are 5.1 and 23.1 percent, respectively, of the total Cost to Maintain Highways and Bridges. At this level of investment, average user costs on all highways in 2024 would be maintained at their 2004 levels. User costs would increase on some sections and functional classes and would decrease on others. In the case of Interstate highways, average user costs in both urban and rural areas would decrease.

For the "Maximum Economic Investment" scenario, the investment scenario estimates for rural and urban Interstates total $5.5 billion (4.2 percent of total) and $29.8 billion (22.6 percent of the total), respectively. This represents the highest level of capital expenditures that could be attained while investing only in improvements that are cost-beneficial. See Chapter 7 and Appendix A for more on the investment analysis methodology used in this report.

Exhibits 11-15 through 11-18 show the impacts of different levels of future capital spending on the physical conditions and operational performance of rural and urban Interstates. The first line in each exhibit shows current values for each of the measures, and the second line corresponds to the maximum economic efficiency level of investment. All investment levels are in constant 2004 dollars.

Exhibits 11-15 and 11-17 show the impact of different levels of combined highway rehabilitation and expansion spending on pavement condition, for rural and urban Interstates, respectively. Exhibits 11-16 and 11-18 show the impact of these same outlays on measures of operational performance for rural and urban Interstates, respectively. Highway rehabilitation and system expansion investments are modeled by the Highway Economic Requirements System (HERS) (see Appendix A).

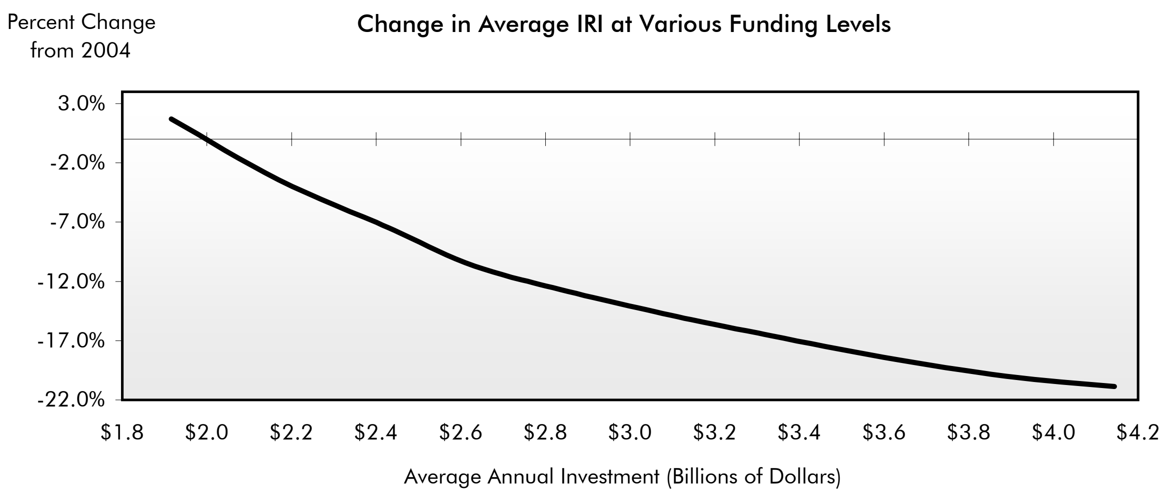
Expenditures on system enhancement (including traffic operational improvements, safety improvements, and environmental enhancements) are not directly modeled and are not included in the totals shown in the exhibits. Bridge rehabilitation investments are discussed separately below.

Rural Interstates

Exhibit 11-15 shows projected values for average IRI, a measure of average pavement ride quality, and the percentage of VMT at an IRI below 95 and below 170. As indicated earlier in this chapter, these two levels are used to define good and acceptable levels of pavement ride quality. The exhibit shows that the 2004 rehabilitation and expansion investment level of $3.7 billion on rural highways is only slightly below the maximum economic investment level of $4.1 billion estimated by HERS.

Exhibit 11-15

Projected Rural Interstate Pavement Condition in 2024 for Different Possible Funding Levels



Average Annual Highway Rehabilitation + Expansion Investment (Rural Interstates) (Billions of 2004 Dollars)	Percent Change in Average IRI	Percent of VMT on Roads with IRI<95	Percent of VMT on Roads with IRI<170	Funding Level Description: Investment Required to...
$3.7		**74.0%**	**97.6%**	2004 Values
$4.1	-20.9%	88.9%	100.0%	
$3.9	-20.0%	88.5%	100.0%	
$3.6	-18.4%	87.9%	99.9%	
$3.3	-16.6%	86.3%	99.9%	
$3.1	-15.0%	84.5%	99.9%	
$2.8	-12.4%	81.3%	99.8%	
$2.6	-10.4%	78.5%	99.7%	
$2.4	-7.5%	74.8%	99.5%	...Maintain VMT with IRI<95
$2.2	-3.4%	70.0%	99.2%	...Maintain Average IRI
$1.9	1.7%	64.3%	98.6%	

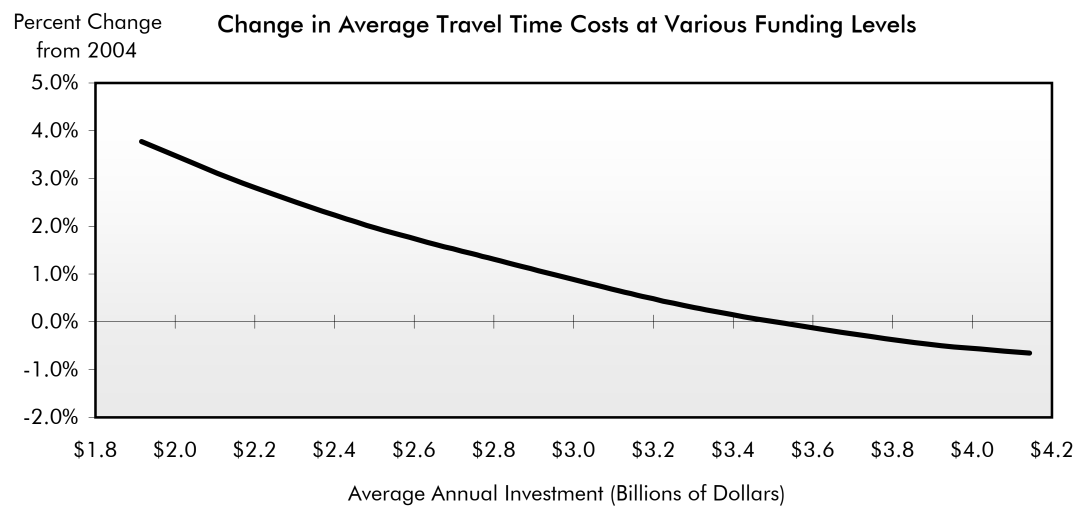
Source: Highway Economic Requirements System.

If current funding levels were sustained, and the mix of highway rehabilitation and widening investments recommended by HERS were implemented, then average IRI would be projected to improve by more than 18.4 percent over 20 years, and the percentage of travel on roads with good ride quality would rise to over 88 percent. Virtually all travel on rural Interstates would occur on roads with at least acceptable ride quality. The annual level of funding required to maintain average IRI at its 2004 level is between $1.9 billion and $2.2 billion.

Exhibit 11-16 shows how future values for average delay per VMT (discussed in Chapter 9), total user costs, and travel time costs on rural Interstates would be affected by different levels of highway rehabilitation and expansion investment. Average user costs on rural Interstates would be maintained at an average annual investment level of $2.4 billion, while average travel time costs would increase by 2.2 percent at that funding level. If current funding levels were sustained, and the mix of highway rehabilitation and widening investments recommended by HERS were implemented, then reductions could be achieved in both average total user costs and average travel time costs.

Exhibit 11-16

Projected Rural Interstate Conditions and Performance in 2024 for Different Possible Funding Levels



Average Annual Highway Preservation + Expansion Investment (Rural Interstates) (Billions of 2004 Dollars)	Percent Change in Average Total Delay	Total User Costs	Travel Time Costs	Funding Level Description: Investment Required to...
$3.7				2004 Values
$4.1	-20.9%	-1.2%	-0.7%	
$3.9	-17.8%	-1.1%	-0.5%	
$3.6	-13.0%	-1.0%	-0.1%	...Maintain Average Travel Time Costs
$3.3	-7.7%	-0.8%	0.2%	
$3.1	-1.4%	-0.7%	0.7%	...Maintain Average Delay
$2.8	9.1%	-0.4%	1.3%	
$2.6	15.5%	-0.2%	1.7%	
$2.4	22.6%	0.0%	2.2%	...Maintain Average User Costs
$2.2	34.6%	0.5%	2.9%	
$1.9	47.8%	1.0%	3.8%	

Source: Highway Economic Requirements System

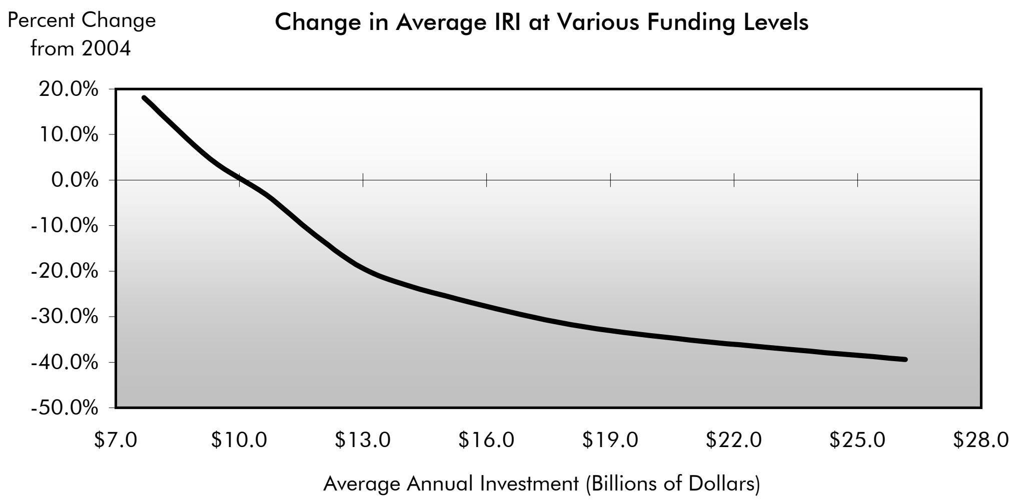
Average delay on rural Interstates would be maintained at an investment level between $2.8 billion and $3.1 billion and would decline by over 13 percent at 2004 rehabilitation and expansion expenditure levels. It should be noted, however, that average delay on rural Interstates is a small fraction of that on urban Interstates and is overwhelmingly related to incident delay. Thus, the large percentage changes in rural delay at different funding levels indicated in Exhibit 11-16 are not as significant as they may appear.

Urban Interstates

Exhibits 11-17 and *11-18* show the impacts on the same measures of conditions and performance for different levels of capital spending on urban Interstates. Exhibit 11-17 shows that an average annual highway rehabilitation investment of between $9.3 billion and $10.6 billion would be required to maintain average IRI at 2004 levels. As with rural Interstates, the percentage of travel on urban Interstate pavements with good or acceptable ride quality would increase at this level of investment.

Exhibit 11-17

Projected Urban Interstate Pavement Condition in 2024 for Different Possible Funding Levels

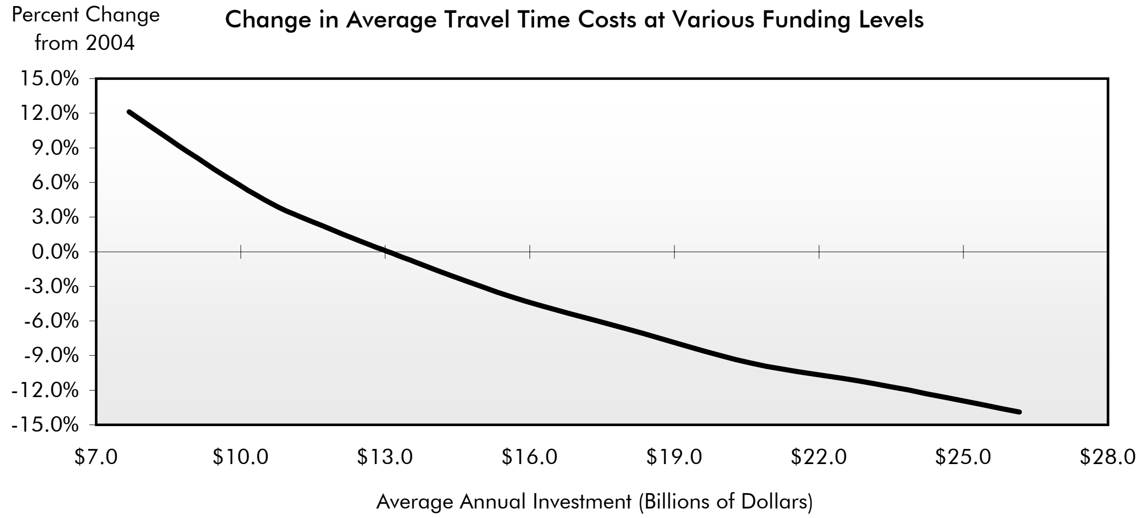


Average Annual Highway Preservation + Expansion Investment (Urban Interstates) (Billions of 2004 Dollars)	Percent Change in Average IRI	Percent of VMT on Roads with IRI<95	Percent of VMT on Roads with IRI<170	Funding Level Description: Investment Required to...
$7.7		**49.5%**	**89.8%**	2004 Values
$26.2	-39.4%	95.0%	99.6%	
$23.1	-37.0%	93.0%	99.4%	
$20.6	-34.7%	91.0%	98.7%	
$18.0	-31.8%	88.1%	98.1%	
$15.6	-26.9%	84.2%	97.0%	
$13.3	-20.5%	79.0%	95.8%	
$11.8	-12.1%	75.2%	94.5%	
$10.6	-3.2%	70.7%	92.4%	...Maintain Average IRI
$9.3	4.7%	66.6%	90.4%	...Maintain VMT with IRI<170
$7.7	18.1%	59.8%	87.4%	

Source: Highway Economic Requirements System.

Exhibit 11-18

Projected Urban Interstate Conditions and Performance in 2024 for Different Possible Funding Levels



Average Annual Highway Preservation + Expansion Investment (Urban Interstates) (Billions of 2004 Dollars)	Percent Change in Average Total Delay	Total User Costs	Travel Time Costs	Funding Level Description: Investment Required to…
$7.7				2004 Values
$26.2	-44.6%	-11.1%	-13.9%	
$23.1	-36.5%	-9.8%	-11.4%	
$20.6	-31.1%	-8.9%	-9.7%	
$18.0	-21.2%	-7.3%	-6.7%	
$15.6	-12.6%	-5.7%	-3.9%	
$13.3	-1.8%	-3.6%	-0.3%	…Maintain Avg Delay and Avg Travel Time Costs
$11.8	3.6%	-2.0%	2.0%	
$10.6	8.6%	-0.6%	4.2%	…Maintain Average User Costs
$9.3	18.5%	1.5%	7.6%	
$7.7	31.0%	4.4%	12.1%	

Source: Highway Economic Requirements System.

If current funding levels were sustained, and the mix of highway rehabilitation and widening investments recommended by HERS were implemented, then average IRI on urban Interstates would be expected to worsen by 18.1 percent, and the percent of VMT on roads with acceptable ride quality would fall slightly, to 87.4 percent. The results suggest that a substantial increase in urban Interstate investment would be necessary to prevent average pavement condition on urban Interstates from deteriorating in the future.

Exhibit 11-18 indicates that an average annual investment level in highway rehabilitation and capacity expansion of between $11.8 billion and $13.3 billion would be needed to maintain average delay on urban Interstates. Total user costs would be maintained at investment levels of about $10.6 billion, and travel time costs on urban Interstates would be maintained at funding levels of about $13.3 billion. These amounts are significantly higher than the comparable 2004 funding level of $7.7 billion. The results suggest that, if average annual funding were maintained (in constant dollars) at 2004 levels through 2024, average delay on urban Interstates would increase by 31 percent, total user costs would increase by 4.4 percent, and travel time costs would increase by 12.1 percent.

Bridge Rehabilitation and Replacement

As described in Chapter 7, the National Bridge Investment Analysis System (NBIAS) model analyzes rehabilitation and replacement investment for all bridges, including those on Interstates. The current Interstate bridge investment backlog is estimated at $19.1 billion.

Exhibit 11-19 describes what the Interstate bridge backlog after 20 years would be at different funding levels. An average annual investment in bridge rehabilitation and replacement of $2.0 billion would be required so that the Interstate bridge investment backlog would not increase above its current level over a 20-year period. An average annual investment of $2.9 billion would be sufficient to eliminate the existing Interstate bridge investment backlog and correct other deficiencies that are expected to develop over the next 20 years, where it is cost-beneficial to do so.

Exhibit 11-19

Projected Interstate Bridge Investment Backlog in 2024 for Different Possible Funding Levels

(Billions of 2004 Dollars)

Average Annual Investment	2024 Interstate Bridge Backlog
$2.9	$0.0
$2.8	$1.9
$2.6	$5.7
$2.4	$10.4
$2.1	$16.2
$2.0	$19.1
$1.8	$23.6
$1.4	$31.0

Source: National Bridge Investment Analysis System.

Exhibit 11-13 indicates that bridge rehabilitation expenditures on Interstates totaled $3.0 billion in 2004. Thus, if this level of funding were maintained in constant dollars over 20 years, NBIAS projects that the Interstate bridge backlog could be eliminated.

Current Spending and Future Investment

Exhibits 11-15 through 11-19 indicate that 2004 levels of highway rehabilitation and system expansion investment on rural Interstates are above the levels necessary to maintain conditions and performance in the future, although there remain significant opportunities for cost-beneficial improvements to the system. The 2004 level of rural and urban Interstate bridge investment would be adequate to address the economic backlog of bridge deficiencies, if that level of investment could be sustained.

On urban Interstates, significant increases in funding for rehabilitation and expansion above current levels would be required to prevent both average physical conditions and operational performance from becoming degraded.

CHAPTER 12

National Highway System

National Highway System

This chapter provides a snapshot of the current physical conditions, operational performance, and finance of the National Highway System (NHS), and projects the potential impacts of future investment on the NHS. The NHS includes the Interstate System as well as other routes most critical to national defense, mobility, and commerce. This chapter represents a supplementary analysis to the information presented for all highways and bridges in Chapters 2 through 9.

Background

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 provided for 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 NHS was limited to 155,000 miles, plus or minus 15 percent.

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 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 (described in Chapter 11), 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), described later in this chapter, which are highways important to military mobilization. The fourth is the system of STRAHNET connectors, also described in this chapter, 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 are highways that provide access between major intermodal passenger and freight facilities and the other four subsystems making up the NHS.

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 has authorized funds for this and other purposes aimed at preserving and improving the NHS.

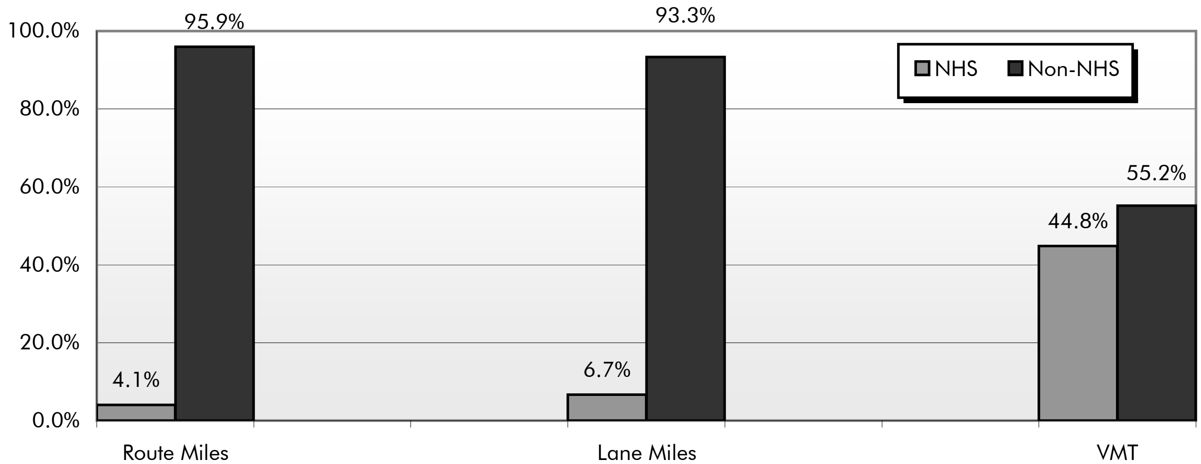
System Characteristics and Conditions

Exhibit 12-1 summarizes NHS route miles, lane miles, and vehicle miles traveled (VMT) for the NHS components. The NHS is overwhelmingly concentrated on higher functional systems. All Interstates are part of the NHS, as are 84.0 percent of rural other principal arterials, 87.5 percent of urban other freeways and expressways, and 35.9 percent of urban other principal arterials. The share of minor arterials, collectors, and local roads on the NHS is relatively small. There are currently 162,158 route miles on the NHS, excluding some sections not yet open to traffic.

Exhibit 12-1

Highway Route Mileage, Lane Mileage, and VMT on the NHS Compared with All Roads, by Functional System, 2004

Percent Comparison: NHS vs. All Other Roads



	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	31,477	100.0%	128,012	100.0%	267,397	100.0%
Other Principal Arterial	80,430	83.8%	214,301	85.9%	211,995	87.9%
Minor Arterial	1,901	1.4%	4,731	1.7%	4,466	2.6%
Major Collector	705	0.2%	1,530	0.2%	1,326	0.7%
Minor Collector	11	0.0%	1,530	0.0%	5	0.0%
Local	37	0.0%	88	0.0%	55	0.0%
Subtotal Rural NHS	**114,562**	**3.8%**	**348,680**	**5.7%**	**485,244**	**45.3%**
Urban NHS						
Interstate	15,359	100.0%	84,016	100.0%	459,766	100.0%
Other Freeway & Expressway	9,016	87.5%	42,431	88.8%	193,155	92.4%
Other Principal Arterial	21,576	35.9%	79,898	38.0%	185,710	40.9%
Minor Arterial	1,200	1.2%	3,676	1.5%	6,347	1.7%
Collector	328	0.3%	902	0.4%	1,238	0.8%
Local	117	0.0%	281	0.0%	246	0.1%
Subtotal Urban NHS	**47,596**	**4.8%**	**211,205**	**9.5%**	**846,463**	**44.5%**
Total NHS	**162,158**	**4.1%**	**559,884**	**6.7%**	**1,331,707**	**44.8%**

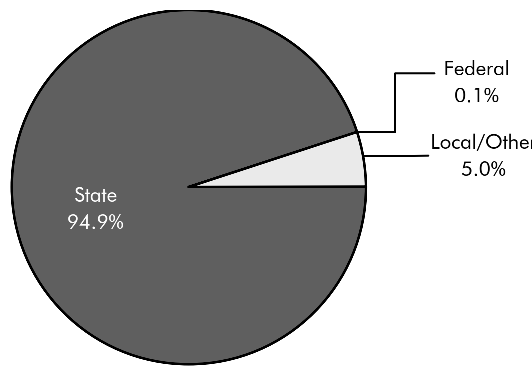
Source: Highway Performance Monitoring System.

While only 4.1 percent of the Nation's total road mileage is on the NHS, these roads carry 44.8 percent of VMT. This represents an increase since 1997, when 43.5 percent of total VMT were on the NHS. The 559,884 lane miles on the NHS in 2002 represent 6.7 percent of the national total, reflecting the fact that NHS routes are wider on average than non-NHS routes.

Exhibit 12-2 describes the ownership of NHS mileage. Approximately 94.9 percent of route miles were State-owned in 2004. Only 5.0 percent were locally owned, and the Federal government owned the remaining 0.1 percent. By comparison, 20.4 percent of all route miles in the United States were State-owned, 76.5 percent were locally owned, and the Federal government owned 3.1 percent. (See the "Highways by Ownership" section of Chapter 2.) Since the NHS is concentrated on higher functional systems, the percentage of locally owned NHS routes is relatively small.

Exhibit 12-2

NHS Mileage by Owner, 2004



Source: Highway Performance Monitoring System.

Pavement Ride Quality

The *Federal Highway Administration 1998 National Strategic Plan* introduced a new descriptive term for pavement condition: "acceptable ride quality." That plan stated that, by 2008, 93 percent of the NHS mileage should meet pavement standards for "acceptable ride quality," which was defined as having an International Roughness Index (IRI) value less than or equal to 170 inches per mile. This goal was accomplished in 1999.

The Federal Highway Administration (FHWA) subsequently revised this metric to be based on the percentage of VMT on NHS pavements with acceptable ride quality. This revised metric placed greater emphasis on the benefits of ride quality to highway users and presented a more challenging performance target.

The FHWA has since adopted an even more exacting performance measure and goal. The new performance measure is the total VMT on the NHS on pavements meeting the standard for "good ride quality," defined as having an IRI value less than 95 inches per mile.

Routes on the NHS tend to have better overall pavement condition than the remainder of the highway system pavement. In 2004, the percent of VMT on NHS routes with good ride quality was 52.0, compared with 40.7 percent for the total highway system.

The percentage of NHS VMT on pavements with good ride quality has risen sharply over time, from 37 percent in 1996 to 52 percent in 2004. The VMT on NHS pavements meeting the less stringent standard of acceptable ride quality grew more slowly, from 89 percent in 1996 to 91 percent in 2004. [*Exhibit 12-3*]

Exhibit 12-3

Percent of NHS VMT on Pavements with Good and Acceptable Ride Quality, 1996 –2004

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Good (IRI<95)	37%	39%	43%	46%	48%	49%	50%	52%	52%
Acceptable (IRI ≤170)	89%	89%	90%	91%	91%	91%	91%	91%	91%

Source: Highway Performance Monitoring System.

Rural NHS routes tend to have better pavement conditions than urban NHS routes, as 68.0 percent of rural NHS VMT was on pavements with good ride quality while 42.5 percent of the urban NHS VMT was on pavements with good ride quality. However, the total traffic in urban areas was higher than in rural areas.

Rural NHS VMT on pavements providing good ride quality increased from 66.6 percent in 2002 to 68.0 percent in 2004. The percent of VMT on rural pavements meeting the standard of acceptable ride quality remained fairly constant between 2002, 96.9 percent, and 2004, 97.0 percent. The percentage of NHS VMT on pavements with good ride quality in urban areas increased from 38.6 percent in 2002 to 42.5 percent in 2004. The urban NHS VMT on acceptable pavements rose slightly from 86.3 percent in 2002 to 86.9 percent in 2004. [*Exhibit 12-4*]

Exhibit 12-4

Percent of VMT on Pavements with Good and Acceptable Ride Quality, by Population Area, 2002 vs. 2004

	2002	2004
Rural		
Good (IRI<95)	66.6%	68.0%
Acceptable (IRI ≤170)	96.9%	97.0%
Urban		
Good (IRI<95)	38.6%	42.5%
Acceptable (IRI ≤170)	86.3%	86.9%

Source: Highway Performance Monitoring System.

Bridges

The National Bridge Inventory (NBI) shows 115,104 bridges on the NHS. This 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 2004. 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.

As shown in *Exhibit 12-5*, approximately 5.6 percent of NHS bridges were classified as structurally deficient in 2004, down from 5.9 percent in 2002. The percentage classified as functionally obsolete also declined, from 17.2 percent in 2002 to 14.9 percent in 2004. The overall percentage of deficient NHS bridges has continued to decline over time, from 28.7 percent in 1995 to 23.0 percent in 2002 and 20.5 percent in 2004. (See the "Bridge System Conditions" section in Chapter 3 for definitions of these deficiency classifications.)

Exhibit 12-5

NHS Bridge Deficiency Percentages, 1995 –2004

	1995	1997	2000	2002	2004
Structurally Deficient	7.9%	7.7%	6.0%	5.9%	5.6%
Functionally Obsolete	20.9%	18.4%	17.7%	17.2%	14.9%
Total	28.7%	26.1%	23.7%	23.0%	20.5%

Source: National Bridge Inventory.

As shown in *Exhibit 12-6*, while 19.4 percent of all bridges were on the NHS, bridges on the NHS represented 14.9 percent of the Nation's total deficient bridges in 2004. Of the total deficient deck area on all bridges in 2004, 46.6 percent was on deficient NHS bridges, which carried 63.4 percent of the travel on deficient bridges. Among structurally deficient bridges, NHS bridges made up only 8.2 percent, but among functionally obsolete bridges, NHS bridges constituted 21.4 percent of the total.

Exhibit 12-6

NHS Bridges Compared with All Bridges, 2004

	NHS as Percent of Total for All Bridges
Total Bridges	
Percent by Number	19.4%
Percent of Deck Area	49.5%
Percent of Travel Carried	71.1%
Structurally Deficient Bridges	
Percent by Number	8.2%
Percent of Deck Area	42.3%
Percent of Travel Carried	62.6%
Functionally Obsolete Bridges	
Percent by Number	21.4%
Percent of Deck Area	49.0%
Percent of Travel Carried	63.7%
Total Deficient Bridges	
Percent by Number	14.9%
Percent of Deck Area	46.6%
Percent of Travel Carried	63.4%

Source: National Bridge Inventory.

Strategic Highway Network

STRAHNET is a network of highways critical to the U.S. Department of Defense's (DoD's) 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 62,250-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 12-7* 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.

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.

As shown in *Exhibit 12-8*, the percent of VMT on STRAHNET on pavements providing "good" ride quality increased from 54.2 percent in 2002 to 56.9 percent in 2004. The percent of VMT on pavements meeting the "acceptable" standard remained fairly constant from 2002, 92.7 percent, to 2004, 93 percent.

Exhibit 12-7

STRAHNET Miles by Functional Class, 2004

	Miles
Rural	
Interstate	31,477
Other Principal Arterial	10,588
Minor Arterial	903
Major Collector	214
Minor Collector	4
Local	18
Subtotal Rural	**43,204**
Urban	
Interstate	15,359
Other Freeway and Expressway	1,533
Other Principal Arterial	1,933
Minor Arterial	188
Collector	28
Local	6
Subtotal Urban	**19,047**
Total	**62,250**

Source: Highway Performance Monitoring System.

Exhibit 12-8

Percent of STRAHNET VMT on Pavements with Good and Acceptable Ride Quality, 2002 vs. 2004

	2002	2004
Rural		
Good (IRI<95)	69.8%	72.2%
Acceptable (IRI ≤170)	97.1%	97.6%
Urban		
Good (IRI<95)	43.1%	47.6%
Acceptable (IRI ≤170)	89.6%	90.3%
Rural and Urban		
Good (IRI<95)	54.2%	56.9%
Acceptable (IRI ≤170)	92.7%	93.0%

Source: Highway Performance Monitoring System.

In 2004, approximately 72,024 bridges were on the STRAHNET system. This was slightly more than 12.1 percent of all bridges on the Nation's roadway system. Approximately 54.3 percent of the STRAHNET bridges were located in rural areas and 45.6 percent were in urban areas.

In 2004, 20.3 percent of the bridges on the STRAHNET system were rated as deficient compared with 20.6 percent in 2002 [*Exhibit 12-9*]. In comparison, 26.7 percent of the bridges on the total roadway system for the Nation were rated as deficient in 2004.

Approximately 4.9 percent of STRAHNET bridges were structurally deficient in 2004, down from 5.2 percent in 2002. About 15.4 percent were functionally obsolete in 2004, up slightly from 15.3 percent in 2002. By comparison, of the Nation's total bridges, 13.1 percent were structurally deficient and 13.6 percent were functionally obsolete in 2004.

Exhibit 12-9

STRAHNET Bridge Deficiency Percentages, 2002 vs. 2004

	2002	2004
Deficient Bridges	20.6%	20.3%
Structurally Deficient Bridges	5.2%	4.9%
Functionally Obsolete Bridges	15.3%	15.4%

Source: National Bridge Inventory.

The structurally deficient bridges were distributed fairly equally between rural and urban areas with approximately 48 percent in rural and 52 percent in urban areas. Rural areas contained approximately 43 percent of the functionally obsolete bridges, while 58 percent were in urban areas.

In 2004, the total deck area of STRAHNET bridges represents more than 32 percent to the Nation's total bridge deck area. The percent of deck area on deficient bridges on STRAHNET was slightly less than 26 percent in 2004. The majority of the deck area on deficient bridges was on functionally obsolete bridges, approximately 18 percent, with the remaining nearly 8 percent being on structurally deficient bridges.

Operational and Safety Performance

Many of the operational performance measures discussed in Chapter 4 are not computed separately for the NHS. However, data for the Daily Vehicle Miles Traveled (DVMT) per Lane Mile metric are available and demonstrate the change in the demand being placed on the NHS. From 2002 to 2004, DVMT per lane mile on the rural NHS decreased from 4,193 to 3,802 and from 11,011 to 10,950 on the urban NHS. The decrease in DVMT per lane mile on the rural NHS can be attributed in part to the transfer of rural lane-miles and the accompanying travel volumes to urban areas due to the urban-rural boundary changes resulting from the 2000 Census. The lane miles that were reclassified from rural to urban would be expected to have a higher than average traffic level for rural areas, so that removing them from the rural category would tend to bring down the rural average DVMT per lane mile. However, these reclassified line miles would also be expected to have lower than average traffic levels for urban areas, so that adding them to the urban category would tend to bring down the urban average as well. This accounts in part for the slight decrease in the DVMT per lane mile on the urban portion of the NHS. (Comparable data for all roads can be found in the "DVMT per Lane Mile" section in Chapter 4).

As stated earlier in this chapter, the NHS carried 44.8 percent of the total VMT on the Nation's roadway system in 2004. The total number of fatalities on the Nation's roadways was 42,636 for 2004. Of these, 13,583, or 31.9 percent, were on the NHS. The fatality rate for 2004 was 1.02 fatalities per 100 million VMT on the NHS, compared with 1.44 per 100 million VMT for all roads.

Finance

Exhibit 12-10 describes highway capital outlay on the NHS by functional system in 2004. Approximately $12.3 billion were spent on NHS rural arterials and collectors in 2004, and another $22.3 billion were spent on urban arterials and collectors on the NHS. Reported State government spending on NHS routes functionally classified as rural local or urban local was negligible in the year 2004. It is not currently possible to identify spending by local government on these routes, which would mainly consist of intermodal connectors and STRAHNET Connectors.

Of the total $34.6 billion spent by all levels of government for the capital improvements to the NHS in 2004, approximately 45.0 percent was used on the Interstate component of the NHS.

Exhibit 12-11 categorizes capital spending on the NHS by type of improvement. System rehabilitation expenditures of $14.8 billion constituted 42.7 percent of total NHS capital spending in 2004. The $17.0 billion spent for system expansion represented 49.3 percent of total NHS capital spending, while the $2.8 billion spent for NHS system enhancement constituted 8.0 percent.

Exhibit 12-10

Highway Capital Outlay on the NHS by Functional System, 2004

Functional Class	Total ($Billions)	Percent of Total NHS
Rural Arterials and Collectors		
Interstate	$4.5	13.0%
Other Principal Arterial	$6.9	19.9%
Minor Arterial	$0.6	1.7%
Major Collector	$0.4	1.0%
Minor Collector	$0.0	0.0%
Subtotal	**$12.3**	**35.6%**
Urban Arterials and Collectors		
Interstate	$11.0	32.0%
Other Freeway and Expressway	$5.5	15.9%
Other Principal Arterial	$5.0	14.6%
Minor Arterial	$0.4	1.1%
Collector	$0.3	0.8%
Subtotal	**$22.3**	**64.4%**
Subtotal, Rural and Urban	**$34.6**	**100.0%**
Rural and Urban Local	**$0.0**	0.0%
Total, All Systems	**$34.6**	**100.0%**

Source: Highway Statistics 2004 and unpublished FHWA data.

The $34.6 billion spent for capital improvements to the NHS in 2004 constituted 49.2 percent of the $70.3 billion identified in Chapter 6 as the total amount of highway capital investment on all roads. Approximately 40.5 percent of total highway rehabilitation investment on all roads was directed toward the NHS, including 16.4 percent directed toward rural NHS routes and 24.2 percent directed toward urban NHS routes.

Of total highway system expansion investment on all roads in 2004, approximately 61.9 percent was directed toward the NHS, including 19.9 percent directed toward rural NHS routes and 42.0 percent directed toward urban NHS routes. Approximately 43.7 percent of total capital expenditures classified as system enhancements on all roads in 2004 was directed toward NHS routes. (See the "Capital Outlay by Improvement Type" section in Chapter 6 for definitions of these improvement types.)

Exhibit 12-11

NHS Capital Expenditures, 2004

	Total Invested (Billions of Dollars)			Percent of Total NHS	NHS Percent of Total Capital Expenditures for All Highways		
	Rural	Urban	Total		Rural	Urban	Total
System Rehabilitation							
Highway	$4.6	$5.4	$10.0	28.8%	17.7%	20.7%	38.4%
Bridge	$1.4	$3.4	$4.8	13.9%	13.0%	32.9%	45.9%
Subtotal	**$6.0**	**$8.8**	**$14.8**	**42.7%**	**16.4%**	**24.2%**	**40.5%**
System Expansion							
Additions to Existing Roadways	$2.9	$4.4	$7.3	21.2%	22.8%	34.3%	57.1%
New Routes	$2.3	$6.3	$8.6	24.8%	17.4%	48.0%	65.4%
New Bridges	$0.3	$0.9	$1.1	3.3%	18.3%	54.6%	72.9%
Subtotal	**$5.5**	**$11.5**	**$17.0**	**49.3%**	**19.9%**	**42.0%**	**61.9%**
System Enhancement	**$0.9**	**$1.9**	**$2.8**	**8.0%**	**13.5%**	**30.2%**	**43.7%**
Total Investment	**$12.3**	**$22.3**	**$34.6**	**100.0%**	**17.5%**	**31.7%**	**49.2%**

Sources: Highway Statistics 2004, Table SF-12A and unpublished FHWA data.

Future Capital Investment and Performance

This section mirrors the investment analysis in Chapter 11 for rural and urban Interstates, expanding it to include the non-Interstate sections of the NHS. Exhibits 12-12 through 12-15 show the impacts of different levels of future capital spending on the physical conditions and operational performance of the rural and urban portions of the NHS. The first line in each exhibit shows current values for each of the measures, and the second line corresponds to the maximum economically efficient level of investment. All investment levels are in constant 2004 dollars.

Exhibits 12-12 and 12-14 show the impact of different levels of combined highway rehabilitation and expansion spending on rural and urban pavement condition, respectively, and Exhibits 12-13 and 12-15 show the impact of these same outlays on measures of rural and urban operational performance. Highway rehabilitation and system expansion investments are modeled by the Highway Economic Requirements System (HERS) (see Appendix A).

Expenditures on system enhancement (including traffic operational improvements, safety improvements, and environmental enhancements) are not directly modeled and are not included in the totals shown in the exhibits. Bridge rehabilitation and replacement investment is discussed separately below.

Rural NHS Routes

Exhibit 12-12 shows projected values for the average IRI and the percentage of VMT at an IRI below 95 ("good" ride quality) and below 170 ("acceptable" ride quality). The exhibit shows that the 2004 rehabilitation and expansion investment level of $10.1 billion on rural NHS routes exceeded the maximum economic investment level of $7.8 billion estimated by HERS. As a result,

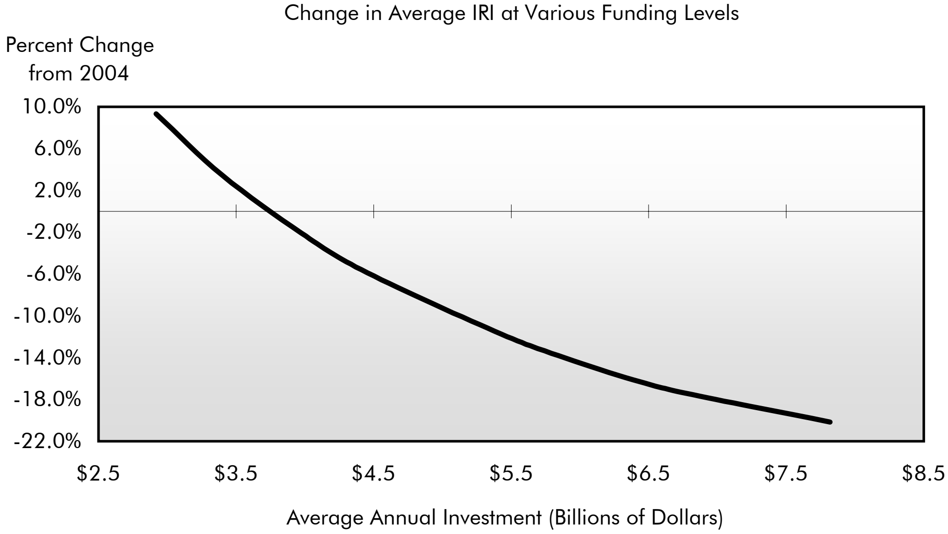
Q&A

Is it possible to spend above the Maximum Economic Investment (Cost to Improve) level in a given year, while still investing only in cost-beneficial projects?

Yes. The values identified in this report for the "Maximum Economic Investment" scenario are average annual values for a 20-year period. There is currently a significant backlog of cost-beneficial improvements that could be made. It would be possible for investment to exceed the Cost to Improve level for several years before this backlog would be exhausted.

Exhibit 12-12

Projected Rural NHS Pavement Condition in 2024 for Different Possible Funding Levels



Average Annual Highway Rehabilitation + Expansion Investment (Rural NHS) (Billions of 2004 Dollars)	Percent Change in Average IRI	Percent of VMT on Roads with IRI<95	IRI<170	Funding Level Description: Investment Required to...
$10.1		**68.4%**	**96.9%**	2004 Values
$7.8	-20.2%	85.2%	99.4%	
$6.8	-17.4%	83.1%	98.9%	
$6.4	-16.1%	82.0%	98.7%	
$5.9	-14.1%	79.9%	98.4%	
$5.4	-11.8%	77.5%	98.0%	
$4.5	-5.9%	70.3%	97.2%	...Maintain VMT with IRI<95
$4.0	-2.1%	65.7%	96.8%	...Maintain Avg IRI
$3.4	3.5%	59.5%	96.2%	
$2.9	9.3%	53.4%	95.2%	

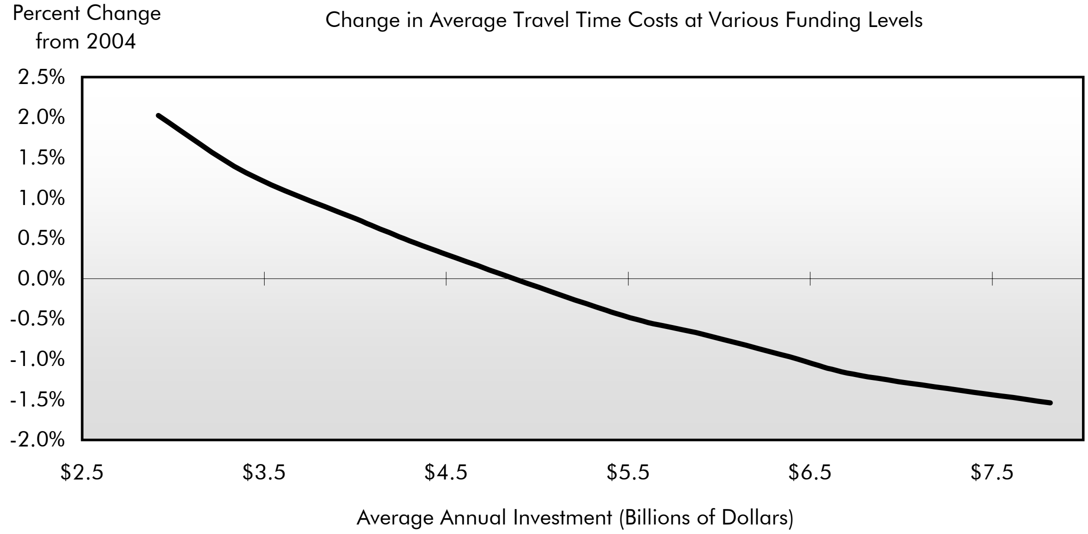
Source: Highway Economic Requirements System.

significant improvements in pavement quality on the rural NHS would be expected if 2004 funding levels were maintained in constant dollars over 20 years. Once the existing backlog of pavement deficiencies is addressed, the model suggests that investments of this type could be cost effectively scaled back. The percent of rural NHS travel on roads with "good" ride quality could be maintained at a funding level of $4.5 billion annually.

Exhibit 12-13 indicates that significant improvements in operational performance on the rural portion of the NHS would also result if the rehabilitation and expansion investment levels for 2004 were continued in the future, with values for average delay per VMT (discussed in Chapter 9), total user costs, and travel time costs all declining by a wide margin. Average user costs on rural NHS routes would be maintained at an average annual investment level of $4.0 billion, while average delay and average travel time costs could be maintained at a funding level of $5.4 billion. As also noted for the rural Interstate component of the NHS in Chapter 11, while the percentage changes in average total delay at various funding levels are large, they are applied to a relatively small base, as delay on the NHS in rural areas is significantly lower than in urban areas.

Exhibit 12-13

Projected Rural NHS Conditions and Performance in 2024 for Different Possible Funding Levels



Average Annual Highway Rehabilitation + Expansion Investment (Rural NHS) (Billions of 2004 Dollars)	Percent Change in Average Total Delay	Percent Change in Total User Costs	Percent Change in Travel Time Costs	Funding Level Description: Investment Required to...
$10.1				2004 Values
$7.8	-16.9%	-2.2%	-1.5%	
$6.8	-13.3%	-1.9%	-1.2%	
$6.4	-10.3%	-1.8%	-1.0%	
$5.9	-7.6%	-1.6%	-0.7%	
$5.4	-4.1%	-1.4%	-0.4%	...Maintain Avg Delay and Travel Time Costs
$4.5	4.5%	-0.8%	0.3%	
$4.0	9.5%	-0.4%	0.8%	...Maintain Average User Costs
$3.4	15.2%	0.1%	1.3%	
$2.9	22.9%	0.7%	2.0%	

Source: Highway Economic Requirements System.

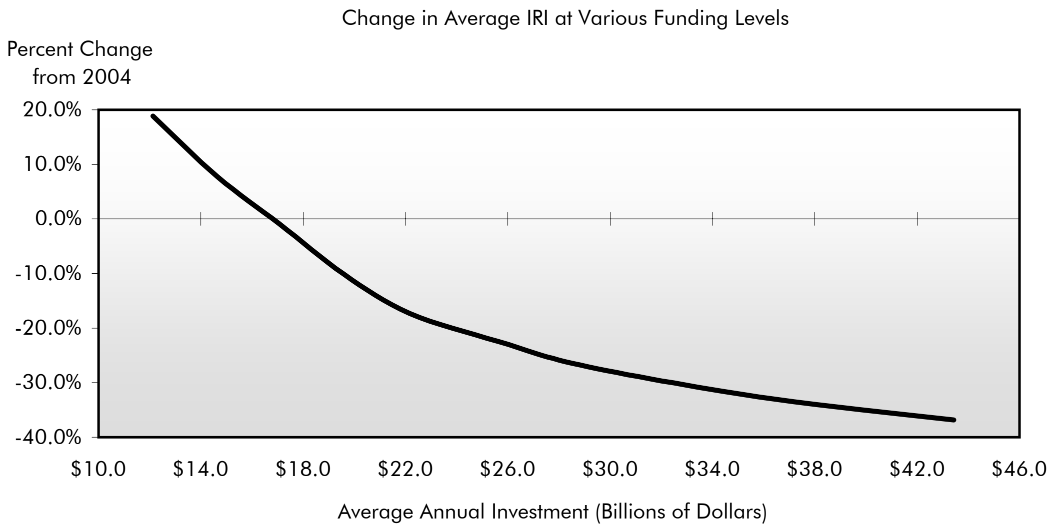
Urban NHS Routes

Exhibit 12-14 shows that the current rehabilitation and expansion investment level of $16.9 billion on urban NHS sections would likely be sufficient to maintain average IRI and the percentage of travel on pavements with "acceptable" ride quality on these sections, assuming the mix of future rehabilitation and capacity investments was consistent with those that HERS has identified. The percentages of travel on urban NHS pavements with "good" ride quality would increase significantly at this level of investment.

Exhibit 12-15 indicates that an average annual investment level in highway rehabilitation and capacity expansion of between $17.1 and $19.6 billion would be needed to maintain average total user costs on urban NHS routes. These amounts are higher than the 2004 level of rehabilitation and expansion expenditure on these roads ($16.9 billion). Funding levels between $19.6 and $22.2 billion annually would be required to maintain average total delay and average travel time costs on the NHS in urban areas. These amounts are approximately $3 billion to $5 billion higher than the comparable 2004 funding. Rehabilitation and expansion funding levels on the urban NHS as a whole are thus much closer (in percentage terms) to the levels that would be needed to maintain performance than is the case for the Interstate portion of the NHS alone.

Exhibit 12-14

Projected Urban NHS Pavement Condition in 2024 for Different Possible Funding Levels



Average Annual Highway Rehabilitation + Expansion Investment (Urban NHS) (Billions of 2004 Dollars)	Percent Change in Average IRI	Percent of VMT on Roads with IRI<95	Percent of VMT on Roads with IRI<170	Funding Level Description: Investment Required to...
$16.9		**44.1%**	**87.8%**	2004 Values
$43.4	-36.8%	88.6%	98.5%	
$36.3	-32.9%	85.0%	97.1%	
$29.1	-27.1%	80.2%	95.2%	
$25.6	-22.4%	76.5%	93.9%	
$22.2	-17.3%	71.7%	92.5%	
$19.6	-10.1%	67.1%	90.6%	
$17.1	-0.9%	61.0%	87.9%	...Maintain Avg IRI and VMT with IRI<170
$14.6	7.7%	55.2%	85.1%	
$12.1	18.9%	49.2%	81.9%	

Source: Highway Economic Requirements System.

Bridge Rehabilitation and Replacement

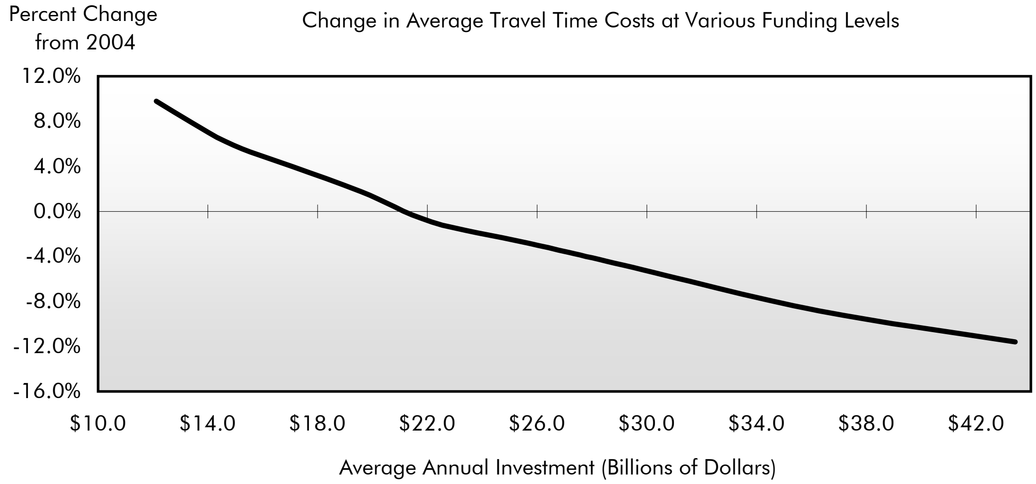
As described in Chapter 7, the National Bridge Investment Analysis System (NBIAS) model analyzes rehabilitation and replacement investment for all bridges, including those on the NHS. The current NHS bridge investment backlog is estimated at $32.1 billion. (See the "Bridge Investment Backlog" section in Chapter 7).

Exhibit 12-16 describes what the NHS bridge backlog after 20 years would be at different funding levels. An average annual investment in bridge rehabilitation and replacement of $3.5 billion in constant 2004 dollars would be required so that the NHS bridge investment backlog would not increase above its current level over a 20-year period. An average annual investment of $5.1 billion is estimated to be sufficient to eliminate the existing NHS bridge investment backlog and correct other deficiencies that are expected to develop over the next 20 years, where it is cost-beneficial to do so.

Exhibit 12-10 indicated that bridge rehabilitation expenditures on the NHS totaled $4.8 billion in 2004. If this level of investment were maintained in constant dollar terms over 20 years, NBIAS projects that the bridge investment backlog would decline to $5.6 billion.

Exhibit 12-15

Projected Urban NHS Conditions and Performance in 2024 for Different Possible Funding Levels



Average Annual Highway Rehabilitation + Expansion Investment (Urban NHS) (Billions of 2004 Dollars)	Percent Change in Average Total Delay	Total User Costs	Travel Time Costs	Funding Level Description: Investment Required to…
$16.9				2004 Values
$43.4	-35.6%	-9.0%	-11.6%	
$36.3	-26.7%	-7.5%	-8.9%	
$29.1	-13.7%	-5.2%	-4.8%	
$25.6	-7.6%	-4.0%	-2.8%	
$22.2	-2.0%	-2.7%	-1.0%	…Maintain Avg Delay and Travel Time Costs
$19.6	5.6%	-1.0%	1.7%	…Maintain Average User Costs
$17.1	11.9%	0.6%	4.0%	
$14.6	18.1%	2.2%	6.2%	
$12.1	27.9%	4.6%	9.8%	

Source: Highway Economic Requirements System.

Current Spending and Future Investment

Exhibits 12-12 through 12-16 indicate that current levels of highway rehabilitation and system expansion investment on rural sections of the NHS are well above the levels necessary to maintain conditions and performance in the future, and even exceed the maximum level of economic investment estimated by HERS. The same is true of current levels of bridge investment relative to the levels identified in NBIAS for maintaining or eliminating the NHS bridge investment backlog. On urban Interstates, maintaining current funding levels for rehabilitation and expansion would be expected to result in improved pavement quality, but a slight decline in overall operational performance.

Exhibit 12-16

Projected NHS Bridge Investment Backlog in 2024 for Different Possible Funding Levels

(Billions of 2004 Dollars)

Average Annual Investment	2024 NHS Bridge Backlog
$5.1	$0.0
$4.8	$5.6
$4.6	$11.1
$4.4	$15.0
$3.9	$24.2
$3.5	$32.1
$3.1	$40.1
$2.6	$52.5

Source: National Bridge Investment Analysis System.

CHAPTER 13

Innovative Finance

Innovative Finance

While the traditional financing mechanisms discussed in Chapter 6 provide most of the funding that supports surface transportation, innovative financing mechanisms are playing an increasingly important role. This report defines "Innovative Finance" broadly, reflecting a wide array of techniques designed to supplement traditional financing mechanisms.

Innovative finance techniques include a series of administrative and legislative initiatives undertaken in recent years designed to accelerate surface transportation project development and expand the base of available resources by (1) removing barriers to private investment; (2) bringing the time value of money into Federal program decision making; (3) encouraging the use of new revenue streams, particularly to retire debt obligations; and (4) reducing financing and related costs, thus freeing up savings for transportation system investment. These financing initiatives and techniques, which are commonly used in the private sector, are relatively new to Federally-aided transportation funding and are thus frequently referred to collectively as "innovative finance."

Innovative finance concepts have evolved over time. The Intermodal Surface Transportation Efficiency Act (ISTEA) and Transportation Equity Act for the 21st Century (TEA-21) laid the foundations for several new concepts designed to fund transportation investment. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) has continued the development of innovative financing mechanisms, including credit assistance, innovative debt financing, and **Public-Private Partnerships**. The current status of these programs is described in more detail below.

Previous editions of the C&P report have included discussions of private investment and other innovative funding sources in Chapter 6. This discussion was moved to a stand-alone chapter in this edition to highlight the growing importance of these revenue sources. However, it is important to recognize that the revenue sources described in this chapter overlap those in Chapter 6. For example, for statistical reporting purposes, State governments are instructed to include contributions from private developers as part of their miscellaneous receipts for highways. Thus, the figures presented here are not additive to those in Chapter 6. While this report does not endorse any particular level of future highway or transit investment and does not assign cost responsibility by level of government, it is clear that **the quality of the future conditions and performance of the Nation's transportation system may depend to a significant degree on the success of efforts to leverage public funds with private investments**, such as those described in this chapter.

Credit Assistance

Federal credit assistance for transportation projects takes various forms and can provide an efficient means of utilizing scarce Federal budget authority. Secured (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. Two of the most significant Federal credit assistance programs, introduced in recent years, the Transportation Infrastructure and Finance Innovation Act (TIFIA) and the State Infrastructure Bank (SIB) programs, are discussed below, along with Section 129(a) loans.

Transportation Infrastructure and Finance Innovation Act (TIFIA)

The TIFIA program was created under TEA-21, and reauthorized under SAFETEA-LU. The program is administered by the U.S. Department of Transportation (DOT), and offers eligible applicants the opportunity to compete for secured (direct) loans, loan guarantees, and standby lines of credit for up to one-third of the cost of construction for nationally and regionally significant projects, provided that the borrower has an associated revenue stream, such as tolls or local sales taxes, that can be used to repay the debt issued for the project. To qualify, a project must meet certain dollar thresholds, reflecting congressional intent to assist major projects that are able to attract substantial private capital with limited Federal investment. These eligibility thresholds were reduced under SAFETEA-LU. Under the new criteria, projects must have eligible costs that total at least $50 million or exceeded 33 percent of a State's Federal-aid highway apportionments for the most recent fiscal year, whichever is smaller. Intelligent transportation system projects are subject to a lower minimum threshold of $15 million.

Through July 2006, the 12 projects receiving commitments of TIFIA credit assistance represented more than $13.2 billion of infrastructure investment in the United States. The 13 credit agreements (one project has multiple agreements) executed or under negotiation amounted to almost $3.2 billion in Federal credit assistance at a budget cost of less than $190 million in contract authority. Borrowers have drawn about 20 percent of the TIFIA proceeds made available through these agreements. No TIFIA borrower has defaulted on a loan repayment. Since June 2002, five borrowers have retired their TIFIA loans, either by early repayment or by refinancing the loan prior to draws. *Exhibit 13-1* displays key information about the TIFIA projects, which include highway toll roads and bridges, transit systems, rails stations, ferry terminals, and intermodal facilities.

Exhibit 13-1

Financial Performance of TIFIA-assisted Projects (as of July 15, 2006)

Credit Agreement	Location	Status	Project Cost	TIFIA Amount	Amount Disbursed	Percent Disbursed	Project Completion
Tren Urbano	Puerto Rico	Paid In Full	$2,250,000,000	$300,000,000	$300,000,000	100.00%	6/6/05
Miami Intermodal Center [1]	Florida	Paid In Full	1,349,700,000	269,076,000	15,000,000	5.57%	4/18/09
Cooper River Bridges	South Carolina	Refinanced	677,000,000	215,000,000	0	0.00%	7/9/05
Staten Island Ferries	New York	Paid In Full	482,200,000	159,225,300	159,161,429	99.96%	7/1/06
Reno ReTRAC	Nevada	Paid In Full	279,900,000	50,500,000	50,500,000	100.00%	11/18/05
Central Texas Turnpike [2]	Texas	Active	3,659,900,000	916,760,000	0	0.00%	12/1/07
WMATA Capital Program [3]	DC, VA, MD	Active	2,324,000,000	600,000,000	0	0.00%	6/30/09
Miami Intermodal Center [4]	Florida	Active	[5]	170,000,000	0	0.00%	6/30/07
SR 125 South Toll Road	California	Active	628,800,000	140,000,000	102,268,025	73.05%	12/1/07
183 A Toll Road [2]	Texas	Active	331,200,000	66,000,000	0	0.00%	3/1/07
LA-1 Project [2]	Louisiana	Active	247,300,000	66,000,000	0	0.00%	8/1/09
Warwick Intermodal Station	Rhode Island	Active	222,300,000	42,000,000	0	0.00%	10/1/09
Moynihan Station	New York	Term Sheet	795,000,000	160,000,000	0	0.00%	tbd
Total			**13,247,300,000**	**3,154,561,300**	**626,929,454**	**19.87%**	

[1] The first of two Miami Intermodal Center (MIC) loans helped finance elements constructed by Florida DOT.

[2] Disbursements will occur near the project's completion date in order to refinance short-term Bond Anticipation Notes (BANs).

[3] The TIFIA assistance is a loan guarantee. Disbursements would only occur if the borrower is unable to repay its third-party loan.

[4] The second of two MIC loans helps finance construction of a consolidated rental car facility.

[5] The project cost is incorporated into the cost of the first MIC loan.

Source: *Transportation Infrastructure Finance and Innovation Act Report to Congress*, July 2006.

State Infrastructure Banks (SIBs)

Section 350 of the National Highway System Designation Act of 1995 (NHS Act) authorized DOT 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. SAFETEA-LU established a new SIB program under which all States and territories are authorized to enter into cooperative agreements with the Secretary of Transportation to establish infrastructure revolving funds eligible to be capitalized with Federal transportation funds authorized for 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.

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 fiscal years 2005 through 2009.

Exhibit 13-2 reflects the number of SIBs loans and loan agreements by State. As of June 2005, $5.1 billion in loan agreements had been made by 33 States, of which $3.7 billion had been disbursed for 457 loan agreements. Twenty-one States had signed SIB cooperative agreements with the Federal Transit Administration (FTA), and eight had executed at least one public transit loan. Total SIB public transit loan activity was equal to $94.5 million.

SIB transit funds may be used to assist a variety of transit capital projects, such as facility construction, asset purchase and rehabilitation, or asset leasing. Each SIB (subject to the negotiated term of its cooperative agreement with the FTA) has the ability to offer diverse forms of credit assistance for these projects, such as direct loans, loan guarantees, subsidized interest rates, loan subordination, or bond insurance. The eight States that have executed public transportation SIB loans are assisting $318.7 million in projects. Many of the loans have assisted communities with local project match requirements, enabling local governments to accelerate the implementation of transportation infrastructure and services that might otherwise have been postponed.

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 a means to recycle Federal-aid highway funds by lending them out to pay for projects with dedicated revenue streams, obtaining repayments from project revenues, 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 generating a toll or that have some

Exhibit 13-2

State Infrastructure Bank Loans and Loan Agreements by State, as of June 2005

State	Number of Agreements	Loan Amount ($000)	Disbursements
Alaska	1	2,737	2,737
Arizona	49	564,000	474,000
Arkansas	1	31	31
California	2	1,120	1,120
Colorado	4	4,400	1,900
Delaware	1	6,000	6,000
Florida	50	867,000	281,000
Indiana	2	5,715	5,715
Iowa	2	2,879	2,879
Maine	23	1,635	1,635
Michigan	33	22,207	22,207
Minnesota	17	102,776	96,447
Missouri	15	92,557	82,770
Nebraska	2	6,792	6,792
New Mexico	4	25,216	17,815
New York	10	27,700	27,700
North Carolina	2	1,713	1,713
North Dakota	2	3,891	3,891
Ohio	70	221,739	177,379
Oregon	19	34,394	25,052
Pennsylvania	62	39,000	24,000
Puerto Rico	1	15,000	15,000
Rhode Island	1	1,311	1,311
South Carolina	8	2,605,000	2,092,000
South Dakota	3	28,776	28,776
Tennessee	1	1,875	1,875
Texas	54	277,237	260,358
Utah	1	2,888	2,888
Vermont	2	1,975	1,300
Virginia	1	18,000	17,985
Washington	3	2,376	487
Wisconsin	3	1,813	1,813
Wyoming	8	77,977	42,441
Total	**457**	**5,067,730**	**3,729,017**

other dedicated revenue such as excise, sales, property, and motor-vehicle taxes and other beneficiary fees, so 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 Federal Highway Administration (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 the opportunity to get more mileage out of annual apportionments. Since Federal funds are cycled through a section 129 loan and such loans 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 to be used to fund any project eligible for funding under Title 23 and as a means of credit enhancement (in the form of bond insurance or capital reserve for project debt).

Q&A

What are some other innovative finance techniques being used as part of the Federal-aid Highway Program?

When trying to accelerate project construction, States often face challenges in aligning funding needs and availability. To address this, grant management tools commonly referred to as "cash flow tools" are being utilized to broaden a State's options for meeting matching requirements and to relax the timing restrictions placed on obligating funds.

Advance construction (AC) allows States to seek approval and begin Federal-aid highway projects using their own funds before any Federal funds have been obligated. An AC project may be "converted" to Federal assistance, either in stages or in its entirety, once there is sufficient Federal-aid funding and obligation authority for the project. Through December 2004, projects totaling over $1.2 billion had entered into AC agreements.

Other cash flow management tools available to States include flexible match, tapered match, or the use of toll credits to meet the local financing share requirements for Federal-aid highway projects.

Debt Financing

Because of their complexity, cost, and lengthy design and construction periods, transportation projects are often financed by issuing bonds. Repayment of the bonds over several years has traditionally been covered by sources such as State and local taxes or revenue generated from highway user fees. More recently, highway and transit project sponsors have begun issuing debt instruments called Grant Anticipation Notes (GANs), backed by anticipated grant moneys. Grant Anticipation Revenue Vehicles (GARVEEs) are a particular form of GAN being used for transportation projects.

Grant Anticipation Revenue Vehicle (GARVEE)

GARVEE bonds permit an expanded variety of debt issuance expenses to be reimbursed with anticipated Federal funds. In addition to traditional debt service (principal and interest), expenses such as underwriting fees, bond insurance, and financial counsel are also eligible for reimbursement. Prior to the NHS Act of 1995, eligible reimbursement expenses were limited to principal repayment and were restricted to certain categories of construction projects. Debt instruments issued by special purpose nonprofit corporations (classified as 63-20 corporations by the Internal Revenue Service) may be repaid with Federal-aid funds if the bonds are issued on behalf of the State and the proceeds are used for projects eligible under Title 23. As of May 2006, the amount of GARVEE debt issued nationally had reached about $5 billion [*Exhibit 13-3*]. As of December 2005, transit grant anticipation debt had exceeded $3.5 billion.

GARVEEs have become facilitators in the creation of public-private partnerships. They expand access to capital markets, supplementing general revenue bonds, and provide immediate and reliable sources of funding, making large projects possible and allowing construction to begin more quickly—all of which attract greater private sector involvement because of the GARVEE's ability to yield immediate influxes of up-front capital for major highway projects in the form of bond proceeds at tax-exempt rates.

Exhibit 13-3

GARVEE Transactions to Date, as of May 2006

State	Number of Issue	Issues (Millions)	Rating Moody's/S&P/Fitch	Projects Financed	Backstop
Alabama	Apr-02	$200.0	Aa3/A/na	County Bridge Program	All Federal construction reimbursements. Also insured.
Alaska	Apr-03	$102.8	Aa2/AA/AA	Eight Road and Bridge Projects	Full faith and credit of state.
Arkansas	Mar-00 Jul-01 Jul-02	$175.0 $185.0 $215.0	Aa2/AA/na Aa2/AA/na Aa2/AA/na	Interstate Highways	Full faith and credit of state, plus state motor fuel taxes.
Arizona	Jun-00 May-01 Jul-03 ** May-04 Oct-04	$39.4 $142.9 $122.7 $51.0 $104.4	Aa3/AA-/AA- Aa3/AA-/AA- Aa3/AA-/AA- Aa3/AA-/AA Aa3/AA-/AA	Maricopa freeway projects	Certain sub-account transfers.
California	Mar-04	$615.0	Aa3/AA-/AA-	Eight Road Projects	Insured except 2005 series
Colorado *	May-00 Apr-01 Jun-02 Aug-03 May-04	$537.0 $506.4 $208.3 $100.0 $135 .0	Aa3/AA/AA Aa3/AA/AA Aa3/AA/AA Aa3/AA/AA Aa3/AA/AA	Any project financed wholly or in part by Federal funds	Federal highway funds as allocated annually by CDOT; Other state funds.
Kentucky	May-05	$139.60	Aa3 / AA-/AA-	Three Interstate widening and rehabilitation projects	No backstop; bond insurance obtained.
Maine	Dec-04	$48.4	Aa3/NA/AA-	Replacement of the Waldo-Hancock Bridge	No backstop; bond insurance obtained.
Montana	Mar-05	$122.8	Aa3/A+	44 miles of US 93 improvements	No backstop; bond insurance obtained.
New Mexico	Sep-98 Feb-01	$100.2 $18.5	Aa A2/A/na	New Mexico SR 44	No backstop; bond insurance obtained.
North Dakota	Jun-05	$51.40	AA1/AA/na	Highway and bridge projects	Bond insurance obtained
Ohio	May-98 Aug-99 Sep-01 Sep-02 Jan-04	$70.0 $20.0 $100.0 $135.0 $113.8	Aa3/AA-/AA- Aa3/AA-/AA- Aa3/AA/AA- Aa3/AA/AA- Aa3/AA/AA-	Various projects including: Spring-Sandusky and Maumee river improvements	Moral Obligation pledge to use state gas tax funds and seek general fund appropriations in the event of Federal shortfall.
Oklahoma***	3/4/2004 8/1/2005	47.6 48.9	Aa3/na/A+ Aa3/na/A+	Projects in 12 corridors	None
Puerto Rico	Apr-04	$136.0	A2/A/na	Various Transportation Projects	Mix of tax and fee revenue
Rhode Island	11/3/2003 03/06/06	$217.0 $184.6	Aa3/A+/AA- Aa3/A+/AA-	Freeway, Bridge and Freight Rail Improvement Projects	None
Virgin Islands	Oct-02	$20.8	na/na/AAA	Enighed Pond Port Project and Red Hook Passenger Terminal Building	Insured
Total		**$4,963.1**			

* Colorado DOT issued $400.2 million in June 2002 and $280.2 in May 2004 to refund prior bonds.
** Excludes $26.3 million in proceeds used to refund outstanding June 2000 bonds
*** With premiums on net proceeds worth $50 million

Public-Private Partnerships

States are increasingly looking to the private sector as a potential source of highway and transit funding, either in addition to or in concert with new credit and financing tools. The private sector often has expertise that may not be readily available in the public sector that can bring innovation and efficiency to many projects. There is a long history of private

Q&A

What is a public-private partnership?

A public-private partnership (PPP) is a broad term that collectively refers to contractual agreements formed between public and private sector partners, where the private sector partner steps outside of its traditional role and becomes more active in making decisions as to how a project will be completed.

sector involvement in providing highway transportation dating back to the late 1700s and early 1800s when numerous private toll roads were built to open interior areas of the country for commerce and settlement. In more recent times, private residential and commercial real estate developers have contributed directly to the growth of the transportation network by constructing local property access roads and upgrading adjacent collector or arterial routes, or by paying impact fees to local governments for use in improving the regional transportation system.

While private sector involvement in highway financing and construction slowed somewhat with the advent of dedicated public funding for highways, there has been renewed interest in private sector involvement in highway construction programs in recent years as highway budgets have been stretched. A variety of institutional models are being used including (1) concessions for the long-term operation and maintenance of individual facilities or entire highway systems; (2) purely private sector highway design, construction, financing, and operation; and (3) public-private partnerships in designing, constructing, and operating major new highway systems. While a few States currently account for the majority of private sector financing, many more States have expressed interest in the potential for greater private sector involvement.

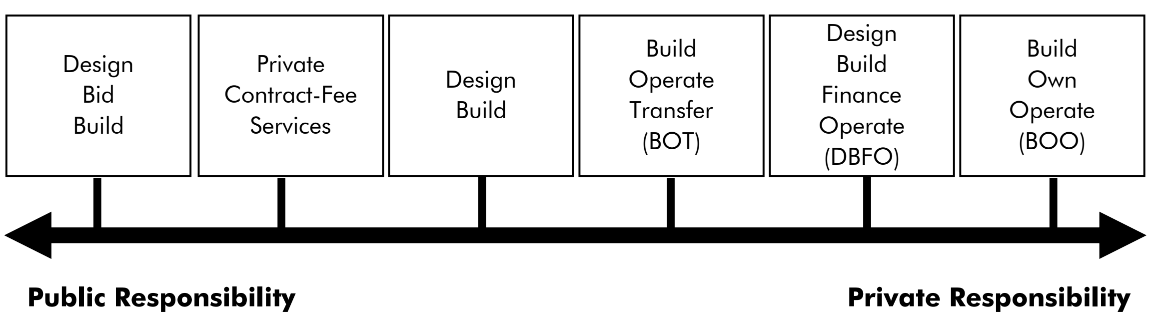
Public-Private Partnership Options

Exhibit 13-4 depicts some of the more common PPP options currently being utilized in the United States, showing how the range of responsibilities shifts from the public sector to the private sector with different PPP options. Options for PPPs stretch across a spectrum of increased private responsibilities and range from transferring tasks normally done in-house to the private sector, to combining typically separate services into a single procurement or having private sector partners assume owner-like roles.

Traditionally, private sector participation in surface transportation projects has been limited to separate planning, design, or construction contracts, but the PPP options shown here depict the ways in which private sector responsibilities can be expanded through the use of partnerships. The services and responsibilities for PPPs differ from one project to another because of the many different PPP options and the combinations in which they may be utilized.

Exhibit 13-4

Public-Private Partnership Options and Range of Responsibility



Public-Private Partnership Agreements

This section provides examples of four PPP Agreements, the legal document establishing the rights and obligations of transportation infrastructure owners and their private sector partners to develop PPP projects; agreements also describe the service to be provided, standards to be maintained, and the business and financial relationships between public agencies and their private sector partners.

Q&A

What are some examples of the more common public-private partnership options in the United States?

- Design-Bid-Build. Design-bid-build models segregate design and construction responsibilities by awarding them to an independent private engineer and a separate private contractor, separating the delivery process into three linear phases: (1) Design, (2) Bid, and (3) Construction.
- Private Contract-Fee Services. In order to tap technical, management, and financial planning expertise readily available to the private sector, an increasing number of public agencies are transferring responsibility for services they would typically perform in-house to private sector companies, through the awarding of competitively procured contracts to the bidder providing the best value, reflecting both price and technical qualifications.
- Design-Build. Design-build combines two usually separate services into a single contract as a method of project delivery. In a design-build procurement, owners execute a single, fixed-fee contract for both architectural/engineering services and construction to a design-build entity; a design-build entity may be a single firm, a consortium, joint venture, or other organization assembled for a particular project.
- Build-Operate-Transfer (BOT)/Design-Build-Operate-Maintain (DBOM). BOT/DBOM or "turnkey procurement," is an integrated partnership that combines the design and construction responsibilities of design-build procurements with operations and maintenance, so that design, construction, and operation of a facility or group of assets can be transferred to a private sector partner.
- Design-Build-Finance-Operate (DBFO). The DBFO approach bundles and transfers the responsibilities for designing, building, financing, and operating to private sector partners. There is a great deal of variety in DBFO arrangements in the United States, especially the degree to which financial responsibilities are actually transferred to the private sector.
- Build-Own-Operate (BOO). Under the BOO model, 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.

South Bay Expressway (California State Route 125)

After being on the drawing board for more than two decades, the South Bay Expressway successfully obtained financing in the amount of $773 million and will now be built, creating a major transportation corridor that will facilitate increasing traffic and trade across the U.S.-Mexico border crossing at Otay Mesa with Chula Vista and other suburbs east of San Diego.

With completion expected in the first quarter of 2007, the South Bay Expressway is one of the few private toll roads to be financed in the United States in recent years. The project is being advanced under a concession agreement between the California Department of Transportation and the San Diego Expressway Limited Partnership (SDELP), a wholly owned subsidiary of project sponsor Macquarie Infrastructure Group. Macquarie, who has invested more than $150 million in the South Bay Expressway project, acquired the project from the prior owners and developed an integrated financing and security package incorporating private equity, senior bank debt, and significant public investment. A portion of the public investment came in the form of donated right-of-way; the remainder came in the form of a $140 million TIFIA loan, without which the project most likely would not have advanced.

Under the South Bay Expressway concession, the SDELP will design, finance, construct, and then operate the toll road for a 35-year period. The concession, which was granted by CALTRANS in 1991, allows the

SDELP flexibility in setting tolls. In addition to the $635 million South Bay Expressway, Macquarie will manage the construction of two sections (the 1.9-mile connection to S.R. 125 North and the 1.2-mile connection to S.R. 54) of untolled government-funded road at a cost of $138 million.

This TIFIA project, advanced with substantial private equity and bank loans, demonstrates how innovative Federal financing tools can attract private investment to critical transportation projects.

Chicago Skyway

In January 2005, the City of Chicago announced that it had entered into an agreement with the Cintra-Macquarie consortium to lease the 7.8-mile Chicago Skyway Toll Bridge System for 99 years; under the lease agreement Cintra-Macquarie paid the City of Chicago $1.83 billion for the rights to operate and collect tolls on the Chicago Skyway. The privatization of the Skyway, an existing toll road, is the first agreement of its kind in the United States. The lease agreement establishes maximum toll rates and sets performance standards that must be maintained on the facility. The Cintra-Macquarie consortium will be responsible for all operating and maintenance costs of the Skyway and will have the right to all toll and concession revenue.

Trans Texas Corridor (TTC-35)

In March 2005, the Texas Department of Transportation and Cintra-Zachary, an international consortium of engineering, construction, and financing firms, signed an agreement to develop the Trans Texas Corridor (TTC-35). Under the agreement, Cintra-Zachary will invest $6 billion to build a toll road between Dallas and San Antonio by 2010 and pay the State $1.2 billion for the concession and negotiate a 50-year contract to maintain and operate the new highway as a toll road.

Indiana Toll Road

The Indiana Toll Road is a 157-mile roadway that runs from Ohio to Chicago across the northern part of Indiana. In March 2006, Indiana agreed to lease the Indiana Toll Road to the Cintra-Macquarie consortium. Under the agreement, Indiana will lease the toll road to Cintra-Macquarie for 75 years in exchange for a lump sum payment of $3.8 billion, which the State will invest in infrastructure improvements.

Special Experimental Project No. 15 (SEP-15)

SEP-15 is a new experimental process within FHWA to identify, for trial evaluation, new PPP approaches to project delivery. SEP-15 is designed to allow the FHWA to identify regulations that currently inhibit the creation of Public-Private Partnership and private investment in transportation improvements, yet at the same time allowing the FHWA to develop

Q&A

What is required to participate in a SEP-15 experiment?

All SEP-15 applications must be submitted by a State department of transportation to its FHWA Division Office. Although localities and private transportation ventures may be joint project sponsors, the State department of transportation should be the primary sponsor. All applications must contain a brief description of the project, any proposed experimental techniques, and the reasons why the experiment is sought. Experimental techniques may involve changes to the FHWA's traditional project approval procedures, modifications in the implementation of FHWA policy, or deviation from current Title 23 requirements for Federal-aid projects.

At various milestones during the experiment, both public and private sector sponsors must independently prepare and submit reports summarizing the experiment that was undertaken and the lessons learned from the SEP-15 process. Sponsors must also evaluate the process, including whether or not it was successful and the impact that it had on the project, and make recommendations for statutory or regulatory changes to the process that would expedite the successful delivery of Federal-aid projects.

Q&A

What additional tolling authority is available under SAFETEA-LU?

New provisions in SAFETEA-LU that provide States with expanded authority and increased flexibility to use tolling on highways are as follows:

- Under the **Interstate System Construction Toll Pilot Program**, a State may collect tolls on Interstate highways, bridges, or tunnels for the purpose of constructing new Interstate highways; the program is limited to three projects in total nationwide.
- The **Express Lane Demonstration Program** allows States, public authorities, or public or private entities to apply for participation in projects (15 total nationwide) that would permit the automated collection of tolls on existing toll facilities, existing High Occupancy Vehicle (HOV) facilities, and newly created toll lanes to demonstrate the impact that tolling can have on managing high levels of congestion, reducing emissions in non-attainment and maintenance areas, and financing the addition of Interstate lanes for the purpose of reducing congestion. Tolls charged on 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 the strides made with passage of ISTEA, the NHS Act of 1995, and TEA-21 in increasing the flexibility that States have to levy tolls on highways.

- The Congestion Pricing Pilot Program, established under Section 1012(b) of ISTEA, was reborn in the form of the Value Pricing Pilot Program under Section 1216(a) of TEA-21. The **Value Pricing Pilot Program** was mandated as an experimental program by Congress to examine the potential effects that different value pricing approaches would have on congestion reduction. SAFETEA-LU continues the Value Pricing Pilot Program basically unchanged from its authorization under TEA-21. For additional information on the Value Pricing Pilot Program, visit http://www.fhwa.dot.gov/tolling_pricing/.
- The **Interstate System Reconstruction and Rehabilitation Toll Pilot Program** was established under Section 1216(b) of TEA-21 as a construction revenue source and allowed tolling on up to three existing Interstate facilities (highway, bridge, or tunnel) to fund needed construction or rehabilitation on Interstate highway corridors where work had halted because the estimated improvement costs exceeded available funding and could not otherwise be adequately maintained or functionally improved. SAFETEA-LU makes no revision to this program.

procedures and approaches to address these impediments. It is anticipated that these new approaches will increase project management flexibility, encourage innovation, improve timely project construction, and generate new revenue streams for Federal-aid transportation projects, allowing for the efficient delivery of transportation projects without impairing the FHWA's ability to carry out its stewardship responsibilities to protect both the environment and American taxpayers.

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.

Private Activity Bonds

SAFETEA-LU amended the Internal Revenue Code to include highway facilities and surface freight transfer facilities among the types of privately developed and operated projects that can utilize tax-exempt private activity bond financing. The new bonds would be subject to the Internal Revenue Code rules that govern exempt facility bonds, except that they would not count against a State's private activity bond volume cap. The maximum aggregate amount of bonds that could be issued under the provision would be $15 billion. The Secretary of Transportation would allocate the $15 billion of authority among eligible projects. Highway facilities eligible for financing under the program would consist of any surface transportation project eligible for Federal assistance under Title 23, or any project for an international bridge or tunnel for which an international entity authorized under Federal or State law is responsible. Surface freight transfer facilities would consist of facilities for the transfer of freight from truck to rail or rail to truck, including any temporary storage facilities directly related to those transfers. Examples of eligible surface freight transfer facilities would include cranes, loading docks, and computer-controlled equipment that are integral to such freight transfers. Examples of nonqualifying facilities would include lodging, retail, industrial, or manufacturing facilities. A number of States have expressed interest in applying for an allocation of these funds. As of December 2006, about $1.9 billion had been allotted for a highway concession in Texas.

Other Initiatives

In the last few years, the USDOT has undertaken a number of initiatives to help remove barriers and increase the role of the private sector in highway construction, operation, and maintenance, such as conducting outreach workshops to facilitate knowledge exchange between State governments and the private sector; case studies on how States and local governments have overcome institutional barriers to PPP implementation; and the development and launch of the PPP Web site that contains links to many PPP resources, both domestic and international.

Q&A

What are some non-finance related provisions in SAFETEA-LU that will assist in attracting private sector investment?

SAFETEA-LU modified the current Design-Build provisions to allow transportation agencies to proceed with certain actions related to entering into a design-build contract prior to the completion of the National Environmental Policy Act process. The change is designed to encourage Public-Private Partnerships by allowing private sector partners to be involved much earlier in the project definition stage of project development. SAFETEA-LU also eliminates the $50 million floor on the size of eligible design-build contracts.

Other SAFETEA-LU provisions that will encourage private sector involvement in highway infrastructure projects include a new environmental review process and the establishment of pilot programs where States assume all USDOT environmental responsibilities under NEPA and other environmental laws. Additional information on the new environmental review process and the new pilot programs is available in Fact Sheets for Highway Provisions in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) at http://www.fhwa.dot.gov/safetealu/factsheets/factsheets-safetea-lu.pdf.

In December 2004, the USDOT issued a *Report to Congress on Public-Private Partnerships*, a source of information on the value that these types of partnerships can add to our nation's transportation system that included quantifiable cost and time savings; anecdotal evidence suggesting that quality and innovation increase by involving the private sector in the early stages of a project; and case studies. The FHWA also published the *Manual for Using Public-Private Partnerships on Highway Projects*, intended to provide a one-stop resource for States interested in pursuing PPPs.

The PPP Web site created by the FHWA contains examples of different types of PPPs, case studies, a resource library, and links to other PPP Web sites in order to provide a comprehensive, electronic source of information to States and the public. Both the *Report to Congress on Public-Private Partnerships* and the *Manual for Using Public-Private Partnerships on Highway Projects* can be found on the PPP Web site at http://www.fhwa.dot.gov/ppp.

CHAPTER 14

Freight Transportation

Freight Transportation

A Federal Committee established in 1944 the vision for what became the Interstate System. Its findings were documented in *Interregional Highways: Message from the President of the United States Transmitting A Report of the National Interregional Highway Committee Outlining and Recommending a National System of Interregional Highways* (78th Congress, 2nd Session, House Document 379, Committee on Roads, January 12, 1944. Page 18). One part of that vision was "...the Committee does not suggest that there is need of special highway facilities for the accommodation or encouragement of long-distance trucking. ... The probable early development of an efficient commercial air-freight service, together with the keener competition of a rejuvenated rail service, would seem to forecast a future shortening rather than lengthening of average highway-freight hauls."

Contrary to that forecast, long-distance trucking grew dramatically with the development of the Interstate Highway System. By 2002, approximately 525,000 trucks (excluding pickups, vans, minivans, and sport utility vehicles) traveled 44 billion miles on trips greater than 200 miles, according to the U.S. Bureau of the Census, *Vehicle Inventory and Use Survey, 2002.* The U.S. Federal Highway Administration (FHWA), Freight Analysis Framework indicates that trucks carried nearly 3 billion tons of goods worth over $4 trillion across state lines, representing one-fourth the weight and half the value of all goods moved by truck.

Trucking is both a critical component of the Nation's economy and a concern to the traveling public, who share increasingly crowded highways with freight-hauling vehicles. For reasons discussed in this chapter, freight is a fast-growing part of traffic on our Nation's highways. This growth affects the condition and performance of the highway system, which in turn influences the ability of trucking to deliver goods in a timely and economical manner. This chapter examines the effects of freight transportation on the performance of the highway system, the consequences of highway performance for freight movement and the Nation's economy, and some of the special investment needs of freight transportation.

The Growth of Freight Transportation

Trucking is a key element of the freight transportation system. Trucks carried 70 percent of the value and 60 percent of the tons of commodities shipped in 2002, not including shipments moved by truck in combination with another mode. (Percentages are lower than previously reported because the estimate of total shipments in the most recent Freight Analysis Framework is more complete.) The Nation's highways handled over 1.5 trillion ton-miles of commodities in 2002. The number and mileage of trucks by industry is shown in *Exhibit 14-1*.

The growth in freight transportation is spurred by continued economic growth. The growth in trucking is stimulated by additional factors, including, but not limited to, increased demand for just-in-time deliveries of lighter and more valuable goods, major reductions in railroad track mileage, and decentralization of business establishments. As shown in *Exhibit 14-2*, this growth shows no signs of abating. Freight tonnage is forecast to increase by 70 percent between 1998 and 2020, and trucking is expected to account for the majority of the projected increase.

Exhibit 14-1

Trucks, Truck Miles, and Average Miles per Truck by Major Use

Major Use	2002 Trucks (Thousands)	Percent Change from 1997 to 2002	2002 Truck Miles (Millions)	Percent Change from 1997 to 2002	Average Miles per Truck 2002 (Thousands)	Percent Change from 1997 to 2002
Total Trucks [1]	85,174.8	17.0	1,114,728.0	6.8	13.1	-8.8
For-Hire Transportation or Warehousing	1,280.2	20.8	72,272.8	-0.8	56.5	-17.9
Vehicle Leasing or Rental	859.2	59.3	20,024.6	45.9	23.3	-8.4
Agriculture, Forestry, Fishing, or Hunting	2,239.9	-38.7	24,120.0	-44.0	10.8	-8.6
Mining	177.6	-29.1	3,411.5	-27.1	19.2	2.9
Utilities	679.3	2.3	10,244.7	8.6	15.1	6.1
Construction	4,541.5	-24.7	75,906.2	-29.8	16.7	-6.7
Manufacturing	782.9	7.3	15,384.5	-9.3	19.6	-15.5
Wholesale Trade	735.9	-41.8	16,963.5	-47.7	23.1	-10.2
Retail Trade	1,530.5	-31.8	27,470.5	-31.8	17.9	V
Information Services	376.6	N	5,622.0	N	14.9	N
Waste Management, Landscaping, or Administrative/Support Services	743.2	N	10,709.3	N	14.4	N
Arts, Entertainment, or Recreation Services	187.1	N	1,784.1	N	9.5	N
Accommodation or Food Services	284.3	N	5,816.3	N	20.5	N
Other Services	2,127.3	N	35,776.2	N	16.8	N
Personal Transportation [2]	65,343.0	28.3	766,639.8	21.4	11.7	-5.3
Not Reported	1,308.2	N	20,820.7	N	15.9	N
Not Applicable [3]	1,978.0	65.8	1,761.4	646.3	0.9	350.1

KEY: N = not available; V = an estimate of less than 50 vehicles, 50,000 miles, or 0.05 percent.

[1] The VIUS includes private and commercial trucks registered (or licensed) in the United States as of July 1, 2002. In addition to larger trucks, includes pickups, vans, mini-vans, sport utility vehicles, and station wagons built on truck chasis. The VIUS excludes vehicles owned by federal, State, and local governments; ambulances; buses; motor homes; farm tractors; unpowered trailer units; and trucks reported to have been disposed of prior to January 1, 2002.

[2] Trucks used in "Personal Transportation" are vehicles operated for personal use, such as travel to work, carpooling, pleasure driving, etc.

[3] Vehicles not in use. When the respondent had partial-year ownership of the vehicle, annual miles were adjusted to reflect miles traveled when not owned by the respondent.

Source: U.S. Department of Commerce, Bureau of the Census, Vehicle Inventory and Use Survey (VIUS), 2002*, Report EC02TV-US, Table 2a.*

Trucks and Congestion

Commercial truck travel doubled over the past two decades. On one-fifth of the mileage of the Interstate Highway System, trucks account for more than 30 percent of all vehicles. As indicated in the Highway Travel section in Chapter 2, the growth in truck travel has been exceeding the growth in passenger travel over time, suggesting that the percentage of trucks in the traffic stream is likely to grow substantially if current trends continue.

Because of their size and operating characteristics, trucks have a greater effect than personal vehicles on traffic flow and highway level of service. Trucks take up more physical space on the roadway and do not accelerate, brake, or maneuver as well as passenger vehicles. These effects vary according to several factors, including type of highway, grades, and lane width.

Exhibit 14-2

Freight Shipments by Tons and Value

Mode	Tons [a] (Millions)			Value [a] (Billion $)		
	1998	2010	2020	1998	2010	2020
Total	**15,271**	**21,376**	**25,848**	**9,312**	**18,339**	**29,954**
Domestic						
Air	9	18	26	545	1,308	2,246
Highway	10,439	14,930	18,130	6,656	12,746	20,241
Rail	1,954	2,528	2,894	530	848	1,230
Water	1,082	1,345	1,487	146	250	358
Total, Domestic	**13,484**	**18,820**	**22,537**	**7,876**	**15,152**	**24,075**
International						
Air	9	16	24	530	1,182	2,259
Highway	419	733	1,069	772	1,724	3,131
Rail	358	518	699	116	248	432
Water	136	199	260	17	34	57
Other [b]	864	1,090	1,259	NA	NA	NA
Total, International	**1,787**	**2,556**	**3,311**	**1,436**	**3,187**	**5,879**

Key: NA = Not available.

[a] Modal numbers may not add to totals due to rounding.

[b] Other includes international shipments that moved via pipeline or by an unspecified mode.

Source: DOT Federal Highway Administration (FHWA), Freight Analysis Framework, 2002.

Trucks contribute significantly to congestion in urban centers. According to a 2004 FHWA report, *Traffic Congestion and Reliability: Linking Solutions to Problems,* trucks account for at least one-fifth of the delay for all vehicles in the 50 worst urban bottlenecks in the Nation. Oak Ridge National Laboratory, in its 2004 study, *Temporary Losses of Highway Capacity and Impacts on Performance: Phase 2*, reported that, on city streets in crowded business districts, pickup and delivery vehicles cause nearly a million hours of vehicle delay each year to other traffic as they stop to serve office buildings and retail establishments.

Freight bottlenecks on highways are not limited to urban areas. A 2005 FHWA assessment, *An Initial Assessment of Freight Bottlenecks on Highways,* located and estimated truck hours of delay for 2,110 truck bottlenecks throughout the United States. These bottlenecks caused more than 243 million hours of delay to truckers annually, at a cost of about $7.8 billion per year.

Intermodal Connectors

In addition to congestion in urban areas and on intercity highways, many trucks have to navigate small intermodal connectors between major terminals and intercity highways. A 2000 FHWA report to Congress on the condition and performance of intermodal connectors found that many of these roads are under maintained. Highway connectors to ports had twice the percentage of mileage with pavement deficiencies as non-interstate routes on the National Highway System. Connectors to rail terminals had 50 percent more mileage in the deficient category that non-Interstate routes. Connectors to airport and pipeline terminals appeared to be in better condition. Supplemental analysis conducted since the release of the 2000 report indicated that approximately one-third of the connector system is in need of additional capacity.

SAFETEA-LU did not specifically address intermodal connectors. It did, however, provide $30 million for six projects aimed at relieving congestion into and out of ports and expanding intermodal facilities and inland freight distribution centers.

Of the four major types of bottlenecks analyzed, 227 highway interchange bottlenecks on freeways serving as urban freight corridors account for the most truck hours of delay, estimated at about 124 million hours annually in 2004. The direct user cost associated with interchange bottlenecks is about $4 billion per year. Other types of bottlenecks include 859 steep grades (66 million hours of delay), 517 signalized intersections (43 million hours of delay), and 507 lane drops (11 million hours of delay).

The top 10 highway-interchange bottlenecks each cause an average of 1.5 million truck hours of delay annually. Of the 227 highway-interchange bottlenecks, 173 cause more than 250,000 truck hours of delay annually. By comparison, only a few dozen of all other truck bottlenecks cause more than 250,000 truck hours of delay annually. For example, of the identified highway truck bottlenecks, only 12 steep-grade bottlenecks, one lane-drop bottleneck, and two signalized intersection bottlenecks accounted for more than 250,000 truck hours of delay.

Over the next 20 years, congestion is expected to continue to spread beyond urban centers, and trucking will contribute to this expansion. By 2020, more than 25,000 miles of highway are likely to carry over 5,000 commodity-carrying trucks each day. Roughly one-fifth of that mileage will be significantly congested.

Trucks and Safety

Truck crashes are a major contributor to delay and a source of public concern with highway safety. The DOT National Highway Traffic Safety Administration (NHTSA) reported in its *Transportation Safety Fact Sheets 2004: Large Trucks* that, in 2004, 416,000 trucks with gross vehicle weight ratings greater than 10,000 pounds were involved in traffic crashes in the United States. Of this total, 4,862 were involved in fatal crashes. A total of 5,190 people died, and another 116,000 were injured in truck crashes.

The NHTSA also found that truck occupants accounted for only 15 percent of those who died in crashes involving a large truck. The majority of the fatalities in these crashes were occupants of another vehicle (77 percent). The remaining 8 percent were pedestrians or bicyclists. Truck tractors pulling semi-trailers accounted for 74 percent of the trucks involved in fatal crashes and approximately 52 percent of the trucks involved in nonfatal crashes.

Incidents involving hazardous materials account for a very small share of total fatalities and injuries involving trucks. In 2003 (the latest year for which data are available), trucks involved in fatal and nonfatal crashes while carrying hazardous materials were 4 percent and 2 percent, respectively, according to the Federal Motor Carrier Safety Administration's *2003 Large Truck Crash Overview*. Hazardous material was released from the cargo compartment in 13 percent of these crashes.

Trucks and Physical Condition

Truck traffic is a major source of physical wear for the Nation's highways. According to the *2002 Vehicle Inventory and Use Survey,* 102,000 trucks with typical operating weights at or above 80,000 pounds drove 4.9 billion miles. The wear and damage to the highways caused by heavy vehicles is a frequent topic of highway cost allocation studies. The FHWA's *1997 Federal Highway Cost Allocation Study* found that trucks were responsible for 40 percent of FHWA program costs, while accounting for less than 10 percent of total vehicle miles traveled (VMT).

Q&A

How is freight transportation performance measured?

As demand for freight services grows, concerns intensify about capacity shortfalls and congestion. Understanding and improving freight flows is becoming a high priority among decisionmakers at all levels of government and in the private sector. An important step in understanding the issues and challenges is to measure the performance of freight transportation. The FHWA's Office of Freight Management and Operations, in partnership with the America Transportation Research Institute and others, sponsors the Freight Performance Measurement initiative to develop performance measures for key freight corridors and U.S. international land-border crossings. This project supports DOT's strategic goals of mobility and global connectivity.

The initiative uses automatic vehicle location (AVL) and mapping technologies to determine average truck speeds and travel time reliability for "freight-significant" highway corridors. Changes in speed and reliability over time can be used to assist in the identification of freight bottlenecks (temporal and infrastructure) and areas along corridors that are the most congested. As of January 2006, one year of data are available for five freight-significant corridors (I-5, I-I-10, I-45, I-65 and I-70). Data collection began in April 2006 on an additional 20 corridors for a total of 25 freight-significant corridors. The 25 Interstates are among the Nation's most significant freight corridors in terms of average daily truck traffic, covering approximately 32,000 miles of highways and representing about 88 percent of commodity-carrying truck vehicle-miles traveled.

Recognizing that delays at U.S. international land-border crossings result in significant economic costs to the freight industry, FHWA's freight performance initiative also includes a component focused on measuring border delay and wait times. The border effort, which started in July 2005, also uses AVL and mapping technologies to examine the performance of the transportation network at five U.S.-Canada border crossings (Ambassador Bridge, Champlain, Peace Arch, Pacific Highway, and Pembina). One year of border data will be available in August 2006.

Results of the freight performance measurement initiative can be used at the national level to guide the development of future freight policies and programs and as a tool for programming and allocating resources. Transportation planners and other professionals could use this information to identify areas in need of improvements and to prioritize future projects.

Additional information on the Freight Performance Measurement initiative is available at www.ops.fhwa.dot.gov/freight/freight_analysis/perform_meas.htm.

Consequences of Highway Performance for Trucking and the Economy

Transportation is a key element of the U.S. economy. The for-hire transportation and warehousing sector alone contributed $333 billion to U.S. gross domestic product and employed approximately 4.3 million people in 2004, according to the U.S. Department of Commerce, Bureau of Economic Analysis's *Industry Economic Accounts* and the U.S. Department of Labor, Bureau of Labor Statistics's *National Employment Hours and Earnings*.

Trucking is a significant component of the cost of doing business in the United States. According to the *2002 Transportation Statistics Annual Report* by the Bureau of Transportation Statistics, trucking costs account for over 7 cents of every dollar of output in the construction industry; over 6 cents in agriculture, forestry and fisheries; about 4 cents in wholesale trade; and about 2 cents in manufacturing and services. In most of these industries, the contribution of in-house trucking is larger than for-hire trucking.

Highway congestion affects motorists, freight carriers, and freight shippers. Shippers are affected through an increase in logistics costs made up of transportation costs, inventory costs, and order costs (involving the size and frequency of an order of goods). Slower and more unreliable transportation increases transportation costs directly, but also increases order costs and inventory costs.

In Shirley and Winston's "Firm Inventory Behavior and the Returns from Highway Infrastructure Investments" (*Journal of Urban Economics, 55* (2004), 298-415) the authors estimate that because of congestion, each 10 percent increase in VMT produces at least a $1 billion increase in annual logistics costs. They note that this is a conservative estimate because it assumes a uniform increase in traffic during all hours of the day and all days of the week, instead of a more realistic assumption of sharper increases during peak periods.

Freight and SAFETEA-LU

The Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) expands or creates several programs to improve freight mobility, economic productivity, and global connectivity. SAFETEA-LU authorizes $4.615 billion for several freight-oriented infrastructure investments: Projects of National and Regional Significance, the National Corridor Infrastructure Improvement Program, the Coordinated Border Infrastructure Program, the Freight Intermodal Distribution Pilot Grant Program, and the Truck Parking Facilities Program.

SAFETEA-LU also expands the array of innovative financing options available for financing freight projects. These programs are described in more detail in Chapter 13.

Major Freight Investment Programs 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—$0.833 billion over 5 years

Freight Intermodal Distribution Pilot Grant Program—$0.030 billion over 5 years

Truck Parking—$0.025 billion over 4 years

Total: $4.615 billion

Innovative Financing

SAFETEA-LU expands eligibility for financing freight projects under the Transportation Infrastructure Finance and Innovation Act (TIFIA) Program to include (1) public freight rail facilities, (2) private freight rail facilities that provide benefit to highway users, (3) intermodal freight transfer facilities, and (4) intelligent transportation systems (ITS). The law also reduces the threshold required for total project cost to $50 million ($15 million for projects related to ITS) and allows for the grouping of smaller related projects. SAFETEA-LU authorizes $610 million for the TIFIA program.

The State Infrastructure Bank (SIB) Program is another source of funding for freight projects. The SIB program enables States to increase the efficiency of their transportation investments by leveraging Federal resources to attract non-Federal public and private investment dollars. SAFETEA-LU extends this program to all States. SIB funds may be used for capital projects, credit insurance, purchase and lease agreements, and interest rate subsidization.

SAFETEA-LU also modifies the tax code to encourage private activity bonds. This provision is intended to encourage $15 billion in investment in freight facilities.

Research and Training

Beyond concrete and steel, SAFETEA-LU also provides support for research, training, and education in freight planning to strengthen decisionmaking capacity at States and local agencies. The act provides $3.5 million over 4 years for FHWA's established Freight Professional Development Program to support targeted training and technical assistance to States and localities. SAFETEA-LU also establishes the National Cooperative Freight Transportation Research Program and studies on rail transportation and regulation and the efficiency of motor carriers.

Framework for a National Freight Policy

To bring together public and private stakeholders around a common vision, the U.S. Department of Transportation has drafted a Framework for a National Freight Policy. The framework lays out a vision and objectives, then details strategies and tactics that the Department and its partners—both public and private—can pursue to achieve those objectives. The Department is actively seeking input and buy-in from the broader freight sector, including public and private sector interests.

The draft Framework is posted at:

http://ostpxweb.dot.gov/freight_policy_framework.html.

CHAPTER 15

Operations Strategies

Operations Strategies

Highways are traditionally viewed as transportation facilities with fixed capacity, carrying traffic that peaks with commuters twice each weekday. Available capacity, however, is highly dynamic; it can be reduced by the actions of individual drivers or by severe weather. Within the confines of available capacity, traffic flow can be improved by implementing different types of operational strategies.

Traffic demand does not only peak twice daily during morning and afternoon "rush hours," but peaks throughout the day, week, and season for many reasons. Some traffic variability is recurring and predictable, but capacity constraints can be driven by temporary and less predictable events. The negative consequences of both predictable and unpredictable variations can be minimized with advanced traffic control systems, timely responses to incidents, and other highway operations strategies. This chapter highlights the variability in traffic demand and highway capacity and examines the operations strategies used by highway agencies to maximize the highway system in the face of this variability.

Dynamic Traffic and Capacity

The traditional view is that traffic demand and highway capacity are relatively static, with traffic volumes increasing in morning and afternoon peak periods each weekday and congestion occurring when the fixed capacity of the highway system is exceeded. This view ignores the large volume of nonwork trips, the volume of freight movements, and the impact on these trips caused by the actions summarized in *Exhibit 15-1.*

Chapter 4 documents the spread of "rush hour" commuting periods to greater shares of each day in cities of all sizes. Other peaks in traffic demand because of weekend shopping, seasonal recreational travel, freight activity, and large events such as professional sports are less well measured, but probably account for an increasing share of congestion and delay as trips to work become a smaller percentage of total travel.

Exhibit 15-1

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

Any peaks in traffic volume can overwhelm the maximum design capacity of a highway system. Bottlenecks such as interchanges, converging lanes, tollbooths, vehicle inspection stations, or poor traffic control can all adversely affect throughput.

Delays resulting from the lack of capacity to accommodate weekday peaks in commuting are captured by the operations performance measures presented in Chapter 4, as well as in the future investment scenarios presented in Chapter 7 and developed using the Highway Economic Requirements System (HERS) model. The HERS model is not as robust in estimating delays from bottlenecks, which have been analyzed independently by the American Highway Users Alliance. Its recent study, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks, 1999–2004,* identified 233 major bottlenecks, a substantial increase over the 167 major bottlenecks it identified just 5 years earlier.

Traffic cannot always take advantage of the maximum capacity of a highway. Reductions in maximum capacity caused by crashes, work zones, bad weather, and other incidents create at least as much delay as the recurring overload of traffic from commuting. Half of the delay reported by the Texas Transportation Institute and cited in Chapter 4 is attributed to incidents alone. Based on a composite of estimates by the Texas Transportation Institute and Oak Ridge National Laboratory, crashes and breakdowns account for about 40 percent of congestion delay, recurring congestion resulting from daily commuting is responsible for approximately 35 percent, work zones account for over 15 percent, and bad weather and poor signal timing account for most of the balance. Cambridge Systematics has developed similar estimates showing bottlenecks creating 40 percent of delay, incidents causing 25 percent, bad weather accounting for 15 percent, and work zones creating 10 percent, with signal timing responsible for approximately half of the remaining balance. Temporary capacity losses due to work zones, crashes, breakdowns, adverse weather, sub-optimal 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, adding over four hours of delay per 1,000 miles of travel in addition to delay from recurring congestion.

The traveling public, shippers, and carriers are affected by the dynamic fluctuations in traffic and capacity because these fluctuations translate into delay and cost. As noted in Chapter 14, unexpected delay from temporary capacity loss causes unpredictable travel and arrival times. This situation is especially costly to the freight transportation community and affects the economy and the American consumer. To overcome constraints on maximum capacity and temporary capacity losses, operations strategies are a critical tool.

In addition to mitigating congestion and expanding existing capacity, operations strategies are needed to enhance the safety and security of the transportation system. Crashes, natural disasters, and other threats to life and property must be quickly identified and appropriate responses mobilized. Disruptions to normal traffic flow, such as work zones and bad weather, are as much a safety problem as a source of delay. Congestion and safety problems may be aggravated by the presence of poor traffic control, inadequate signage, and ineffective traveler information systems.

Types of Operations Strategies

As summarized in *Exhibit 15-2,* highway operations strategies can influence the reliability, efficiency, safety, and security of highway use by responding to fluctuations in traffic demand. Several major operations strategies used to address these conditions are highlighted here and discussed in greater length in a report prepared for the Federal Highway Administration (FHWA) by Cambridge Systematics, Inc., *Traffic Congestion and Reliability: Linking Solutions to Problems.*

Exhibit 15-2

Traveler Problems and Operational Responses

What does the traveling public want?	What gets in the way of what the traveling public wants?	What can traffic managers do about it?
Reliability (reliable, predictable travel time)	Special events Work zones Bad weather Vehicle crashes and breakdowns Double-parked vehicles Lack of information on route conditions and alternatives	Reroute traffic or adjust lanes and traffic control Snow and ice removal Incident response vehicles Parking management Traveler information on disruptions and alternatives
Timeliness	**All of the above plus:** Daily and seasonal peaks of heavy traffic Bottlenecks and impediments Poorly coordinated traffic control	**All of the above plus:** Adaptive signal control Ramp meters Reversible lanes Electronic toll collection Curbside parking management Adjustments to carrier schedules
Safety	Vehicle crashes and breakdowns Work zones Bad weather Poor facility design and traffic control Driver behavior Poor facility design and traffic control Poor physical condition of facilities	Detect and respond to crashes Traveler information on location of crashes and problem areas and on alternative routes Emergency medical services Driver education Better signage and markings Identify and correct unsafe conditions
Security	Property theft Personal assaults Military logistics Terrorism Regional disasters	Visible monitoring as a deterrence Reroute traffic or adjust lanes and traffic control Detect and respond to threats and incidents Identify and correct unsafe conditions Threat assessments and countermeasures and disaster response plans Traveler information

Effective operation of freeways and other major arterials includes monitoring roadway conditions; detecting, verifying, responding to, and clearing incidents quickly; identifying recurring and nonrecurring traffic bottlenecks; providing travel condition information; implementing lane management strategies; controlling flows onto freeways with ramp meters; and restricting some facilities to high occupancy vehicles (HOV). In addition, on minor arterials and major collectors, the timing and coordination of traffic signals are essential to facilitate the flow of traffic.

The operations strategy of access management can be implemented in many different manners and, therefore, can be used to optimize highway performance on all types of roads. One approach, access spacing, increases the distance between traffic signals on major arterials. This improves the flow of traffic, thereby reducing congestion and its effects. Driveway spacing restricts the number of driveways and spaces them farther apart, allowing a more orderly merging of traffic with fewer conflicts for drivers. Dedicated left- and right-turn lanes, indirect left-turns and U-turns, and roundabouts are other useful ways to keep through traffic flowing. Median treatments, such as two-way left-turn lanes and nontraversable raised medians, are effective in regulating access and reducing the number of crashes.

Q&A

How do intelligent transportation systems relate to operations strategies?

Intelligent transportation systems (ITS) include a wide range of advanced technologies used to manage highway transportation and public transit, such 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.

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 over 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 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.

In many places, a transportation management center (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 two of their ITS systems: the Road Flood Warning Systems and the Regional Incident Management System.

In addition to managing the supply of highways, agencies can affect travel demand. In the past, managing demand consisted of encouraging commuters to change their travel mode from driving alone to choosing a carpool, vanpool, public transit, or other commuter alternative. More recent transportation-demand management tools include providing express and shuttle bus services, guaranteed ride programs, transit-van integration programs, partnerships between transportation agencies and employers, and local land-use controls.

Another way of managing transportation demand is through real-time traveler information. Traveler information can affect demand by influencing the choices that people make about how, when, where, whether, and which way they travel to their destinations. Information on traffic conditions, transit service, parking availability, and weather conditions is being delivered through Web sites, dynamic message signs, e-mail alerts, and highway advisory radio. States and metropolitan areas also are implementing 511, the telephone number dedicated by the Federal Communications Commission for relaying information to travelers.

Information is also critical to 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 requires communications standards and institutional coordination among police, fire, emergency medical services, tow truck firms, hazardous materials contractors, and TMCs.

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.

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 de-icing, sanding, or plowing; and inform travelers of changing roadway conditions.

Natural and man-made disasters can have a major impact on a transportation system. These place special demands on the system to bring responders to the scene, transport the ill and injured to medical facilities, and remove the public from potential harm. Effective response requires State and local agencies to cooperate on developing and updating plans and preparing for disasters.

Progress in Implementation

The FHWA monitors the progress in implementation of a number of operations strategies as a leading indicator of future operational performance.

Intelligent Transportation Systems (ITS)

ITS uses advanced technology to improve highway safety and efficiency. The progress of ITS deployment is shown in Chapter 2. In general, the deployment of ITS is increasing with real-time data collection sensors currently deployed on more than one-third of the total freeway mileage and on-call service patrols covering half of the freeway mileage. Substantial progress has been made in deploying integrated infrastructures between 1997 and 2005. The number of areas ranked in low category for ITS deployment decreased from 39 to 12, and the number ranked as high increased from 11 to 30 during this period. (See "Intelligent Transportation Systems" section of Chapter 2.)

Deployment of Regional Architectures

Regional ITS Architecture is a specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them. Of the 311 Regional Architectures identified as needed throughout the Nation, a total of 164, or more than 52 percent, were completed by the end of 2004.

Deployment of 511 Traveler Information Systems

The development and establishment of 511 Traveler Information Systems to provide access to highway and travel conditions in all parts of the Nation have been identified as key elements in the implementation of a successful National operations strategy. The number of active 511 systems at the end of 2004 was 24 located in 21 States, providing access to over 70 million of the U.S. population, or approximately 25 percent.

Work Zone Self-Assessment

The Work Zone Self-Assessment (WZSA) tool is a set of questions designed to assist those with work zone management responsibilities in assessing their programs, procedures, and practices against many of the good work zone practices in use today. The WZSA consists of 46 questions divided into six primary assessment areas that have an effect on work zone management. The six primary areas are Leadership and Policy, Project Planning and Programming, Project Design, Project Construction and Operations, Communications and Education, and Program Evaluation.

Averaging the WZSA results across all the FHWA Divisions provides an indication of the state of the practice in work zone management nationwide. The national average score is based on a 1 to 10 scale, with 10 being highest. The score increased from 7.4 in 2003 to 8.2 in 2005.

Traffic Incident Management Self-Assessment

The Traffic Incident Management (TIM) Self-Assessment (SA) tool consists of a set of 33 questions designed to permit TIM program practitioners to assess the strengths and weaknesses of various components of the TIM programs. The assessment is designed to be conducted by a team consisting of TIM partners from transportation, public safety, and the private sector. The TIM SA is divided into three main sections: Programmatic and Institutional Issues, Operational Issues, and Communications and Technology Issues. Each of these sections has three subcomponents.

The Programmatic and Institutional components are Formal TIM Programs, TIM Administrative Teams, and Performance Measurement. The Operational Issues components are Procedures for Major Incidents, Responder and Motorist Safety, and Response and Clearance Policies and Procedures. The Communications and Technology components are Integrated Interagency Communications, Transportation Management Systems, and Traveler Information.

The national score is based on a scale from 0 percent to 100 percent. The score has increased from 45.9 percent in 2003 to 52.2 percent in 2005.

Congestion Partnerships Self-Assessment

The Congestion Partnerships Self-Assessment is used to establish a baseline from which to measure progress in the implementation of collaborative actions needed to address issues related to transportation operations on a region-wide basis. It is also used to identify gaps and provide an annual measure of the level of regional transportation operations collaboration and coordination within the 75 largest metropolitan areas and other significant areas where transportation safety, security, and reliability are significant regional concerns. It is also used in smaller metropolitan areas, freight corridors, national parks, and tourist areas.

Scoring is on a scale of 0 to 5 and involves five areas: structure, process, products, resources, and performance. A final assessment score is developed averaging the five scores for each metro area. The national average score is an average of the scores of the top 75 metro areas. The national score has increased from 2.0 in 2004 to 2.1 for 2005.

SAFETEA-LU and Operations

The Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) calls for the establishment of a real-time system management information program to provide capabilities to monitor real-time traffic and travel conditions on the Nation's major highways. It also directs this information is to be shared 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. Additional methods to aid in the mitigation of congestion are the implementation of HOV facilities, accessing tolls, overall regional planning and operational agreements, use of exiting technology to provide access and dissemination of pertinent information, and increased safety for workers. A brief overview of these operations strategies is provided in the following subsections.

HOV Facilities and Tolling

Section 1121—HOV Facilities—Clarifies the operation of high occupancy vehicle (HOV) facilities and provides more exceptions to vehicle occupancy requirements, focusing on exemptions/certification for bicycles, motorcycles, and inherently low-emission vehicles (ILEV). States may also establish exceptions for public transportation vehicles, certified low-emission and energy-efficient vehicles, and high occupancy toll (HOT) 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 funding for the Value Pricing Pilot Program; creates a new Express Lanes Demonstration Program to permit tolling on up to 15 demonstration projects to manage congestion, reduce emissions, or finance new lanes to reduce congestion on the highway system; 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, including an important role in the Congestion Management Process in Transportation Management Areas (TMAs) where effective management and operation to address congestion management must be included.

Section 10204—Catastrophic Hurricane Evacuation Plans—Requires U.S. Department of Transportation and Department of Homeland Security Secretaries to coordinate with the Gulf Coast States and contiguous States to jointly review and assess Federal and State evacuation plans for catastrophic events impacting the Gulf Coast Region, and to submit to the Congress a report of their findings and recommendations. 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, planning, and shared project implementation for programs and projects. The program will improve transportation management and operations along Interstate 95 corridor and enhance transportation systems management and operations.

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. The purpose of the program is 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.

The three purposes of the program are to (1) establish, in all States, a system of basic real-time information for managing and operating the surface transportation system; (2) identify longer-range real-time highway and transit monitoring needs and develop plans and strategies for meeting those needs; and (3) provide the capability and means to share the data with State and local governments and the traveling public.

The four anticipated results of the Real-Time System Management Information Program are (1) publicly available traveler information Web site(s) providing access to information that is derived from the real-time information collected by the system established under the program; (2) 511 Travel Information telephone service(s) providing to callers information that is derived from the real-time information collected by the system established under the program; (3) Regional ITS Architectures updated to reflect the systems established under the program; and (4) access to the data collected by the system established under the program in an established data exchange format through standard Internet protocol (IP) communications links.

Section 5508—Transportation Technology Innovation and Demonstration Program—Presents a two-part intelligent transportation infrastructure program (ITIP) 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. *Federal Register* notice was issued in April 2006.

Conclusion

Economic prosperity and a population fast approaching 300 million have combined to produce record demand for personal and freight mobility. Transportation is woven into the economic fabric of the Nation as never before. But, continued economic growth is seriously threatened by congestion, the costs of which shippers, manufacturers, operators, and ultimately consumers all bear. The Administration's objective must be to reduce congestion, not simply to slow its increase. Congestion is not an insurmountable problem.

Without greater attention to operations, Americans will continue to waste many hours because of delay caused by recurring congestion, incidents, work zones, weather, and poor traffic control. Also, needless fatalities and injuries may result from unsafe conditions and crashes not being detected and countered in a timely fashion due to the absence of improved operational strategies. Through more effective operations, transportation system reliability, safety, and security can be improved and productivity increased.

PART IV

Afterword: A View to the Future

Introduction

The data and analyses presented in this report are based on tools and techniques that have been developed over many years (in some cases even predating this report series). This development history has produced models and data collection techniques that are fairly refined and have evolved over time to reflect changing priorities and the latest in surface transportation research to the extent possible. At the same time, there is considerable room for improvement in our understanding of the physical conditions and operational performance of our Nation's surface transportation infrastructure, and in our analyses of future investment in that infrastructure.

This afterword is intended to discuss the gap between our current state of knowledge and understanding and the type of information that would be necessary and desirable to greatly improve this understanding. The 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. Since many of these issues are fundamental or long term in nature, much of the discussion presented below is carried over from the 2004 edition of this report.

A common theme running throughout this section is the importance of high-quality transportation data and the impact 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 the current data sources. In many cases, in order to make significant improvements to the analyses, changes or improvements in data collection would be required to support revised analytical procedures. However, while 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 Highway Performance Monitoring System (HPMS) is the primary data source for many of the highway characteristics, condition, and performance metrics shown in Chapters 2, 3, and 4. The HPMS sample data set is also the primary data input for the Highway Economic Requirements System (HERS), which is used to generate the analyses of future investment for this report (see Appendix A). FHWA is currently conducting a comprehensive reassessment of the entire HPMS data collection process, including data collection methodologies, reporting requirements, data definitions, and the requirements of data users.

Because of the close connections between HPMS and the C&P report, the reassessment is carefully considering many of the condition and performance measurement issues and potential analytical improvements discussed in this Afterword section, including pavement modeling, capacity analysis, safety analysis, and data coverage. FHWA is also working 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://dms.dot.gov.

The current schedule for the reassessment calls for its completion during the first half of 2007. Any changes to HPMS would begin to be implemented during the 2008 reporting year and would thus be reflected in the 2010 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 and bridges, 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. The afterword concludes with a discussion of the analytical approaches used in the report, including the scope and presentation of the report analyses, and discusses additional uses of the tools and techniques developed for the report for other policy analyses.

A number of question and answer (Q&A) boxes are also included in this section, describing ongoing research projects sponsored by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) aimed at addressing 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 OST Office of Economic and Strategic Analysis under the Assistant Secretary for Transportation Policy, the FHWA Office of Freight Management and Operations, and the FHWA Office of Interstate and Border Planning are identified in text 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 unrealistic data requirements. In some cases, improving one part of the analytical procedures can cause complications in other areas, introducing their own 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, 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 in over an extended period of time.

While this afterword is intended to provide a fairly comprehensive discussion of these issues and reflect the Department'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 the Department, stakeholders, and researchers in devising improvements to the analytical processes used in the production of this biennial report.

Conditions and Performance

While significant strides have been made over the last decade regarding our understanding of transportation system conditions and performance, 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 condition 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 being objectively measured and having a direct impact on users of the road. However, concerns have been raised about its sufficiency as an all-encompassing indicator of pavement distress, since it may not adequately reflect pavement structural problems that do not manifest themselves simply through roughness. Collecting other, complementary pavement condition measures could substantially improve our understanding of the true condition of highway pavements and their remaining useful service lives; such measures are already being utilized in many States.

Improved pavement condition data could also be used to update and improve our modeling of pavement deterioration over time resulting from traffic loads and environmental factors. There are concerns that 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. However, any advances that could be made in terms of the precision of these models would depend on the availability of additional data to capture other distresses that are not currently being collected on a nationwide basis.

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 analysis 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 (such as substructure deterioration attributable to scour or vulnerabilities to seismic events) that are not currently being modeled or measured directly. Questions

Q&A

What research projects do FHWA and FTA currently have underway to improve the modeling of conditions and performance?

Current FHWA research projects on conditions and performance include the following:

- **Pavement model improvements.** This multiyear effort is assessing the current methods used to model pavement deterioration in both HERS and in other tools used for highway costs allocation studies. It is also looking at the types of pavement data and pavement modeling procedures currently in use at State highway agencies and evaluating the adequacy of the pavement condition data currently collected by FHWA for improved pavement analysis. One goal of this project is the development of more sophisticated next-generation HERS, which would be targeted for use in the 2010 edition of the C&P report.
- **Safety model improvements.** The FHWA is examining recent research linking average speeds and other highway characteristics to crash rates and severity, as a step toward improving the estimation of the safety cost impacts of highway improvements.
- **Bridge model improvements.** The FHWA is working with State users of the Pontis bridge management software (from which NBIAS was developed) that have customized the model to their own needs. The particular focus is on changes that States may be making to the default deterioration and improvement models, which could assist FHWA in making comparable changes to NBIAS.

Current FTA research on conditions and performance includes the following:

- **Decay Model Improvements.** Beginning in 1999, FTA initiated a program to collect consistent transit condition 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, related maintenance facilities, and stations. Condition assessment research is currently underway for train control, communications, and electrification systems, while analysis of guideway and track is pending.

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 our aging infrastructure. As discussed in Chapter 3, a significant portion of our Nation's bridges fall into the 40- to 60-year age range and thus may be nearing the end of their anticipated design lives. However, the age of a bridge 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 result in required 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 condition concerns the relationship between condition 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 condition 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 our 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 our bridge modeling approach 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.

The FTA uses the Transit Economic Requirements Model (TERM) to estimate transit asset conditions and the investment required to maintain and improve these conditions. 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—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 begun in 2005 and are continuing in 2006. A methodology was developed for each inspection before it was conducted. In most cases, the assets modeled are composed of a more detailed set of assets, each of which are examined and rated in the surveys. TERM has over 50 estimated decay curves. The final asset condition rating for each asset is an average of the conditions of its subcomponents.

The deterioration curves in TERM were initially based on data collected by the Regional Transportation Authority of Northeastern Illinois and the Chicago Transit Authority in the 1990s and mid-1980s and, to a lesser extent, on data collected by the Metropolitan Commuter Rail Authority (Metra) and the suburban bus authority (Pace) at the same time. The guideway deterioration schedules in TERM are still based on this information. FTA is currently examining the alternative for developing new guideway deterioration schedules, including the use of data collected by agencies. Physical inspections of guideway (track and related structures) may disrupt agency operations and are dangerous to perform.

The FTA is in the process of adding an overage index to TERM's condition rating output, defined as the proportion of assets by replacement value exceeding their useful life. This overage index will provide a measure of the level of deferred investment needs.

Over the longer term, FTA will be examining the effect of betterments on asset replacements and the possibility of introducing technical obsolescence as an alternative to physical condition in TERM's replacement criteria.

Operational Performance

Highways

One of the most important limitations in our current approach to highway operational performance is that our key indicators of condition are modeled rather than being 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 that chapter 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 (see Chapter 15). 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 is also using communications and geographic information systems technologies to measure system performance with truck speeds, as described in Chapter 14.

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.

> The FHWA Office of Transportation Policy Studies is studying the impact of highway congestion on truck freight shipments. A recent report identified 14 types of freight bottlenecks that caused 240 million hours of delay and cost highway freight $8 billion in lost time in 2004. 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.
>
> Following the initial assessment, the Transportation Policy Office has begun a follow-on study better identifying the causes and potential solutions for interchange bottlenecks. Work has also been initiated in the FHWA Office of Operations, in conjunction with State highway agencies, to identify locations of recurring congestion.

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 a bottleneck 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 do not work well at modern traffic levels. Such bridges are termed to be functionally obsolete (see Chapter 3).

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 our 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 mean 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 Indexes 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. For example, a worker who would ideally like to work a 9-to-5 schedule 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 such that peak hour delay is not reduced significantly. However, such impacts are not 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 in 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 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 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 in which we need to improve our understanding of the potential impacts of highway investment on highway safety.

The first challenge lies in linking crashes to transportation infrastructure characteristics. Motor vehicle crashes and their severity result from many factors, including driver behavior, vehicle equipment and condition, 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 form 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 to support the HSM analysis include 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 (HCM) 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 the former to some degree, no linkage is made to the latter. As a result, the model may tend to overstate the safety impacts of improving highway speeds on major urban freeways and arterials to some degree, as 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 how investment in transit affects safety. As with highways, this type of analysis would require linking specific transit incidents, injuries, and fatalities to the physical condition of specific transit infrastructure (e.g., a rail line segment). To do so would require agencies to report 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 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 current methodology used in the HERS model to estimate such emissions is based on the latest methods used by the Environmental Protection Agency (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 benefits, while 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 BCA, however, is a more challenging step, as it requires linking emissions, ambient air quality, the adverse impacts 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 for individual pollutants that are employed in HERS reflect the best information possible.

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 would be empirical estimates of the magnitude of such costs, related to the variables used or modeled in HERS (such as traffic levels by vehicle class). Second, noise impacts are very localized, applying only to the immediate vicinity of the roadway. Thus, modeling these effects would require more data on development densities (by type of activity) adjacent to roadways than are currently available. Similar issues would apply to other environmental externalities, such as water quality, climate change, and biodiversity.

TERM considers the social benefits of noise and emission reduction that result when travel is switched from automobile to transit in its benefit-cost analysis.

Two final issues in this area concern the battery of 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 the negative environmental impacts of transportation investment as given, the laws and regulations require that these effects 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.

A 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. It is thus 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, the impact of operations improvements on increasing effective capacity, refining the modeling of transportation demand, and the link between investment needs and financing.

Capacity

Capital improvements for increasing highway capacity 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 factors. Under such circumstances, adding capacity may require more extreme and costly measures, including 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 capacity expansion needs 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 to capture in part the cost of major highway capacity expansion projects and are thus reflected in the national investment scenario estimates. However, the higher cost of such improvements (referred to in HERS as high cost lanes) also 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 of high-cost-lane equivalents helps to 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 be fully capturing all the information used by a highway agency in determining whether to undertake a major, high-cost capacity expansion project. If additional data were available, they could potentially be used to improve our modeling of such improvements. FHWA is exploring ways to improve the quality of this information as part of its HPMS reassessment.

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) or they can 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) 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 our 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. FHWA is also exploring the possibility of collecting interchange performance and capacity data as part of its HPMS reassessment, which would be necessary to support any new modeling techniques.

Another limitation of the current approach to modeling highway capacity improvements is that 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—since few new roads are being built into undeveloped frontier areas at this point in the 21st Century, most new roads effectively substitute for existing roads to a certain degree. However, the new capacity in the model 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). Further, in the real world, 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.

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, i.e., they have speeds below and occupancy rates above certain threshold levels. Passenger waiting times are implicitly included in these performance measurements. No information is collected on passenger ease of access, the cosmetic appearance of the vehicles, or the comfort of the ride. This type of information is difficult to quantify and so is not explicitly considered.

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, since the core sections of these systems are generally found in the densely developed central areas 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, while 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. Chapter 10 includes analyses of the impact that a significant increase in construction costs would have on the investment scenario estimates.

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. For example, almost all freeway reconstruction and expansion projects in large urbanized areas today 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, a fact that 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 and thus raises 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 such deployments. While several such data items are currently collected through HPMS, the reporting of these data has not been sufficient for modeling purposes, requiring them to be supplemented by 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. The Real-Time System Management Information Program referenced in Chapter 15 may also provide an avenue for the collection of ITS deployment information.

At this point, TERM 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. However, opportunities to improve on forecasts that are done at the metropolitan planning organization (MPO) and State levels may be limited, especially when considering the uncertainty inherent 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 sources are very different, with their 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 forecasts (supplied by the States) 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 it is the former. This question is particularly relevant in light of the new procedures in HERS allowing it to simulate changes in user fees through tax surcharges or congestion-based tolls.

As noted in Chapter 10, the constant price assumption regarding the HPMS forecasts seems to be reasonable in the aggregate, though it may not be so for individual sections. This 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.

A separate but related issue regarding the baseline forecasts used in HERS concerns truck volumes and traffic shares. While the HPMS data include current estimates of truck volume shares and current and future estimates of total traffic volumes, there is no estimate in the data for future truck shares. If freight and passenger traffic grow at differing rates, however, then truck shares will be changing over time. The 2004 C&P report included a sensitivity analysis based on alternative estimates of truck volume growth from FHWA's Freight Analysis Framework (FAF). However, these forecasts rely on data that are produced only every 5 years, which limits the update cycle for them (the second generation of the FAF is currently under development). This is why no similar analysis is included in this report. Another significant issue is that the forecasts themselves may not be based on a constant price of travel for truck operators and would thus require additional assumptions about the future cost of travel in order for them to be most appropriately included in the baseline HERS analysis.

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 (in most cases 2002) available from a sample of 92 of the Nation's MPOs, including those from the nation's 33 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 vehicles miles traveled (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.

There are several shortcomings of this methodology. 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. While a strong correlation is found to exist between PMT and VMT, the fact that this estimation does not account for the fact that transit and travel by private vehicle are substitutes is of theoretical concern. 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).

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 would 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.

Q&A

What research projects does FHWA currently have underway to improve the modeling of transportation demand and address pricing issues?

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 as 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 also require some accompanying modifications to the modeling of capacity and delay. As discussed in the accompanying text, 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 universal congestion pricing.

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 increase the complexity of determining equilibrium traffic volumes exponentially. 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 much more limited. The model does not have procedures for balancing supply and demand directly, as it does not calculate the price of travel to users. Instead, the travel growth forecasts are taken as given, 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 users 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

This edition of the C&P report represents the first attempt at analyzing the impacts of alternative pricing mechanisms. However, there are many refinements that could be made to the analysis that is presented in Chapter 10, which is very limited in its present form. 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 realistic analysis would require much more detailed modeling of the actual transportation network, with spillovers and feedback effects between parallel and connecting segments (see the discussion of network effects later in this chapter). Refining the model along these lines would likely reduce the exaggerated impacts shown in Chapter 10.

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.

The revenue effects of pricing are also discussed in the "Finance" section below, and more extensively in Part II and Chapter 10 of this report.

Options for analyzing pricing in TERM (i.e., fare policies) are very limited at the present time, since it does not explicitly model travel demand (as noted above). 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.

> 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 pricing could have on travel, congestion, and investments.
>
> More information on the activities of this office is available at http://ostpxweb.dot.gov/

Finance

As discussed in Part II and elsewhere, this report represents the first attempt to link 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 user surcharges to cover any costs of increased investment under a given scenario, as such charges are presently the dominant revenue source for highway infrastructure improvements in the United States. 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.

One of the results discussed in Chapter 10 regarding the analysis of congestion pricing is the significant amount of revenue that is generated by the congestion tolls. Modifications to the current procedure would be needed to moderate these revenue impacts by allowing these revenues to offset other user fees or funding sources. Issues relating to congestion pricing are discussed in more detail in Part II of this report.

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 and pricing options and the effect of different allocation policies for such revenues.

More information on the activities of this office is available at http://ostpxweb.dot.gov/

There is also room for improvement in the quality of the financial data collected by the Federal government. For example, data on local government highway revenues and expenditures are more limited and less timely than the data collected from States, which necessitates interim estimates that occasionally may diverge 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 government entity. Similar issues arise for public transportation services provided by private firms or organizations.

This type of analysis requires a means of forecasting expenditures by different levels of government over a multiyear period. Since Federal funding depends significantly on both Highway Trust Fund revenues and the program financing structure authorized by Congress, such forecasts are made only for the period covered by a legislative authorization. For this reason, no such projections were included in the 2004 edition of the C&P, which was based on data near the end of the TEA-21 authorization.

The second component of these projections involves forecasts of State and local expenditures. For the 1999 and 2002 reports, such forecasts were made based on an older modeling technique developed by FHWA. This raised concerns, however, over the assumptions about future State and local government behavior that are implicit in this approach. In particular, while transportation funding by State and local governments is influenced by economic conditions and system characteristics, it also depends on legislative actions (such as tax changes). In addition to the difficulty of projecting such funding, questions were raised as to whether it is proper for a Federal agency report to make such assumptions about the behavior of other governmental bodies. For this reason, the analysis in Chapter 8 of this report does not make any projections of State and local government spending (other than to assume that such expenditures would grow at the rate of inflation). Instead, it focuses solely on the effects of projected changes in Federal highway and transit spending under SAFETEA-LU.

Finally, it is implicit in all estimates of highway and transit investment and performance that a strong link exists between the two. However, we do not currently have the data to directly link highway improvements and costs on a given section to changes in conditions and performance over time on that same section.

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.

Security and Emergency Preparedness

The relationship between transportation infrastructure and 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 our 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 redundant, 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? Since redundancy is inherently a network phenomenon, modeling its impacts and benefits would require the type of network analysis tools that are 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.

FTA will be examining the possibility of incorporating increases in security costs external to TERM and incorporating them into its investment analyses.

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 both 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. While the improvements made in one period affect the condition of the system and improvement options available in subsequent periods and benefits 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 to 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

Q&A

What research projects do FHWA and FTA currently have underway aimed at addressing some of these analytical issues?

FHWA has the following projects in progress in this area:

- **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.
- **Productivity benefits and economic impacts.** This project is expected to produce two related studies. One will be a white paper exploring the different mechanisms that translate transportation system performance improvements into productivity impacts, and whether any such impacts might warrant inclusion in the benefit-cost analysis procedures. The second will apply HERS analytical results to a regional economic development model to illustrate the true long-term economic impacts of different levels of highway investment.

FHWA and FTA are also jointly undertaking research on multimodal analysis. These exploratory first steps are focused on the existing analytical tools used in the C&P report, examining the benefit-cost analysis procedures and seeking ways that these could be improved and harmonized with each other.

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.

The 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 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 elsewhere in the report, 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, respectively. 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 transportation system-level performance issues. These issues are discussed in more detail below.

Benefit-cost Analysis Procedures

While each of the three investment tools uses benefit-cost analysis (BCA) 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 BCA 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. The result, however, is that it is difficult to interpret differences in the performance and investment results produced by the models with one another on an economic basis. If the BCA approaches in the models could be harmonized, however, 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 BCA in the models. However, fundamental improvements in the application of BCA also could be made. Investment analysis as practiced for the C&P report involves determining potential condition or performance deficiencies 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, BCA 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 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 DOT on improving the comparability of BCA 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 in the others.

TERM currently evaluates the benefits of each transit mode relative to three potential modal alternatives. These are auto (for nondependent riders), a slower transit alternative (e.g., bus instead of rail), and tax (for dependent riders). Provided sufficient information is available, FTA will expand this range of alternatives to include alternatives such as walking, bicycling, sharing the ride, or not making the trip at all.

In TERM, improvements are selected under one of four different modules (see Appendix C). However, only investments selected under the performance enhancement module are directly subjected to a benefit-cost test at the time the improvement is considered. Instead, the benefit-cost test for other improvements is applied at the end of the analysis to the operations of a particular mode and service provider; operator-mode combinations that fail this BCA test then have all their investments removed from the analysis. As a result, decisions on whether to implement particular asset replacements or performance maintenance improvements are strictly an engineering decision, and there are no trade-offs made between alternative investments on a given mode.

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 BCA conducted in the model remains somewhat fragmented, occurring at separate stages of the analysis and using different procedures that are not closely related to one another.

One of the prime challenges in BCA 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 BCA 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, whereas the NTD and NBI were developed primarily for other purposes. Increased availability of more specific data would offer significant opportunities for improvement in progressing toward a more complete analysis of transportation investments.

Investment Scenarios

The limitations to the BCA 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 for more discussion). While baseline "Cost to Maintain" and "Cost to Improve" scenarios are estimated for each of the three modes, the scenarios themselves represent different concepts. For the "Cost to Improve" scenarios, only the HERS scenario is defined on the basis of maximizing net benefits. While TERM and NBIAS use BCA as a screen or filter, improvements are not selected on that basis. Thus, the "Cost to Improve" scenarios for these two models cannot be described in economic terms at the present time; instead, they represent condition and performance benchmarks only, without direct consideration as to the economic desirability of reaching that level of performance (in HERS, the level of condition and performance reached under the "Improve" scenario is a result rather than a specification).

The Cost to Maintain investment concept, on the other hand, inherently involves reaching some future benchmark condition and performance target that corresponds to the current state of the system. Defining this benchmark, however, can be tricky, and various definitions have been used over the life of this report series. For the TERM analysis, the implementation is relatively straightforward, since condition-related and performance-related improvements are estimated independently of one another. In HERS, however, preservation and expansion improvements are modeled simultaneously, and trade-offs are made among improvements with varying impacts on condition and performance. As a result, different levels of investment will correspond to different benchmarks (see Chapter 9). The Maintain 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 condition and performance measure used for the analysis is based on the dollar cost of the backlog, rather than an actual system-level physical condition measure. Further work is needed to calibrate the models to allow the calculation and prediction of such condition 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 Cost to 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 take account of the fact that there may be trade-offs between alternative highway and transit investments aimed at addressing the same transportation system-level performance issues. These issues are closely related to the concept of performing analysis at the network level for highways, and 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 do not have a direct impact on the performance of any other facility in the models. One of the key characteristics of the highway system in the United States, however, is its extraordinary degree of interconnectivity, with numerous intersecting and parallel routes forming a complete network. Changes on one road can affect another; 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. A network analysis, however, would require data on the full universe of highway segments, which would tremendously increase the data collection burden on States. 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 would 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; doing this at the national level could increase this 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. While there are no direct linkages 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. While this is adequate for purposes of analyzing the benefits and costs of making an investment on an individual section, for purposes of assessing the systemwide impacts of an investment scenario, it would be desirable to track and account for such traffic shifts in a more comprehensive manner.

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 preservation 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 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, knowing 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.

As with highway network analysis, however, significant and perhaps even larger 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. To link up with highway network data, transit data would be needed on a similarly detailed geographic level. Presently, however, as noted elsewhere in the report, NTD data are collected only at the operator-mode level.

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 is using HERS and other tools to examine investments across different freight modes in key trade corridors.

Since driving cars or 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. 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 the deficiency 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, however. As described in Chapter 7, 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 complementary aspects to highway and transit investment, such 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 HOV 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 HOV 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

While the C&P report includes extensive analyses of highway and transit investment, focusing on the system conditions and performance implications of that investment, 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 BCA; 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. However, in recent years questions have been raised and theories proposed about whether some of these impacts might represent additional benefits of investment that are not currently captured in BCA. 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 on land use and economic activity in the area surrounding a potential improvement that is not currently collected. 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, however, there may 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 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 8, an FHWA study catalogued at least $700 million in highway spending by State governments in 2002 that was specifically targeted at regional economic development. These funds included programs tied to specific economic development outcomes (such as collateral

> The FHWA Office of Freight Management and Operations (HOFM) is conducting research to provide better estimates of the impact of highway improvements on the freight transportation sector. Traditionally, only the benefits to carriers have typically been counted, ignoring the benefits to shippers.
>
> The research has documented a range of short-term (first-order) and long-term (second-order) benefits to shippers and carriers from highway improvements. A major first-order benefit is a reduction in transportation costs to individual firms. As the network expands, the number of links increases, making point-to-point trips less circuitous and reducing transport distances. Highway improvements may decrease congestion and travel times. They can also improve reliability, allowing firms to reduce the risk of late deliveries and to reduce inventories and the costs associated with storing goods. Second-order benefits include efficiency improvements and further cost reductions resulting from improvements in logistics and supply chain management and changes in a firm's output or location. As part of this research causal links among highway performance, truck freight rates and shippers' demand for highway freight transportation were estimated.
>
> Additional research is being conducted aimed at the translating the results of the analysis described above into a form suitable for the development of an analytical tool that can be used to allow for a fuller accounting of the positive impacts of proposed freight transportation investments. The tool would differentiate among regions and commodity groups.
>
> More information on this line of research is available at http://ops.fhwa.dot.gov/freight/freight_analysis/econ_methods.htm.

private investment) as well as broader economic development programs, some of which may be implemented in conjunction with State economic development agencies.

From the C&P perspective, 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 condition or performance deficiencies, economic development highway initiatives are intended to meet other goals. In many cases, such initiatives may be targeting existing deficiencies that are seen as a barrier to improved commercial opportunities in a region; this type of investment would likely be included in the C&P estimates as well. In other cases, however, 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 investment analyses, and this portion of economic development highway funding would fall into that category.

The FHWA Office of Interstate and Border Planning is sponsoring research on the economic development impacts of highways. This research looks at the impact of highway investment on economic development from various perspectives. One line of this research has looked at regional development and the types of transportation strategies that can be effective in achieving and sustaining economic growth. Other studies have examined State highway programs targeted at economic development to gauge their extent and impacts. Other research has sought to understand the actual causes and mechanisms through which highways can spur local economic development.

Included in this research effort are a number of before-and-after type case studies of the economic impacts that specific rural freeway and expressway investments have had. This research notes cases where such investment has had success in supporting economic development and cases where it has not, describing some of the broad conclusions 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.

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: the HPMS, the NBI, and the 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, the following 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).

- Since 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 these more detailed data are not required to be reported to FHWA.

- On the transit side, only transit systems in urbanized areas (over 50,000 in population) that receive Federal funding have been required to report to the NTD. This requirement has excluded transit operators in nonurbanized areas and some providers in urbanized areas (though some nonrecipients do report). SAFETEA-LU has mandated that states report data on rural transit systems to the 2005 NTD. Rural needs are currently estimated outside of the TERM model based on alternative, occasional data surveys and added to TERM's estimates of total investment under the scenarios (see Appendix C).

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 Part I chapters 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.

There are two issues that 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 our initial effort along these lines, but this presentation is likely to change over time as our 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 to the extent possible 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?

A final scope issue concerns the particular modes that are included in the report analyses. The highway and transit conditions and performance reports series 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. While some of these modes are typically characterized by private sector control over management, finance, and investment, others do have substantial public involvement in their infrastructure financing. Past analyses (such as the 1995 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 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.

The legislative language authorizing the National Surface Revenue and Policy Study Commission authorized in Section 1909 of SAFETEA-LU directs that study to include analyses of future investment needs. The final report of the commission is due to Congress in September 2007. While the results from this edition of the report are expected to inform the commission's findings, the analytical tools themselves may also be employed in the course of the commission's work to develop scenarios specifically tailored to its mandate.

Another extension of C&P research is to offer the use of the analytical tools to other stakeholders outside of the 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 level, 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 future investment scenario estimates highlighted in Chapters 7 through 10, focusing on changes in methodology since the previous 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 updated improvement cost estimates; new procedures to link investment levels and highway user revenues; and the ability to simulate universal congestion pricing.

The **National Bridge Investment Analysis System (NBIAS)** is the primary tool for analyzing potential future bridge rehabilitation and replacement investments. For this report, the model, which is described in **Appendix B**, has been revised to consider a broader set of standards in determining functional improvement needs.

Appendix C presents 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. Major changes reflected in this report include updated asset inventory data; new asset deterioration schedules for stations and systems; and revised benefit-cost analysis parameters.

Appendix A

Highway Investment Analysis Methodology

Highway Investment Analysis Methodology

Investments in highway resurfacing and reconstruction and 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 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 2004 C&P report. These include two new procedures, one that links investment levels to revenues and another that simulates the effects of universal congestion pricing, as well as 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).

Once HERS determines a section's pavement or capacity is deficient, it will identify 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 (aka minor widening), resurfacing with added lanes (aka 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.

Q&A

Where can I find more detailed technical information concerning the HERS model?

The Federal Highway Administration (FHWA) 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. The recently released 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. Any updates to the HERS-ST model, including those designed to incorporate new features developed for HERS, will be reflected in future editions of the Technical Report.

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 are defined as 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). 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 "disbenefit."

These benefits are divided by the costs of implementing the improvement to arrive at a benefit-cost ratio (BCR) that is used to rank potential projects on different sections. The HERS model implements improvements with the highest BCR first. Thus, as each additional project is implemented, the marginal BCR and the average BCR of all projects implemented decline. 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, since 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. The Part IV Afterword includes more discussion of this issue.

Q&A

What are the average and marginal benefit cost ratios associated with the HERS scenarios presented in this report?

The HERS analysis presented in this report was performed by imposing a funding constraint on the model. Under this type of analysis, HERS ranks potential improvements in order by their benefit-cost ratios, then implements them until the funding constraint is reached (see the Introduction to Part II). Higher funding levels will thus include projects with lower benefit-cost ratios, both at the margin (when the constraint is met) and on average.

For the "Maintain User Costs" scenario, the average benefit-cost ratio was 5.69. The marginal benefit-cost ratios in each of the four funding periods ranged from 2.43 to 3.08. For the "Maximum Economic Investment" scenario, the average BCR was 3.14, and the marginal BCRs ranged from 1.00 to 1.84.

Allocating HERS and NBIAS 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 preservation. For improvements that added lanes, the total cost of the improvement was split between preservation and expansion, since widening projects typically improve the existing lanes of a facility to some degree. Also, 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.

All investment scenarios projected by the National Bridge Investment Analysis System (NBIAS) are classified as rehabilitation only, since new bridge and bridge capacity expansion investments are implicitly modeled by HERS. The HERS model does not currently analyze investments in those types of improvements classified as system enhancements.

Highway Investment Backlog

To calculate this value, 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 to be 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.

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 as a highway becomes more congested, some potential travel on the facility may be deterred and, that when lanes are added to a facility, the volume of travel may increase.

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. As a highway becomes more congested, the cost of traveling the facility (i.e., travel time cost) increases, which tends to constrain the volume of traffic growth. Conversely, when lanes are added and highway user costs decrease, the volume of travel tends to increase.

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.

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.

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 decline 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 has been tempered to some degree by the new HERS revenue procedures described below, which increase user fees at higher levels of investment and thus dampen the effect of highway performance improvements on travel demand.

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 –0.8 would mean that a 10 percent decrease in user costs would result in an 8 percent increase in travel.

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 intelligent transportation system (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 authorities (see Chapter 15), 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 three categories: arterial management, freeway management, and incident management as follows:

- Arterial Management
  - Signal Control
  - Electronic Roadway Monitoring
  - Variable Message Signs (VMS)
- Freeway Management
  - Ramp Metering (preset and traffic actuated)
  - Electronic Roadway Monitoring
  - VMS
- Incident Management
  - Incident Detection (free cell phone call number and detection algorithms)
  - Incident Verification (surveillance cameras)
  - Incident Response (on-call service patrols).

Creating the operations improvements input files for use in HERS involved four steps: determine current operations deployment, determine future operations deployments, determine the cost of future operations investments, and determine the impacts of operations deployments.

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 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. The hypothetical "Full Deployment" scenario illustrates the maximum potential impact of the strategies and technologies modeled in HERS on highway operational performance.

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-1 shows the estimated impacts of the different operations strategies considered in HERS. These effects include the following:

- Incident Management: Incident duration is reduced as well as the number of crash fatalities. 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 and VMS: Delay adjustments are applied to the basic delay equations in HERS.

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.

Exhibit A-1

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)
EM Vehicle Signal Preemption		
VMS	Congestion/Delay	-0.5% incident delay
Freeway Management		
Ramp Metering		
Preset	Congestion/Delay	New delay = 0.16 hrs per 1000 VMT – 0.13(original delay)
Traffic Actuated	Congestion/Delay Safety	New delay = 0.16 hrs per 1000 VMT – 0.13(original delay) -3% number of injuries and PDO accidents
Electronic Roadway Monitoring	Congestion/Delay	Supporting deployment for ramp metering and Traveler Info
VMS	Congestion/Delay	-0.5% incident delay
Incident Management		
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	Incident Characteristics Safety	-25% incident duration -10% fatalities
All Combined	Incident Characteristics Safety	Multiplicative reduction -10% fatalities

HERS Revenue and Pricing Analysis

The most important revisions to the HERS analytical procedures for this report involve highway revenue and pricing analysis. The conceptual basis for these changes and their impacts on the C&P investment analysis are highlighted throughout the report. While these two procedures address related issues, they are implemented distinctly from one another within the model.

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 that investment.

The first step in the procedure is to determine the amount of revenue that is required to be raised. 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 2004 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) that are not modeled in HERS.

The model assumes that any additional revenues needed to support the scenario being analyzed are raised through user surcharges in a manner consistent with the current financing structure. The surcharge tax rate is calculated by simply estimating total VMT and fuel consumption, then dividing this into 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.

Congestion Pricing

Preliminary results from the new HERS congestion pricing feature are presented in Chapter 10. This procedure has been newly developed for this edition of the C&P report and has not yet been subject to extensive testing. When invoked in the model, it estimates and applies a user fee based on the level of congestion on each section.

The congestion pricing feature was constructed using the existing HERS procedures for calculating delay and travel demand. HERS first calculates average user costs in its usual fashion, 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. The model then applies a toll equal to this cost differential, forcing users to "internalize" the externality (and improving efficiency) and determines a new equilibrium volume and price. The congestion pricing procedure is applied to peak period traffic on all roads with a volume/capacity ratio of 0.80 or greater. This is the threshhold used in Chapters 4 and 9 to identify roads as being congested.

It is important to understand that the congestion pricing feature does not operate in conjunction with any of the revenue analysis features described above. As a result, the HERS considers the "revenues" raised by the congestion tolls to be in addition to existing user fees, rather than as a replacement for them.

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. This updating process was continued for this report, though the incremental changes were less extensive than in the prior report.

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. For the purposes of this update, additional data were collected focusing on three of these areas: mountainous regions, large urbanized areas, and high-cost capacity improvements.

The 2004 update had 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 (over 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 had been raised about the degree of construction cost comparability between medium-sized cities and much larger ones. For the update in this report, more project cost data were collected, specifically focusing on major urbanized areas over 1 million in population, and a new category for these areas was added to the cost table.

For rural areas, separate cost values are applied by terrain type and functional class. Because projects in mountainous areas were not well represented in the data used in the previous update, additional information was collected from such areas, and the cost items for this terrain type were revised.

Unit values for high-cost transportation capacity improvements ("high cost lanes" in HERS) were modified for the 2004 report. However, these values were again based on a limited number of data sources. To improve these estimates, FHWA collected data on a larger number of projects of the type that these HERS improvements are intended to represent, including parallel routes, double-decking, tunneling, or purchasing extremely expensive right of way.

HERS Technical Reviews

Peer reviews by panels of outside experts are an effective way to ensure that the methodologies and analytical tools used in the C&P report continue to meet acceptable standards of technical merit. Under the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review*, such reviews are also required for any "highly influential scientific disseminations," a category that has been deemed to include the C&P analytical tools, including HERS and NBIAS.

In its early development, the HERS model received extensive scrutiny from various technical panels that looked at all aspects of the modeling procedure in depth. More recent reviews focused on specific aspects of the model. The last such review was conducted in 1999 and focused on the travel demand elasticity procedures and emissions procedures.

The FHWA has recently completed a new round of technical evaluations of HERS, concentrating on major features added to the model that would be especially well suited for outside review. The chosen focus areas were the HERS ITS/operations analytical procedures, and recent modifications to the HERS elasticity procedures (see Appendix A in the 2004 and 2002 C&P reports for more information on these model enhancements). To conduct the reviews, FHWA hired a contractor to assemble two panels, consisting of three members each, to examine different aspects of the model. A third panel was created to examine the NBIAS model (see Appendix B). The final reports from each of the panels are available at http://www.dot.gov/peerrt.htm.

The HERS Elasticity panel consisted of university researchers with extensive experience in the modeling of travel demand. The panel reviewed the documentation on the HERS elasticity procedures. While the panelists individual reviews focused on refinements made to the procedures to account for vehicle occupancy, section length, and diversion, they considered other aspects of the HERS elasticity approach as well. They noted the difficulties involved in attempting to apply travel demand concepts on a segment-based model, and questioned the assertion that diversionary impacts on other roadways could be ignored both theoretically and practically. They noted the conceptual differences between network-level elasticities and link-level elasticities, and the challenge in navigating between the two for the HERS analysis. One review also raised issues with the manner in which short-run and long-run elasticity effects are operationalized in HERS.

One modification that has been made for this report based on the panel's review was to reduce the elasticity parameter values used in HERS. The concern was that the older values might be too high given the nature of the data used in HERS, which are sample segments intended to represent larger portions or corridors on different functional classes. The lower values used in this report (−0.4 for short-run elasticity and −0.8 for long-run elasticity) are believed to be better representations of corridor-level effects. Chapter 10 includes an analysis of the effect that this parameter change has on the investment scenario estimates.

The peer reviewers of the HERS Operations procedures included experts in highway congestion modeling and ITS development and deployment. The reviewers concluded that the basic approach used to estimate current and future ITS deployment was sound, but that it was limited by the quality of the data sources. They also determined that the impacts of ITS and operations strategies on highway operational performance that are assumed in HERS were reasonable, but that they should continue to be updated as new research on these impacts becomes available. They also made several suggestions about changes to existing data sources that would improve the quality of the analysis. These suggestions are being considered as part of FHWA's current reassessment of the HPMS data process (see the Afterword in Part IV).

Appendix B

Bridge Investment Analysis Methodology

Bridge Investment Analysis Methodology

The National Bridge Investment Analysis System (NBIAS), first introduced in the 1999 edition of the C&P report, models investments in bridge repair and rehabilitation and functional improvements. 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.

The NBIAS incorporates analytical methods from the Pontis Bridge Management System (Pontis). Pontis was first developed by the Federal Highway Administration (FHWA) in 1989 and is now owned by the American Association of State Highway and Transportation Officials, which licenses the system to over 50 State transportation departments and other agencies. The NBIAS is designed to work directly with data from the National Bridge Inventory (NBI) if the more detailed element-level data required by Pontis are not available. The NBIAS also includes some economic analysis features that are not currently included in Pontis.

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.

The NBIAS begins with the NBI database. 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 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.

The NBIAS is composed of two distinct modules. The Analytical Module allows the users to create an NBIAS database from NBI files, specify technical parameters, and define and run budget scenarios for analysis. The "What-If" Analysis Module provides a variety of interactive screens and reports that display the outcomes for a selected scenario.

The following paragraphs provide additional detail on components of the system that differ from the basic analysis approach in Pontis and/or that have been modified since the 2004 C&P Report.

Determining Functional Improvement Needs

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.

Relative to the version of NBIAS used for the 2004 C&P report, the version used for this report considers a broader set of standards in determining whether there is potential need for a functional improvement to a bridge. Functional issues that may result in a deduction in the Sufficiency Rating or in a bridge being classified as structurally deficient or functionally obsolete now are considered in the calculations. Specifically, additional standards are now applied for evaluating bridge width and load ratings that are based on the amount of traffic on and the functional classification of the bridge, consistent with the calculation approach used for NBI Item 67 (Structural Evaluation) and NBI Item 68 (Deck Geometry), and for calculating the Sufficiency Rating. Further, additional standards are now being applied for evaluating vertical clearance and underclearances based on the functional classification of the affected roadways, consistent with the calculation approach used for NBI Item 69 (Underclearances, Vertical and Horizontal), and for calculating the Sufficiency Rating. Potential improvement needs identified using these standards are subject to benefit-cost considerations, as are potential needs identified using user-specified standards described above.

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 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. These costs, based on Pontis defaults, are scaled based on comparison of the default bridge replacement cost in Pontis to a nationwide average value determined based on analysis of the available NBI data.

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 to determine the optimal preservation actions to take to maintain 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

Because the NBIAS analytical approach relies on use of structural element data not available in the NBI, 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. Consistent with the version of the system used for the 2004 C&P report, the current version of NBIAS estimates repair and rehabilitation needs at the element level for each bridge in the NBI. These NBIAS procedures are unchanged from the 2004 C&P report, and were developed through analysis of NBI and element-level data for a sample database of over 10,000 bridges, including representative sample data from bridges across the United States.

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 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. 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 transition from one condition state to another over time. The current version of NBIAS uses the same set of deterioration models as the version used for the 2004 C&P report. That version of the system used a set of models recalibrated using the historical NBI data for the years 1992 to 2002, resulting in a significant revision of the transition probability matrices relative to models used prior to the 2004 C&P report.

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 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. The application of the preservation policy at the bridge level, and consideration of the trade-off between performing bridge rehabilitation or replacement, was a new feature of the system in the version used for the 2004 C&P report, but no further changes have been made in the version used for this report.

Expert Peer Review Panel

Peer reviews by panels of outside experts are an effective way to ensure that the methodologies and analytical tools used in the C&P report continue to meet acceptable standards of technical merit. Under the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review,* such reviews are also required for any "highly influential scientific disseminations," a category that has been deemed to include the C&P analytical tools used for the highway and bridge investment analysis, HERS and NBIAS.

While the HERS model received extensive scrutiny from various external technical panels in its early development, previous reviews of NBIAS had been conducted mainly within the Department. The FHWA recently hired a contractor to assemble three expert panels, two of which charged with reviewing different aspects of the HERS model (see Appendix A). The remaining six-person panel was charged with conducting a more comprehensive review of NBIAS. The final reports from each of the panels are available at http://www.dot.gov/peerrt.htm.

The NBIAS technical review panel included a mix of State practitioners and university researchers, with different areas of relevant expertise including bridge engineering, bridge management, economics, and asset management. The panel reviewed the online and written documentation for NBIAS and found it to be lacking in a number of key areas. It concurred that future reviews of NBIAS could be conducted more effectively if the documentation of the model were improved. The panel identified some aspects of NBIAS that could be useful to States in support of their long-range planning efforts, but that any such application would require improved documentation of the model's procedures.

The panel noted the limitations implicit in the least-cost approach used in NBIAS to select maintenance, repair, and rehabilitation (MR&R) strategies. This approach effectively optimizes its recommended plan of future investments assuming that funding will be available to implement it, which may or may not be the case depending on the scenario being analyzed. This creates the potential that the solution identified by the model may be suboptimal in cases where available funding is constrained, and could cause the model recommendations to deviate further from typical State bridge management practices.

The panel noted the NBIAS's current inability to account for the effects of scour on bridges. An ongoing National Cooperative Highway Research Program (NCHRP) research project was identified that could be used as a possible source of data for developing such procedures in the future for Pontis and NBIAS. One reviewer noted that NBIAS's current simplistic method of computing bridge deck area by multiplying the bridge length and width as coded in the NBI would underestimate the investment scenarios for bridges with varying deck widths and other complex geometrics. It was noted that improvements to this procedure would require additional data to be collected.

The panel recommended that additional calibration of NBIAS should be conducted beyond the data from 11 States originally used to compute values for the various model parameters. It suggested that such calibration should be conducted with an emphasis on obtaining data from all climate zones in the Nation and covering all construction cost areas, to allow the model to reflect the different costs and bridge deterioration rates that exist in different parts of the country.

The panel also questioned FHWA's screening out of culverts from the database, indicating that this resulted in the exclusion of a significant portion of the costs and work associated with maintaining the highway system. (This procedure was originally implemented in NBIAS by FHWA due to concerns that including these investments would double-count those already picked up by the HERS model; further research would be required to determine whether or not this problem still exists).

Appendix C

Transit Investment Analysis Methodology

Transit Investment Analysis Methodology

This appendix contains a technical description of the methods used to determine transit asset conditions (see Chapter 3) and to project transit investment estimates for the "Maintain" and "Improve" scenarios (see Chapter 7). This includes a description of the Transit Economic Requirements Model (TERM), the methodology used to estimate investment for rural transit and special service transit for the "Maintain" and "Improve" scenarios and the processes used to determine asset decay curves and the findings of the surveys undertaken since the 2004 C&P report.

Transit Economic Requirements Model

TERM estimates the physical conditions of U.S. transit assets, as reported in Chapter 3, and the total annual capital expenditures to be undertaken in all urbanized areas from Federal, State, and local governments to maintain or improve the physical condition and level of service of the U.S. transit system infrastructure. TERM also determines the allocation of projected investment among transit asset categories: vehicles; maintenance facilities; guideways; stations; and train control, electrification, and communication systems—over a 20-year period—and the sensitivity of the investment projections to variations in the rate of future growth in the demand for transit services.

TERM Investment Scenarios

TERM estimates projected transit capital investment separately for condition-related and performance-related investments. The main scenarios presented in this report are as follows:

- **Maintain Conditions**

  The Maintain Conditions scenario assumes that transit assets are replaced and rehabilitated over a 20-year period with the target of reaching an average asset condition at the end of the period (2024) that is the same as the asset condition that existed at the beginning of the period (2004). The model does not necessarily maintain the weighted-average condition of the assets in each year over the 20-year period because actual replacement and rehabilitation needs vary from year to year over this forecast period. Specifically, assets are rehabilitated and replaced as their condition falls below industry standards. These minimum condition levels vary according to asset type, and there are no constraints on the level of reinvestment in existing assets in any given period. With TERM, the average condition of the asset base improves significantly during the initial year of investment because the model addresses current backlog needs and then fluctuates between this improved level and the initial condition level, which is reached at the end of the 20-year period.

- **Maintain Performance**

  The Maintain Performance scenario assumes that investments are made in new vehicles and related fixed assets (maintenance facilities, stations, trackwork, etc.), as required to support the projected growth in the demand for transit services over the next 20 years. Here the model uses the projected increase in passenger miles traveled (PMT) as forecast by metropolitan planning organizations (MPOs) representing 92 of the Nation's largest metropolitan areas. TERM adds assets at a rate necessary to accommodate the increase in PMTs to achieve the base year (2004) level of average vehicle utilization and average vehicle speed at the end of the 20-year period (2024).

- **Improve Conditions**

  The Improve Conditions scenario assumes that the rehabilitation and replacement of transit assets is accelerated to improve the average condition of each asset type in the existing asset base to an average level of 4, or "good," by 2024. Assets are replaced at the same or a higher condition level than under the Maintain Conditions scenario, meaning that they are not allowed to depreciate as much before they are replaced. This scenario eliminates any backlog of deferred investments that are needed to reach a "good" condition level. Asset conditions make their most significant improvement in the first year and then trend downward gradually, with year-to-year variations, to an overall condition of "good" by 2022.

Q&A

Do all assets reach a condition of 4 at the end of the 20-year investment period?

The capital investment estimated by TERM to be needed to improve conditions closely approximates 4 for all assets averaged together at the end of the 20-year investment period. Given the uneven age distribution for existing transit assets, some asset types may reach an average condition level of slightly less than 4 and some may reach a level of slightly more than 4. As discussed in Chapter 7, the average asset condition reached for the Improve Conditions scenario is estimated to be 3.7 across all asset types. To achieve a higher average condition level would require replacing vehicles and guideways too early in their useful lives.

- **Improve Performance**

  The Improve Performance scenario simulates capital investments that increase average operating speeds as experienced by passengers and lower average vehicle occupancy to threshold levels by the end of the 20-year period (2024). To improve the nationwide average operating speed, TERM replaces investments in bus vehicles and bus-related infrastructure with investments in rail vehicles and rail-related infrastructure or bus rapid transit (BRT) and related infrastructure in urbanized areas with average operating speeds below a specified minimum threshold. This minimum threshold is set as the average operating speed of all urban transit operators, less a specified fraction of the standard deviation of these operators' average operating speeds. TERM continues to shift from bus to rail or BRT investments until each of the operators in these urbanized areas has an average transit speed at or above this minimum threshold. To lower the nationwide vehicle occupancy rate, TERM makes investments by adding vehicles and supporting infrastructure by agency and by specific mode (e.g., motor bus) when these agency-specific modal services have vehicle occupancy rates above a maximum acceptable threshold level. This maximum is set individually for each mode at the national average occupancy rate for that mode, plus a specified percentage of the standard deviation of the occupancy rate for that mode for all operators. Investments are continued until there are no operators with occupancy rates above the maximum threshold levels. By expanding the level of investment in new fleet vehicles, investments to reduce occupancy also support increases in the frequency of transit service for high occupancy agencies.

Description of Model

TERM comprises four distinct modules:

- **Asset Rehabilitation and Replacement Module.** Reinvests in existing assets to maintain or improve their physical condition.
- **Asset Expansion.** Invests in new assets to maintain operating performance given projected increases in the demand for transit services; i.e., projected PMT.
- **Performance Enhancement.** Invests in new assets to improve operating performance as measured by speed and capacity utilization.
- **Benefit-Cost Tests.** Only investments with a cost-benefit ratio greater than 1.0 are included in the total amount of TERM's estimates of national transit investment. This process roughly corresponds to the "Maximum Economic Investment" concept in the National Bridge Investment Analysis System (NBIAS).

Asset Rehabilitation and Replacement Module

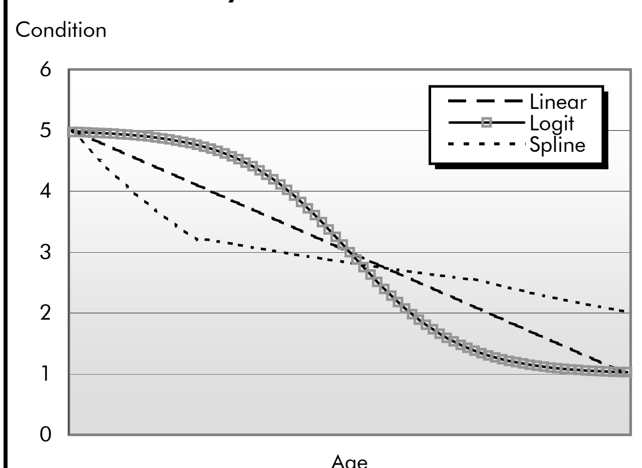
The Asset Rehabilitation and Replacement Module uses statistically determined decay curves to simulate the deterioration of the Nation's transit vehicles, facilities, and other infrastructure components. As these assets are used and as they age, their condition declines and eventually leads to investment for rehabilitation and replacement. (There is a section on describing the asset deterioration curves used by TERM in more detail starting on page C-9 at the end of the Appendix.)

The vehicle, maintenance facility, station, and system decay curves in this module have been estimated on the basis of data collected by the Federal Transit Administration (FTA) through on-site engineering surveys performed between 1999 and 2005. The surveys found that most assets depreciate rapidly in early years, followed by slower decay for an extended period through the asset's mid-life and, finally, a more rapid decline in asset condition toward the end of the asset's useful life. These newly estimated decay curves for vehicles, maintenance facilities, stations, and systems are in the form of "spline" regression models. [*Exhibit C-1* compares the basic forms of a linear, spline, and logit function.] Data on the age of and for some assets on maintenance and use, collected by the National Transit Database (NTD) or FTA asset surveys, are used in conjunction with these curves to estimate their current and future conditions. Surveys of systems undertaken in 2005 achieved a 75 percent level of statistical accuracy. These surveys will continue through 2006. The 2008 C&P report will provide average condition estimates for each system asset based on a larger and more statistically significant sample of system assets. These decay curves are discussed in more detail in the last section of this Appendix.

The decay curves for guideway use "logit" function curves estimated using extensive data sets collected by the Regional Transportation Authority in Northeastern Illinois and the Chicago Transit Authority in the mid-1980s and 1990s.

Exhibit C-1

Asset Decay Curves



These decay curve relationships are applied to a comprehensive inventory of the transit assets of the Nation's transit agencies. This asset inventory was initially developed in the 1990s when all major transit operators were asked to submit detailed listings of their transit capital assets. Since that time, the inventory has undergone periodic updates, primarily through vehicle data collected for the NTD. Over the period 2002 through 2005, the asset inventory was further updated using data collected through NTD's Asset Condition Reporting module and directly from transit agencies. In these recent surveys, transit operators were asked to list the assets they have in operation, as well as the type, age, purchase price, and—when available—quantity of each. The data that are received from each agency are reviewed for completeness and mapped and compared with the existing data in TERM. All data that are deemed reasonable are incorporated into TERM. This information has been converted to a 2004-dollar basis for use in this report.

TERM generates data estimates for agencies with missing data records on the basis of these agencies' characteristics, such as the number of vehicles, stations, track miles, and original years of construction. In 2005 this process was enhanced by developing a methodology to compare TERM's current asset inventory with the number of stations, facilities, and track miles by grade (at-grade, elevated, and subway) as reported to the NTD. This process takes NTD data on route miles, track miles, the number of crossings, maintenance facilities and stations for each agency mode reporting and develops a "base list" of assets that each transit mode must include to make operation feasible. This base is checked against the most recent generated assets data. Generated assets are assigned a "date built" value based on the asset, if known, or the initial date of service for each agency/mode and the asset's expected life.

TERM uses varying replacement scenarios for each of the five major asset categories. Multiple iterations of TERM are run until the "target" condition for each asset type is achieved at the end of the 20-year investment horizon. Under the Maintain Conditions scenario, the target condition for each of the five asset types is set to its initial level. In the Improve Conditions scenario, the target condition for each asset type is set to "good" (condition level 4). The user may also constrain TERM so that assets are not replaced before they have deteriorated to the point where they need replacement. These replacement thresholds are provided in *Exhibit C-2*. The minimum replacement threshold for guideway was raised to a rating level of 1.75 from a rating level of 1.5 used in earlier reports.

Exhibit C-2

TERM Asset Replacement Condition Thresholds

	Maintain	Improve
Facilities	2.75	2.75
Guideway	1.75	1.75
Stations	2.75	2.75
Systems	2.75	2.75
Vehicles	2.64	2.75

Q&A

Why is the replacement threshold for guideways lower than for the other assets?

The replacement threshold for guideways is low due to their high estimated condition overall. This high average condition is the result of the very long life of these assets and the increase in rail investment in the 1970s. Guideway deterioration curves are based on the original set of data from Chicago and are the only assets with a decay curve in the form of a logit function. A great deal of the Nation's guideway elements, i.e., the investments undertaken since the 1970s, is located on the higher portion of the decay curve. This contributes to the higher estimated condition, which necessitates a lower replacement threshold. FTA is investigating the possibility of collecting more information on guideway condition and reestimating their decay curves. If the current guideway decay curves were replaced with a spline function, the functional form found to best approximate the decay of other transit assets, it is very likely that the condition of the Nation's guideways would drop, and the replacement threshold would be lowered.

Asset Expansion Module

The Asset Expansion Module identifies the level of investment that would be required in each major asset category to continue to operate at the current level of service as transit travel (PMT) increases; i.e., to maintain performance. TERM adds assets at a rate necessary to maintain current vehicle occupancy rates over the 20-year analysis period. Investments undertaken by the Asset Expansion Module during the first part of the 20-year forecast period are depreciated, rehabilitated, and replaced by the Asset Rehabilitation and Replacement Module as required.

TERM uses the most recent PMT projections from a sample of the Nation's MPOs, including those from the nation's 33 largest metropolitan areas. These are the most comprehensive projections of transit travel growth available. Projected passenger trips are used when projected PMT is not available and projected vehicle miles traveled (VMT) is used to estimate projected PMT for areas that forecast neither PMT nor trips. Although, intuitively, transit and passenger vehicles are substitutes; empirically, a positive relationship between VMT and transit travel exists. PMT is projected by adjusting VMT growth by a factor of 1.16 based on a regression analysis of 49 areas, projecting both VMT and transit travel. Transit travel growth rates for the urbanized areas for travel projections that were either unavailable or not collected were assumed to be equal to the average growth rate of an urban area of an equivalent population size located within that FTA region. The weighted-average transit PMT growth rate calculated from the MPO forecasts and used in TERM was 1.57 percent (compared with 1.5 percent in the 2004 C&P report), based on a survey of 92 agencies (compared with 76 agencies for the 2004 C&P report). Twenty-two of these agencies provided PMT projections, 27 provided projected passenger trips, and 43 provided projected VMT only. Ten urbanized areas used the same travel projections that were used for the 2004 report.

Performance Enhancement Module

The Performance Enhancement Module simulates investments that improve performance either by increasing average transit operating speed or reducing average vehicle occupancy rate. To raise speed, additional investment is undertaken in heavy rail if an area already has an existing heavy rail service. Otherwise, for areas with populations of over 1 million, additional investment is undertaken in light rail, if light rail exists. If there are bus services only, investment is shifted from bus to light rail. In areas with populations under 1 million, performance enhancements are made by shifting investment from regular bus to BRT unless there is already a rail operator. To reduce occupancy levels, additional infrastructure is purchased for areas and modes with vehicle utilization rates (occupancy levels) above the threshold level.

Benefit-Cost Tests

All investments identified by TERM are subject to a benefit-cost test. The Rehabilitation and Replacement and Asset Expansion modules apply a benefit-cost test to all investments on a by-mode and by-agency basis; i.e., these modules consider the value of investing in a particular transit mode by a particular agency, but do 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.

In the Performance Enhancement module, investments to decrease vehicle utilization also are evaluated by agency and by mode, but investments to increase operating speeds are evaluated on an urbanized area basis rather than on an agency and modal basis to take into account the shift from bus to rail investments. TERM calculates and compares for each mode in each agency or, in the case of speed improvements for each urbanized area, the discounted stream of capital investment and operating and maintenance expenditures combined with the discounted stream of anticipated benefits accruing from the particular type of transit service investment being evaluated during a 20-year period. If the benefit/cost ratio is greater than 1.0, i.e., the discounted stream of benefits exceeds the discounted stream of costs, the model's estimate of the capital investment is included in the overall national investment needs estimate. If the benefit/cost ratio is less than 1.0, the investment is excluded.

The Benefit-Cost module identifies three categories of benefits:

- Transportation System User Benefits

  Travel-time savings, reduced highway congestion and delay, and reduced automobile costs (fuel, insurance, maintenance, depreciation, and parking) and taxi expenses.

- Social Benefits

  Reduced air and noise emissions, roadway wear, and transportation system administration.

- Transit Agency Benefits

  Reductions in operating and maintenance costs.

Whenever possible, the total level of benefits associated with each investment type is modeled on a per-transit PMT or per-auto VMT basis. Most of the benefits from transit investment are estimated by TERM to be transportation system user benefits and accrue to both new and existing passengers under both the Asset Expansion and the Performance Enhancement modules. Transit agency benefits—reduced operating and maintenance costs—are used to evaluate investments recommended by the Rehabilitation and Replacement and Asset Expansion modules, while social benefits—reduced air and noise emissions, roadway wear, and transportation system administration—are used to evaluate both Asset Expansion and Performance Enhancement investments.

Two revisions have been made to the benefit-cost data since the last report. First the benefit-cost test for performance enhancing investments was customized to provide a better reflection of the unique cost and ridership experience of each transit agency. The benefit-cost input parameters that are used to evaluate performance-enhancing investments (e.g., operating and maintenance costs, average fare and mode speed) are now specific to each agency mode. Prior to this change, the analysis used national modal averages for these parameters. These changes led to no changes in the Maintain Conditions and Performance scenario and led to a decline of roughly 10 percent in investments to improve performance. Secondly, the congestion delay cost used by TERM was reduced to accord more closely with the 1997 Highway Cost Allocation Study and the level of congestion by population stratum. Prior to this revision, the benefit-cost analysis had assumed a single measure of congestion for all agencies. These revisions led to a decrease in the amount of investments crossing the benefit-cost hurdle and a 22 percent reduction in investments to improve performance.

The benefit-cost analysis performed by TERM uses elasticities to measure the effect of changes in user costs on transit ridership that result from shifting from a private vehicle to transit or from reducing travel time by expanding the transit asset base either to increase speed or reduce occupancy levels (by increasing service frequency). This is only a first-order response. Any subsequent decreases in performance from the increased ridership and subsequent investments to meet this ridership are not considered. TERM assumes that these cost 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.

Projected Investment Estimate for Rural and Specialized Transit Service Providers

Projected investment for rural providers is based on data collected in 2000 by the Community Transportation Association of America (CTAA). These data include the number and age of rural transit vehicles, according to vehicle type, such as buses (classified according to size) or vans. Projected investment is estimated by determining the number of vehicles that will need to be replaced in each year over the 20-year investment period, totaling them and multiplying by an estimated average vehicle purchase price based on information reported to FTA by transit operators for vehicle purchases in 2004. (These average prices are also used in TERM.) The number of rural vehicles that will need to be purchased to maintain/improve conditions is calculated by dividing the total number of each type of bus vehicle or van by its replacement age, with different assumptions made of the replacement ages needed to maintain or improve conditions. The replacement age to maintain conditions is assumed to be higher than the industry recommended replacement age because surveys have revealed that transit vehicles are often kept beyond their recommended useful life. The Maintain Conditions replacement age is calculated by multiplying the industry-recommended replacement age for each vehicle type by the ratio of the average age to the industry-recommended age of large buses. The Improve Conditions replacement age is assumed to equal the industry-recommended age, and small vehicles are all assumed to be replaced with higher-cost vehicles accessible to the disabled. The Improve Conditions scenario also assumes additional vehicle purchases in the first year to eliminate the backlog of overage vehicles. The number of vehicles necessary to improve performance was estimated by increasing fleet size by an average annual rate of 3.5 percent over the 20-year projection period. A 1994 study by CTAA, and more recent studies examining rural transit investment considerations in five states, identified considerable unmet rural transit needs in areas where there is either no transit coverage or substandard coverage. The assumed 3.5 percent growth in the rural vehicle fleet is less than half the 7.8 percent average annual increase in the number of rural vehicles in active service between 1994 and 2000. The rural investment estimates to improve performance provided in the 2002 and 2004 C&P reports also assumed a 3.5 percent average annual growth in the rural fleet.

Rural maintenance and administrative facilities investment needs are based on data collected in 2000 by the CTAA. These data include the information on the total maintenance facilities and percent of operators surveyed planning to expand their facilities, planning to replace their facilities, and planning to acquire facilities; data are also provided on the number of administration facilities, the percent that own their own facilities, and the percent that own their facilities and are dissatisfied with them. The amount needed to maintain the conditions and performance of rural maintenance facilities is calculated by multiplying the number of facilities that are planning to replace (maintain conditions) and expand (improve conditions) by an estimate of the cost. The amount needed to improve the performance of maintenance facilities was estimated as the number planning to acquire new facilities multiplied by an estimate of the cost. Maintenance facility replacement and acquisition costs are assumed to be the same and based on per-foot facility cost information from TERM. Maintenance facility expansion costs are assumed to equal 50 percent of replacement costs. The amount to improve the conditions of administrative facilities is calculated by multiplying the number of operators who own their facilities and are dissatisfied with them by an estimate of average administrative facility cost. Projected investment does not include amounts to maintain the conditions or improve the performance of rural administrative facilities. These needs will be relatively small.

Projected investment for special service vehicles, comprised principally of vans, is based on methodology similar to the one applied to estimate investment for rural vehicles. A replacement age of 7 years was assumed to maintain conditions and 5 years to improve conditions. The Improve Conditions scenario also assumes additional vehicle purchases in the first year to eliminate the backlog of overage vehicles. No projections were made for performance enhancements. The inventory of existing special service vehicles as estimated by FTA increased from 28,664 in 2000 to 37,720 in 2002. This study has not been updated; the 2002 value is used as a proxy for 2004 in this report. Investment projections for special service administrative and maintenance facilities have not been made due to a lack of information. These needs will be relatively small.

Asset Deterioration Curves in TERM

Vehicles

The FTA has found that the condition of transit vehicles can vary considerably even if they are the same age. Vehicle conditions depend on how well vehicles are maintained and the location in which they operate. Vehicles that are well maintained are generally in better condition for their age than vehicles that are not. Vehicles that operate in coastal areas or in areas where salt is extensively used to melt ice during the winter deteriorate more rapidly than vehicles that do not operate under these conditions.

As shown in *Exhibit C-3*, between 1999 and 2003, FTA inspected 1,110 transit vehicles. Each of these vehicles was assigned an overall level of condition based on a weighted average of the condition of its subcomponents. For example, in the case of commuter rail, for which the most recent inspections were made, the subcomponents that were examined included the couplers, frame, bolster, gearbox, pneumatic piping, and wiring and connections. Vehicle exterior and interior subcomponents also were rated.

Exhibit C-3

National Condition Assessments of Transit Vehicles

		Vehicles	Number of Agencies
Buses		**895**	**43**
	1999	572	31
	2001–2002	323	12
Commuter Rail		**93**	**9**
	2003	93*	9
Heavy Rail		**94**	**6**
	2000	92	5
	2001	2	1
Light Rail		100	**11**
	2000	28	5
	2001	72*	6
Total Number of Vehicles Inspected		**1,182**	

* The number of commuter rail vehicles inspected has been revised to 93 (from 88 in the 2004 C&P report) and the number of light rail vehicles inspected has been reduced to 72 (from 74 in the 2004 C&P report).

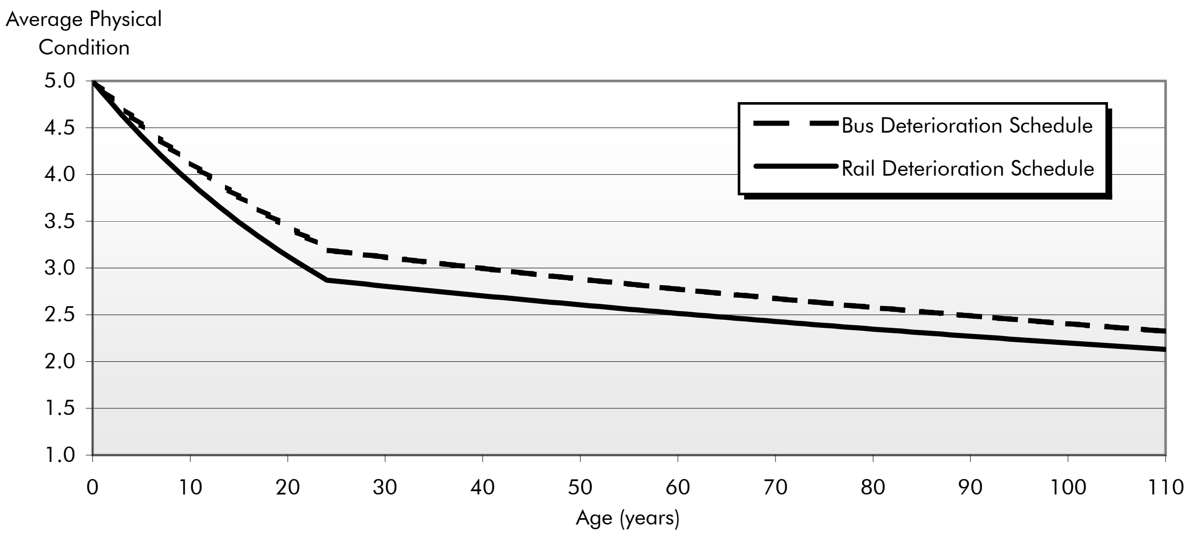
Source: National Bus and Rail Condition Assessments.

Maintenance Facilities

The deterioration schedules for maintenance facilities are based on 165 on-site maintenance facility surveys conducted at 45 rail and bus agencies between 1993 and 2003. Facility conditions were determined by the conditions of a range of facility components and subcomponents including roof structure, heating and ventilation systems, mechanical and plumbing systems, electrical equipment, specialty shops, and work bays and their subcomponents. Bus and rail maintenance facilities have similar, but not identical, deterioration schedules. The conditions of both decline mostly rapidly in the first 23 years of these assets' lives. During this time, facilities undergo relatively little major rehabilitation. After 23 years, they begin to undergo periods of rehabilitation, which leads to a very gradual deterioration over their remaining years. Bus maintenance facilities are, on average, in slightly better condition than rail maintenance facilities of the same age [*Exhibit C-4*].

Exhibit C-4

Average Conditions and Ages of Bus and Rail Maintenance Facilities



Source: National Bus and Rail Condition Assessments.

Rail Stations

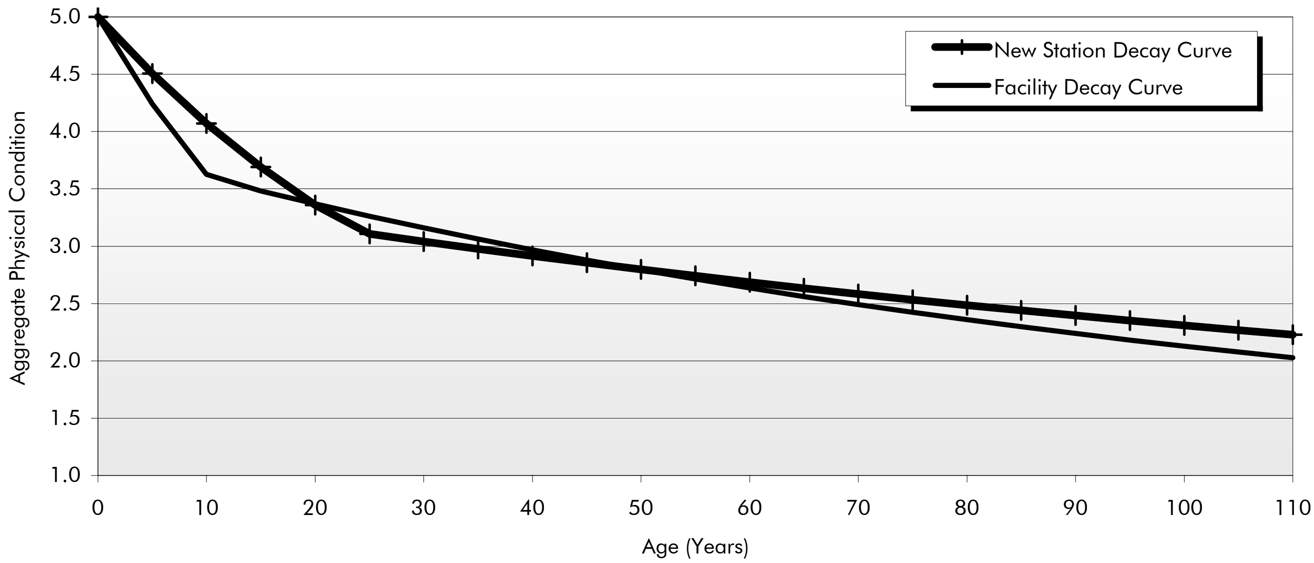
The deterioration schedules for rail stations have been revised based on on-site inspections of 94 heavy rail stations at 10 agencies and 41 light rail stations at 7 agencies conducted in 2004. Condition data were collected for up to 16 different categories of station assets (e.g., parking lots, building structure, electrical equipment) and between 4 and 20 different subcategories. The final station inspection samples provide a level of statistical accuracy close to 90 percent for heavy rail and close to 95 percent for light rail.

This station survey found that the deterioration schedules for stations was similar to the decay curve for maintenance facilities, which had been used to estimate station conditions in the prior two editions of this report [*Exhibit C-5*].

The on-site inspections revealed that the average condition of heavy rail stations was worse than the average condition of light rail stations, reflecting the lower average age of the Nation's light rail investments. Light rail stations were found to decay more slowly than heavy rail stations in the first 20 years of life and to be, on average, in better condition than heavy rail stations at any given age. However, average heavy rail conditions

Exhibit C-5

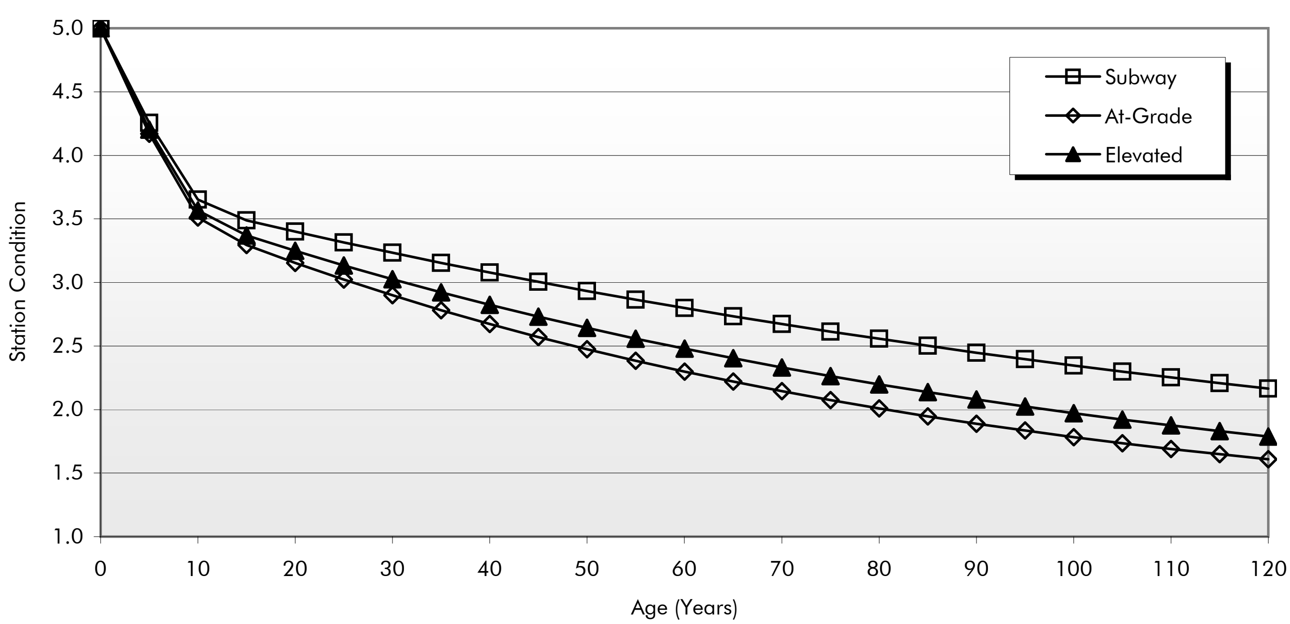
New Station Decay Curve vs. Facility Decay Curve



were found to be slightly better than previously estimated and average light rail station conditions slightly worse than previously estimated. After 10 years of age, subway stations are, on average, in better condition than elevated stations, and elevated stations are in better condition, on average, than stations at grade This is true both for light rail and for heavy rail. These relationships are shown for heavy rail in *Exhibit C-6*.

Exhibit C-6

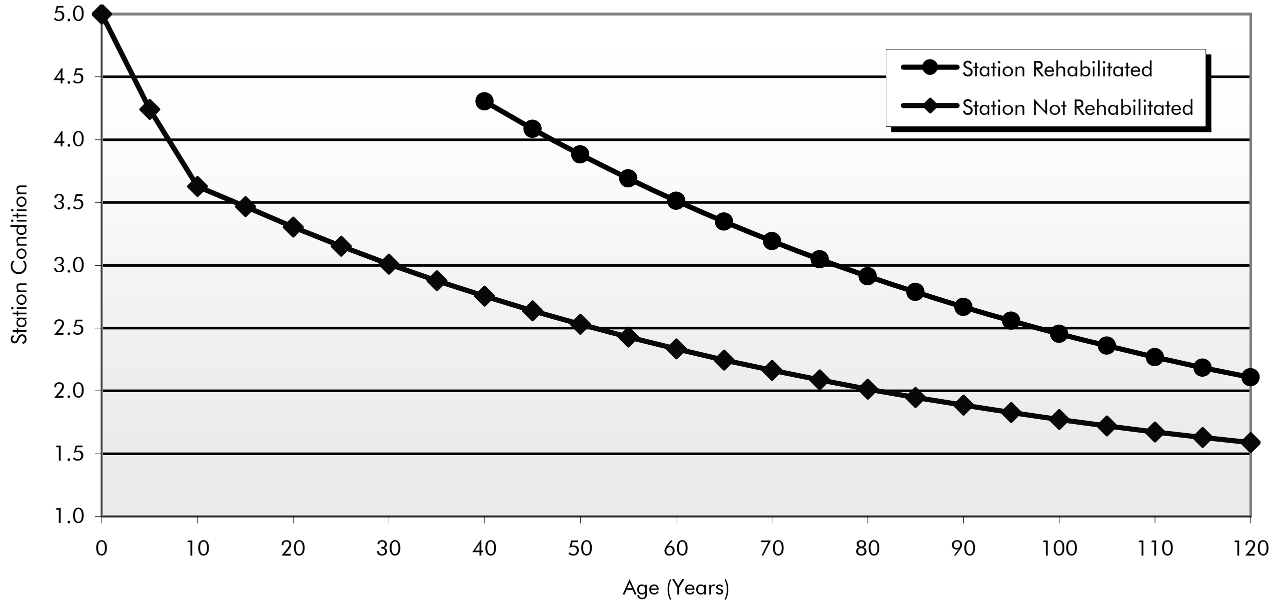
Heavy Rail Station Conditions



Stations more than 50 years old that had been rehabilitated were, on average, in considerably better condition than stations of the same age that had not been rehabilitated [*Exhibit C-7*].

Exhibit C-7

Station Condition vs. Age: Impact of Rehabilitation



No surveys were made of bus stations. Bus stations are assumed to have the same deterioration schedule as light rail stations.

Rail Train Control, Electrification, and Communications Systems

The deterioration curves for rail train control, electrification, and communications systems are based on on-site inspections conducted in 2005. Inspectors collected condition data for 41 track segments ranging from 0 to 100 years old from 7 different transit agencies. These inspections were conducted for each system—train control, electrification, and communications—by category and by segment. Train control centers were categorized as either a central instrument house or wayside equipment. Central instrument house components include the structure, power, environmental control, fire suppression relays, wiring, terminations, controller, event recorders, and data/voice communications systems. Wayside equipment includes signal, train stop, train ID, bond, loops, wiring, termination, and cable. Electrification systems were categorized as substations, third rail, and catenary. Substation components include the substation structure, high tension cables, AC breakers, and power: third rail has one component, the rail contact, and catenary has one component, the wire contact. Electrification systems were segmented into power transmission, transformation, rectification, control/indication, and track delivery. Communications systems were segmented into fiber optics, copper optics, wireless optics, equipment wiring, terminations, enclosures and environmental control. The surveys conducted in 2005 have a level of statistical accuracy of about 75 percent. These surveys are continuing in 2006 to raise this accuracy level.

Guideway

The condition of other guideway is estimated on the basis of decay curves relating condition to age; the decay curves for elevated structures and trackwork relate condition both to age and to use. This information is based primarily on rail asset information collected by the Chicago Transit Authority during the 1980s and 1990s for an Engineering Condition Assessment.