2004 Status of the Nation's Highways, Bridges, and Transit:

# Conditions & Performance


U.S. Department of Transportation

**Federal Highway Administration**

**Federal Transit Administration**

**REPORT TO CONGRESS**

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

FEB 16 2006

The Honorable J. Dennis Hastert
Speaker of the House of Representatives
Washington, DC 20515

Dear Mr. Speaker:

The enclosed report is submitted in accordance with the requirements of Section 502(g) 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, 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 report consolidates conditions, performance, and finance data provided by States, local governments, and transit operators to provide a national level summary. Some of these underlying 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.

This report provides dramatic evidence of the impact that funding under the Transportation Equity Act for the 21st Century (TEA-21) has had on highway and transit systems. Significant increases in Federal assistance, combined with large increases in State and local investment have led to unprecedented transportation enhancements, improvements, and expansions. The report's findings also explain some of the challenges for transportation agencies. While highway conditions improved overall, this improvement was uneven across all functional systems. Highway operational performance, as measured by congestion, worsened throughout the country. Bus conditions have shown slight improvements, while rail vehicle conditions have declined marginally. While transit use increased and average rail speeds improved slightly, vehicle utilization rates decreased for most 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 system to society and our economy.

An identical letter has been sent to the President of the Senate and the Chairmen and Ranking Members of 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,

Norman Y. Mineta

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# Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ACM | Asset Conditions Reporting Module |
| ADA | Americans with Disabilities Act of 1990 |
| ADT | Average daily traffic |
| APTA | American Public Transportation Association |
| ATS | Alternative transportation (transit) system |
| BAC | Blood alcohol concentration |
| BCR | Benefit/cost ratio |
| BLM | Bureau of Land Management |
| BNIP | Bridge Needs and Investment Process |
| BTS | Bureau of Transportation Statistics |
| C&P | Conditions and Performance |
| CMAQ | Congestion Mitigation and Air Quality Improvement Program |
| CMV | Commercial motor vehicle |
| CNG | Compressed natural gas |
| Combo | Combination truck |
| COP | Certificate of participation |
| CPI | Consumer Price Index |
| CR | Compliance Review |
| CTAA | Community Transportation Association of America |
| DHS | U.S. Department of Homeland Security |
| DMS | Dynamic message sign(s) |
| DoD | U.S. Department of Defense |
| DOI | U.S. Department of the Interior |
| DOT | U.S. Department of Transportation |
| DVMT | Daily vehicle miles traveled |
| FARS | Fatality Analysis Reporting System |
| FHMR | Federal Hazardous Materials Regulation |
| FHWA | Federal Highway Administration |
| FLHP | Federal Lands Highway Program |
| FLMA | Federal Lands Management Agency |
| FMCSA | Federal Motor Carrier Safety Administration |
| FMCSR | Federal Motor Carrier Safety Regulation |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| FY | Fiscal year |
| GAN | Grant Anticipation Note |
| GAO | Government Accountability Office |
| GARVEE | Grant Anticipation Revenue Vehicle |
| GDP | Gross domestic product |
| GPS | Global positioning system |

| | |
|---|---|
| HBRRP | Highway Bridge Replacement and Rehabilitation Program |
| HERS | Highway Economic Requirements System |
| HFCS | Highway Functional Classification System |
| HTF | Highway Trust Fund |
| HOV | High occupancy vehicle |
| HPMS | Highway Performance Monitoring System |
| HPMS-AP | Highway Performance Monitoring System Analytical Process |
| HSIP | Highway safety improvement program |
| HSPD | Homeland Security Presidential Directive |
| IHSDM | Interactive Highway Safety Design Model |
| IRI | International Roughness Index |
| ISAC | Information Sharing and Analysis Centers |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991 |
| ITS | Intelligent Transportation System |
| LNG | Liquefied natural gas |
| LPG | Liquefied petroleum gas |
| LTAP | Local Technical Assistance Program |
| LUST | Leaking Underground Storage Tank |
| MMUCC | Model Minimum Uniform Crash Criteria |
| MPO | Metropolitan planning organization |
| MSA | Metropolitan statistical area |
| MTA | Mass Transit Account, New York Metropolitan Transportation Authority |
| NAFTA | North American Free Trade Agreement |
| NBI | National Bridge Inventory |
| NBIAS | National Bridge Investment Analysis System |
| NBIP | National Bridge Inspection Program |
| 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 |
| NTI | National Transit Institute |
| OIG | Office of Inspector General (DOT) |
| PMT | Passenger miles traveled |
| POE | Port of entry |
| PPP | Public-Private Partnerships |
| PRISM | Performance and Registration Information Systems Management |
| PSR | Present Serviceability Rating |
| PT-ISAC | Public Transportation-Information Sharing and Analysis Centers |
| PV | Passenger vehicle |
| ROR | Run off the road |
| SAFETEA | Safe, Accountable, Flexible, and Efficient Transportation Equity Act |
| SBRP | Special Bridge Replacement Program |
| SDDCTEA | Surface Deployment and Distribution Command Transportation Engineering Agency |

| | |
|---|---|
| SEPTA | Southeastern Pennsylvania Transit Authority |
| SIB | State Infrastructure Bank |
| SQC | Synthesis, Quantity, and Condition |
| ST-ISAC | Surface Transportation-Information Sharing and Analysis Centers |
| STP | Surface Transportation Program |
| STRAHNET | Strategic Highway Network |
| SU | Single-unit truck |
| SUV | Sport utility vehicle |
| TEA-21 | Transportation Equity Act for the 21st Century |
| TEAM | Transit Electronic Award and Management |
| TERM | Transit Economic Requirements Model |
| TIFIA | Transportation Infrastructure and Finance Innovation Act of 1998 |
| TMC | Transportation management center |
| TPMS | Transit Performance Monitoring System |
| TSI | Transportation Safety Institute |
| TTI | Texas Transportation Institute |
| TVMT | Truck vehicle miles traveled |
| USDA | U.S. Department of Agriculture |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| V/SF | Volume to service flow |
| VMT | Vehicle miles traveled |
| VRM | Vehicle revenue mile |

# Introduction

This is the sixth 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 requirements of the Nation's highway and transit systems. This report incorporates highway and bridge information required by Section 502(g) 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 existing report series that covered highways and transit separately 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 *2004 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* report to Congress (C&P report) draws primarily on 2002 data. The 2002 C&P report, transmitted January 16, 2003, was based on 2000 data.

## Report Purpose

This document is intended to provide Congress and other decision makers with an objective appraisal of the physical conditions, operational performance, financing mechanisms, and future investment requirements of highways, bridges, and transit systems. 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 report consolidates conditions, performance, and finance 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 requirements analyses are developed specifically for this report and provide national-level projections only.

## Report Organization

The report begins with an Executive Summary section that highlights the key findings in each chapter. This section will also be distributed as a separate stand-alone summary document.

The main body of the report is organized into five 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 2002 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 both report users who want a multimodal perspective, as well as those who may primarily be interested in only one of the two modes.

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

- **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 comprise the core prospective analyses of the report.

- **Chapter 7** projects future highway, bridge, and transit capital investment requirements under certain defined scenarios.
- **Chapter 8** compares current levels of capital investment for highways, bridges, and transit with projected future investment requirements.
- **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 projections of future highway and transit investment requirements would be affected by changing the assumptions about travel growth and other key variables.

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

- **Chapter 11** describes several current Federal safety initiatives and how they address the safety issues introduced in Chapter 5.
- **Chapter 12** discusses the potential for operations strategies to address the congestion problems identified in Chapter 4.
- **Chapter 13** discusses the role of freight transportation and identifies future investment requirements specific to the freight area.
- **Chapter 14** illustrates the importance of transit by exploring user characteristics and transit benefits.
- **Chapter 15** provides additional statistics relating to the conditions and performance of the Nation's bridges, along with a discussion of the Federal bridge programs.

Part IV, "Supplemental Analyses of System Components," builds on the analyses developed in Chapters 2 through 10 by focusing more closely on particular components of the Nation's highway and transit systems.

- **Chapter 16** discusses the conditions, performance, and future investment requirements for the Interstate System.
- **Chapter 17** provides comparable information for the National Highway System (NHS).
- **Chapter 18** describes current conditions on the Strategic Highway Network (STRAHNET).
- **Chapter 19** analyses the costs and benefits of investments in rail grade crossings.
- **Chapter 20** assesses transit systems on Federal lands.

Part V, "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, as well as describing 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.

# Highway Data Sources

Highway condition 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.

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.

# Bridge Data Sources

Bridge inventory and inspection data are obtained from the National Bridge Inventory (NBI) collected annually by the Federal Highway Administration. 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' evaluation 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 datasets 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 program provides information needed for planning public transportation services and investment strategies. By supplementing this information on transit facilities and fleets with additional information collected directly from transit operators, we are able to provide a more complete picture of the Nation's transit facilities and equipment in this report.

## Other Data Sources

Other data sources are also used in the special topics and supplemental analyses sections of the report. For example, some highway safety performance data are drawn from the Fatality Analysis Reporting System (FARS). The Nationwide Household Travel Survey (NHTS) provides general information on transportation system users and the nature of their trips. 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 Requirement Analytical Procedures

The earliest versions of the reports in this combined series relied exclusively on engineering-based estimates for future investment requirements, 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 projection of future investment requirements. 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 requirements 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 requirements 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 requirement 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 transit investment requirements (or vice versa).

It is important to recognize that, in reality, highway, bridge, and transit investments are not made optimally to achieve maximum benefit-cost results. Consequently, the HERS, NBIAS, or TERM models may understate the actual level of investment that would be needed to achieve a particular level of performance. Note, however, that other factors may cause the models to overestimate investment requirements. For example, the highway investment requirements analysis does not account for demand management options, such as congestion pricing. If widely adopted, such strategies would improve the operating efficiency of the highway system, reducing the level of investment required to achieve a particular level of performance below the level that would be estimated by HERS.

# Highlights

This edition of the C&P report is based primarily on data through the year 2002, covering the first 5 years of the 6 years for which Federal highway and transit funding was authorized by the Transportation Equity Act for the 21st Century (TEA-21). The trends identified in this report reflect not only more recent data than the last edition, but also 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 future investment that will be required to maintain and improve this transportation infrastructure.

While this Highlights section focuses on the TEA-21 period, the report also includes data from other years and comparisons to other periods (such as the two years since the last edition of the C&P report).

## Highlights: Highways and Bridges

Since TEA-21 was enacted, combined investment by all levels of government in highway infrastructure has increased sharply. Total highway expenditures by Federal, State, and local governments increased by 33.3 percent between 1997 and 2002, to $135.9 billion. This equates to an 18.4 percent increase in constant dollar terms. Highway capital spending alone rose from $48.4 billion in 1997 to $68.2 billion in 2002, a 41.0 percent increase. Federal cash expenditures for highway capital purposes increased 56.7 percent from 1997 to 2002, while State and local capital investment increased by a smaller (though still robust) rate of 29.7 percent. 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 has 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.

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 preservation" (the resurfacing, rehabilitation, or reconstruction of existing highway lanes and bridges) increased from 47.6 percent in 1997 to 52.6 percent in 2002. The combined result of the increase in total capital investment and the shift in the types of improvements being made was a 55.6 percent increase in spending on system preservation, from $23.0 billion in 1997 to $35.8 billion in 2002. Compared with system expansion projects, system preservation 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 23.2 percent from $21.5 billion in 1997 to $26.5 billion in 2002.

### *Physical Conditions Have Improved*

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 highway mileage with "acceptable" ride quality rose from 86.6 percent in 1997 to 87.4 percent in 2002, while the percentage of highway mileage with "good" ride quality improved from 42.8 percent to 46.6 percent over the same period. The improvement has been concentrated on rural roads and higher-order roads in urban areas; conditions on lower-order urban roads have worsened in some cases.

The percentage of bridges considered deficient dropped from 31.4 percent in 1996 to 27.5 percent in 2002, 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.

## *Operational Performance Has Declined*

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 steadily deteriorated over the past decade. This is reflected in measures of congestion in all urbanized areas developed for FHWA by the Texas Transportation Institute (TTI). From 1997 to 2002, the estimated percent of travel occurring under congested conditions has risen from 27.4 percent to 30.4 percent. Annual hours of traveler delay has risen from an average of 19.4 hours in 1997 to 23.8 hours in 2002. [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 towards the most heavily populated areas.]

## *Future Investment Scenarios*

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, 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 2002 levels, based on projections of future highway use. The average annual investment level for this scenario is projected to be $73.8 billion (in constant 2002 dollars) for 2003 to 2022, which is 8.3 percent more than the $68.2 billion of capital spending in 2002. Note that, if capital spending were to rise to the Cost to Maintain level, the vast majority of this increase, given current sources of highway funding, would likely be borne by highway users. Note that this "gap" reflects future investment requirements stated in constant dollars; additional annual increases in investment would be required 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.

Additional increases in highway capital investment would also 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 $118.9 billion for 2003 to 2022 (stated in constant 2002 dollars). This is 74.3 percent higher than the $68.2 billion of total capital investment by all levels of government in 2002. Note that this scenario is largely theoretical in nature, and does not reflect practical considerations such as whether the highway construction industry or the highway planning process would be capable of absorbing such a large increase in funding within the 20-year analysis period. In particular, the legal and political complexities frequently associated with major highway capacity projects can significantly extend the time required for their implementation.

The highway investment analysis procedures used to develop the investment requirements scenarios have been modified for this edition of the report to reflect the impact that certain types of operational strategies and Intelligent Transportation Systems (ITS) deployments may have on system performance. Considering operations strategies and investments, which are considerably less costly in terms of initial outlays than conventional capacity investments, results in a lower estimate of the amount of investment necessary to achieve a given level of performance. Any more aggressive and effective deployment of ITS and other technologies beyond that which has been modeled in this analysis would be expected to further reduce the level of future capacity investment required to achieve any specific level of performance.

It is important to recognize that, in reality, highway, bridge, and transit investments are not made optimally to achieve maximum benefit-cost results. Consequently, the models used for the investment analyses in this report may understate the actual level of investment that would be needed to achieve a particular level of performance. Note, however, that other factors may cause the models to overestimate investment requirements. For example, the highway investment requirements analysis does not account for demand management options, such as congestion pricing. If widely adopted, such strategies would improve the operating efficiency of the highway system, reducing the level of investment required to achieve a particular level of performance below the level that would be estimated by the models.

## *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 2002 levels in constant dollar terms, 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 requirements in this report suggest that (1) there is substantial room for cost-beneficial investment in system preservation that would reduce average highway user costs and (2) the most effective mix of investments at the funding level reflected in the "Cost to Maintain Highways and Bridges" scenario would include a higher percentage for system preservation than is currently the case. However, the analyses also suggest that, if funding levels were to be raised significantly, an increasing number of potential system capacity investments would be among the most cost-beneficial options. Such investments are generally more expensive than preservation improvements, but proportionally more of them could be justified at higher funding levels. Thus, 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.

## *Conclusion*

Since the enactment of TEA-21, combined Federal, State, and local investment in highway infrastructure has increased substantially. This investment led to improved highway and bridge conditions, particularly on higher-order functional systems. Despite record levels of funding, however, congestion increased throughout the country. Analysis of highway and bridge needs and investment requirements suggests that, while devoting a larger share of investment toward system preservation would be more cost beneficial at current funding levels, future increases in investment might best be oriented more toward system expansion to reduce user costs and enhance system performance.

# 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 2002. Total funding by Federal, State, and local governments reached its highest level of $26.6 in 2002, a 52.2 percent increase in current dollars from $17.5 billion in 1997, equal to 40.0 percent increase in constant dollar terms. Federal funding in current dollars increased by 32.8 percent, from $4.7 billion in 1997 to $6.3 billion in 2002, equal to a 22.2 percent increase in constant dollar terms. State and local funding in current dollars increased by 59.4 percent, from $12.7 billion in 1997 to $20.3 billion in 2002, equal to a 46.7 percent in increase in constant dollar terms. Total funding for transit, including system-generated revenues, increased by 40.6 percent from $26.0 billion in 1997 to $36.5 billion in 2002, an increase of 29.3 percent in constant dollars.

In 2002, total transit agency expenditures for capital investment were $12.3 billion in current dollars, accounting for 34.9 percent of total transit spending. Federal funds provided $5.0 billion of total transit agency capital expenditures, State funds provided $1.4 billion, and local funds provided $5.9 billion. Capital investment funding for transit from the Federal government increased by 20.7 percent from 1997 to 2002, and capital investment funding for transit from State and local sources increased by 108.9 percent from 1997 to 2002. 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 54.7 percent in 1997 to 47.2 percent in 2000 to 40.6 percent in 2002.

## *Transit Infrastructure Has Expanded*

The significant growth in total capital investment under TEA-21 is reflected in an expansion of the National transit infrastructure. Between 1997 and 2002, the number of active urban transit vehicles as reported to the National Transit Database increased by 12.0 percent, from 102,258 to 114,564. Track mileage grew by 8.1 percent, from 9,922 miles in 1997 to 10,722 miles 2002. The number of stations increased by 6.8 percent, from 2,681 in 1997 to 2,862 in 2002; and the number of urban maintenance facilities increased by 5.5 percent, from 729 in 1997 to 769 in 2002.

## *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 14.3 percent, from 40.2 billion in 1997 to 45.9 billion in 2002. PMT on nonrail transit (primarily buses) increased by 12.0 percent, from 19.0 billion in 1997 to 21.3 billion in 2002. PMT on rail increased by 16.5 percent from 21.1 billion in 1997 to 24.6 billion in 2002. The distance traveled by all transit vehicles in revenue service, adjusted for differences in carrying capacities, increased by 15.7 percent, from 3.6 billion full-capacity bus miles in 1997 to 4.2 billion equivalent miles in 2002.

## *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 3.19 in 2002. Rail vehicle conditions were about the same, 3.42 in 1997 compared with 3.47 in 2002, although they were somewhat lower in the intervening years.

Bus facility conditions improved from 3.23 in 2000 to 3.34 in 2002. Average condition is not available for 1997. Sixty-eight percent of bus maintenance facilities were in adequate (3) or better condition in 2002 compared with 71 percent in 2000 and 77 percent in 1997. However, the percent in poor condition fell from 5 percent to 1 percent, affecting the condition average. Rail facility conditions improved from 3.20 in 2000 to 3.56 in 2002. As with buses, average condition is not available for 1997. Eighty percent of rail facilities were estimated to be in adequate or better condition in 2002, compared with 64 percent in 2000 and 77 percent in 1997. (These vacillations result from changes in facility deterioration schedules between 1997 and 2000 and asset inventory information collected between 2000 and 2002.) The conditions of track and structures improved. Changes in the conditions of power systems were mixed depending upon the specific asset type. The conditions of stations and yards declined. Nonrail stations are, on average, in better condition than rail stations. The changes in the condition of nonvehicle assets reflect both actual changes and changes based on new information. Almost half of the nonvehicle transit asset data used by FTA to estimate conditions has been updated since the last report as a result of information collected by FTA directly from transit agencies.

## *Operational Performance, Mixed Results*

Vehicle utilization is a measure of service effectiveness and vehicle crowding. Between 1997 and 2000, vehicle utilization rates increased for commuter rail, heavy rail, light rail and ferry boat and decreased for all other modes. Vehicle utilization rates for all modes decreased from 2000 to 2002.

Average vehicle speed as experienced by passengers declined from 20.5 miles per hour in 1997 to 19.6 miles per hour in 2000, increasing to 19.9 miles per hour in 2002. Rail speed declined from 26.1 miles per hour in 1997 to 24.9 miles in 2000 increasing to 25.3 miles per hour in 2002. Nonrail speed declined from 13.8 miles per hour in 1997 to 13.7 miles per hour in 2000 and 2002.

## *Future Investment Scenarios*

The estimated average annual "Cost to Maintain" transit asset conditions and operating performance is estimated to be $15.5 billion, 26.8 percent more than 2002 capital spending. Between 45 to 68 percent of these projected funding requirements are for asset rehabilitation and replacement. Asset rehabilitation and replacements accounts for a larger portion of total investment requirements if performance is maintained and a smaller portion if performance is improved. These increased investment requirements reflect an enlarged transit infrastructure base, new information collected on transit assets from field surveys and data provided to FTA by transit agencies, updated capital cost estimates, and a downward revision in the average condition of rail vehicles as a result of improvements to deterioration schedules.

Eighty-seven percent of transit investment requirements are expected to be in urban areas with populations over 1 million, which is not surprising given that 91.6 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. Vehicles account for the highest proportion, but less than half, of projected capital outlays for both rail and nonrail modes. Changes in investment needs by asset type from 2000 to 2002 varied considerably. The most notable change was an increase in the amount needed for stations and a decrease in the amount needed for guideways. These changes principally reflect new data collected since the last report.

The average annual "Cost to Improve" both the physical condition of transit assets and transit operational performance to targeted levels by 2022 is estimated to be $24.0 billion in constant dollars, 95.1 percent higher than transit capital spending of $12.3 billion in 2002. This scenario is an upper limit of the economically justifiable level of transit investments. The scenario assumes that all assets reach an average level of 4 by the end of the investment period Eighty-four percent of the additional amount for the "Cost to Improve," or $6.6 billion annually, is for performance improvements to increase average operating speeds as experienced by passengers and lower average vehicle occupancy levels to threshold levels by 2022, by undertaking investments in systems with slower passenger speeds and higher occupancy rates.

Projected investment requirements are sensitive to forecasts of PMT. The estimated investment requirements presented in this report are based on an average annual increase in ridership of 1.5 percent, an average of transit travel forecasts from 76 metropolitan planning organizations (MPOs). The previous report used projected growth of 1.6 percent per year based on the forecasts of 33 MPOs. The projected rate is above the actual 0.9 percent average annual rate of growth between 2000 and 2002, but below the actual average annual growth of 2.7 percent occurring between 1993 and 2002. Transit travel between 2000 and 2002 was affected by a 0.7 percent average annual decline in passenger miles traveled on heavy rail, reflecting a drop in New York City ridership following the September 11, 2001 terrorist attacks.

## *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 2002. Passenger miles traveled have increased substantially from 1997 to 2002, but more gradually between 2000 and 2002 than in the preceding 3 years. Vehicle utilization rates for all nonrail modes were lower in 2002 than in 1997; utilization rates for commuter rail, heavy rail and light rail were higher in 2002 than in 1997. Vehicle speeds as experienced by passengers declined from 1997 to 2002, but were slightly higher in 2002 than in 2000. The amount to maintain conditions and performance has increased very slightly since the last report; the amount to improve conditions and performance has increased by more. The larger increase in the amount to improve conditions and performance has resulted principally from upward revisions, on average, in rail capital costs, coupled with a shift in capital investment from bus to rail, assumed by the improve scenario. Since the last report, FTA has undertaken two major studies updating light and heavy rail capital cost information.

# The Role of Highways and Transit

### *The Nation's Transportation System*

America's transportation system is the essential element facilitating the movement of goods and people within the country. It forms the backbone of local, regional, national, and international trade, making most economic activity critically dependent upon this resource.

### *The Role of Highway Transportation*

The use of private automobiles on the Nation's large highway network provides Americans with a high degree of personal mobility. Automobile transportation allows people to travel where, when, and with whom they want. In 2001, 87 percent of daily trips involved the use of personal vehicles.

Highways are also a key conduit for freight movement in the United States, accounting for 71 percent of total freight transport by weight (and 80 percent by value) in 1998.

### *The Role of Transit*

Transit plays a vital role in enhancing the 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; it provides broader transportation choices to people with cars, as well as reduced travel times and road congestion in major transportation corridors. It also facilitates economic growth and development and supports environmentally sustainable and safe communities.

Transit is particularly important to people with limited incomes and without cars, especially older adults and people with disabilities. Transit enables them to take advantage of a wider range of job and educational opportunities, to obtain the health care that they require, to be more active members of their communities and to build and maintain social relationships.

### *The Complementary Roles of Highways and Transit*

Highways and transit serve distinct but overlapping markets. Highway and transit investments expand the travel options available to people. While highways provide the highest degree of mobility, transit is essential for those who do not have access to a private vehicle and is often preferable for certain types of trips. Highway investments can also encourage transit usage by improving access to transit facilities; well-maintained highways improve the operating efficiency of transit modes that use highways. Transit can help mitigate highway congestion by offering an alternative during peak travel times. (Note that the analytical models used to develop the investment analyses later in this report do not quantify the potential for highway or transit investments to serve as complements or substitutes.)

### *The Evolving Federal Role in Surface Transportation*

The Federal government has played a key role throughout the country's history in shaping the transportation system. This role has evolved over time to meet changing needs and priorities.

The Federal-aid highway program is administered by the States with assistance from the Federal government. In recent years, Congress has increased statutory authority for States to assume certain Federal-aid highway project oversight responsibilities, where appropriate. FTA works with grantees eligible or receiving funds for New Starts capital investment projects to choose the best projects, and facilitate the most effective design and implementation.

Highways and transit are closely linked in their function and funding sources. FHWA and FTA work closely with each other and 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.

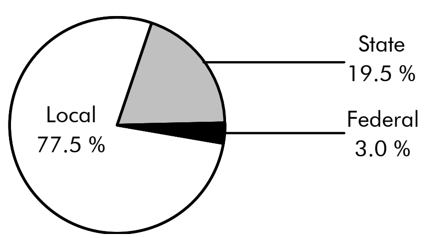
# System Characteristics: Highways

There were almost 3.98 million miles of public roads in the United States in 2002. **This mileage was overwhelmingly rural and locally owned.** About 3.08 million miles were in rural areas in 2002, or 77 percent of total mileage. The remaining 901,000 miles were in urban communities. There are 591,707 bridges in the United States.

Numerous trends are changing the extent and use of the American highway network. **While total road mileage increased between 1993 and 2002, total rural mileage has decreased.** This has been an ongoing trend, partly reflecting the reclassification of Federal roads and the growth of metropolitan areas throughout the United States.

In 2002 about 77.5 percent of the highway miles were locally owned, States owned 19.5 percent, and 3.0 percent were owned by the Federal Government.

*Highway Mileage by Jurisdiction, 2002*



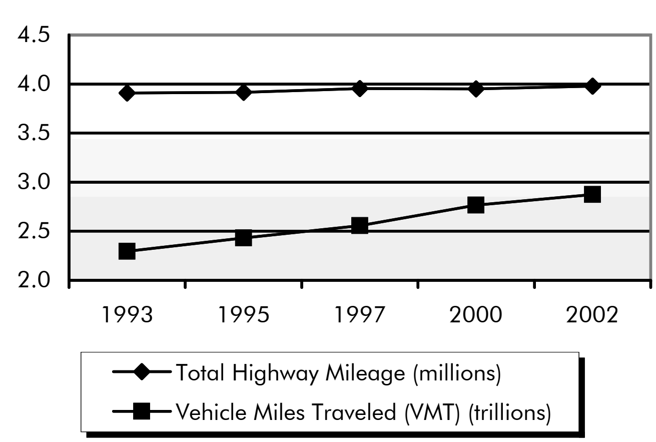

Americans traveled nearly 2.9 trillion vehicle miles in 2002. While highway mileage is mostly rural, a majority of highway travel (over 60 percent) occurred in urban areas in 2002. From 2000 to 2002, however, **rural travel grew at a slightly faster average annual rate** (2.8 percent) than urban travel (2.4 percent). This continues the trend noted in the 2002 C&P report. In the decade prior to 1993, urban travel growth rates were greater than rural. Vehicle miles traveled (VMT) nevertheless increased on every highway functional system from 2000 to 2002.

*Percentage of Highway Miles, Lane Miles, and Vehicle Miles Traveled by Functional System, 2002*

| Functional System | Miles | Lane Miles | Vehicle Miles Traveled |
|---|---|---|---|
| **Rural Areas** | | | |
| Interstate | 0.8% | 1.6% | 9.8% |
| Other Principal Arterials | 2.5% | 3.1% | 9.0% |
| Minor Arterial | 3.5% | 3.5% | 6.2% |
| Major Collector | 10.8% | 10.4% | 7.5% |
| Minor Collector | 6.8% | 6.5% | 2.2% |
| Local | 52.9% | 50.6% | 4.9% |
| **Subtotal Rural** | **77.3%** | **75.7%** | **39.4%** |
| **Urban Areas** | | | |
| Interstate | 0.3% | 0.9% | 14.3% |
| Other Freeway and Expressway | 0.2% | 0.5% | 6.6% |
| Other Principal Arterial | 1.3% | 2.3% | 14.3% |
| Minor Arterial | 2.3% | 2.8% | 11.9% |
| Collector | 2.3% | 2.3% | 5.0% |
| Local | 16.2% | 15.5% | 8.4% |
| **Subtotal Urban** | **22.7%** | **24.3%** | **60.6%** |
| **Total** | 100.0% | 100.0% | 100.0% |

In recent years, growth in VMT has exceeded the increase in highway lane miles. **Between 1993 and 2002, lane miles grew by 0.2 percent annually, while VMT increased by 2.5 percent annually**. VMT for trucks grew faster between 2000 and 2002 than did VMT for passenger vehicles.

*Highway Mileage and Travel, 1993–2002*



# System Characteristics: Transit

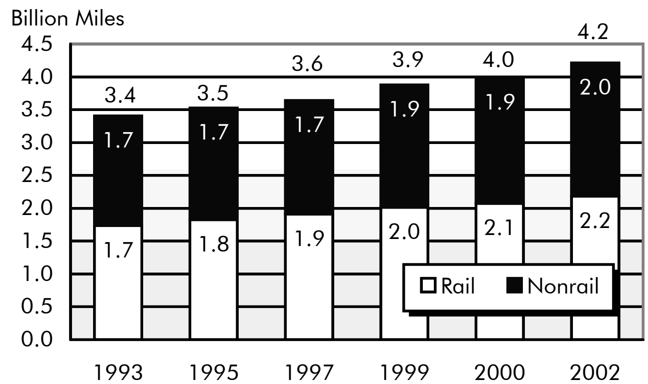
**Transit system coverage, capacity, and use in the United States continued to increase between 2000 and 2002.** In 2002, there were 610 transit operators serving urbanized areas, of which 538 were public agencies. A public transit provider may be a unit of a regional transportation agency, a State, a county, or a city government or it may be independent. In 2000, the most recent year for which information is available, there were 1,215 operators serving rural areas; and in spring 2004, it was estimated that there were 4,836 providers of special services to older adults and persons with disabilities receiving Federal Transit Administration (FTA) funds.

In 2002, transit agencies in urban areas operated 114,564 vehicles, of which 87,295 were in areas of more than 1 million people. Rail systems comprised 10,722 miles of track and 2,862 stations. There were 769 bus and rail maintenance facilities in urban areas, compared with 729 in 2000. The most recent surveys 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 2002, transit systems operated 235.3 billion directional route miles, of which 225.8 billion were nonrail and 9.5 billion were rail route miles. Total route miles increased by 14.2 percent between 2000 and 2002. Nonrail route miles increased by 14.7 percent and rail route miles increased by 2.8 percent during this period.

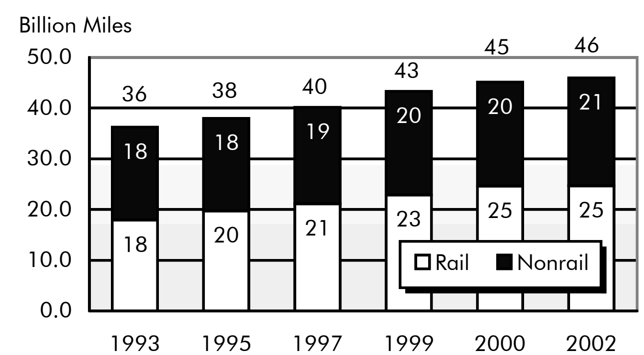
**Transit system capacity, as measured by available seating and standing capacity, increased by 18.7 percent between 2000 and 2002.** Rail capacity increased by 19.7 percent and nonrail capacity by 17.7 percent. The capacities of rail and nonrail modes were similar in 2002, 2.2 and 2.0 billion capacity-equivalent miles, respectively, for a total of 4.2 billion miles.

*Urban Capacity-Equivalent Revenue Vehicle Miles (Billions)*




**Transit passenger miles traveled (PMT) increased by 1.9 percent between 2000 and 2002, from 45.1 billion to 45.9 billion.** PMT traveled on nonrail modes increased from 20.5 billion in 2000 to 21.3 billion in 2002, or by 4.0 percent. PMT on rail transit modes increased from 45,101 million in 2000 to 45,944 million in 2002. The growth in rail PMT was affected by a decline in heavy rail PMT in New York after the September 11 terrorist attacks destroyed parts of the subway system.

*Urban Passenger Transit Miles (Billions)*

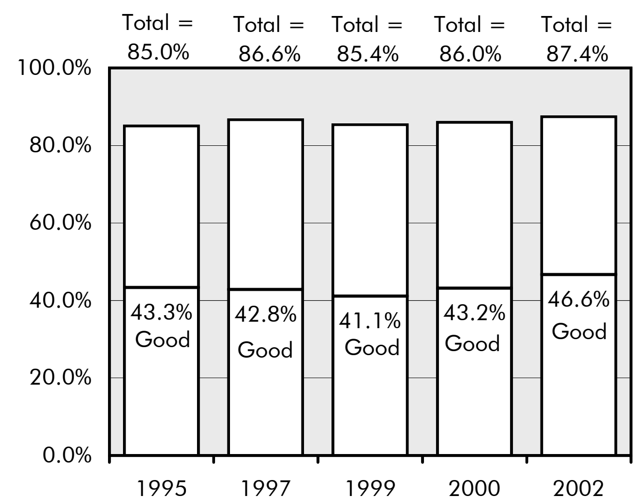



In 2002, vehicle occupancy was 10.9 persons compared with 11.3 persons in 2000. Vehicle occupancy of transit vehicles, adjusted to the capacity of a bus, fluctuated between 10.6 persons and 11.3 persons per vehicle between 1993 and 2002.

# System Conditions: Highway and Bridges

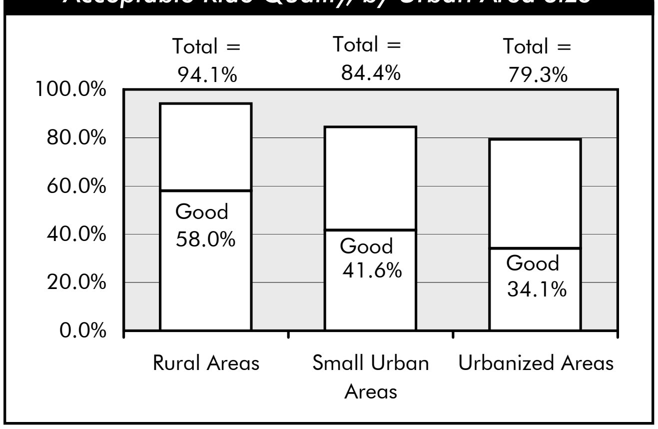
**The ride quality of 87.4 percent of the Nation's total road mileage was rated "Acceptable" in 2002,** up from 86.0 percent in 2000. Ride quality is defined based on pavement roughness. Pavements with roughness below 170 inches per mile are considered to have "acceptable" ride quality. Pavements with "good" ride quality comprised 46.6 percent of total highway mileage in 2002.

***Percentage of Pavement Mileage with Acceptable Ride Quality***




Pavement ride quality is generally better on higher functional class roads, and is better in rural areas (where 94.1 percent of travel is on pavements with acceptable ride quality) than in urbanized areas.

***Percentage of VMT on Pavement with Acceptable Ride Quality, by Urban Area Size***




Information on ride quality on the National Highway System (the basis of the pavement performance measures in DOT's *Strategic Plan*) is located in Chapter 17.

The number of deficient bridges is widely used by policymakers to describe bridge quality nationwide. Deficient bridges include those characterized both as *structurally deficient* (deteriorated condition and the reduced load-carrying capacity) and as *functionally obsolete* (based appraisals of clearance adequacy, deck geometry, and alignment). Of the 591,707 bridges in the inventory, 162,869 (27.5 percent) were deficient in 2002. Of these, 81,304 (13.7 percent) were classified as structurally deficient and 81,565 (13.8 percent) were classified as functionally obsolete.

The percentage of bridges classified as deficient declined from 28.5 percent in 2000 to 27.5 percent in 2002. This reduction is mostly due to work done to correct problems on structurally deficient bridges. The percentage of functionally obsolete bridges has not changed significantly.

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

| Year | 1998 | 2000 | 2002 |
|---|---|---|---|
| **Rural Bridges** | | | |
| Structurally Deficient | 17.4% | 16.2% | 15.1% |
| Functionally Obsolete | 11.4% | 11.4% | 11.4% |
| **Total Deficiencies** | **28.8%** | **27.6%** | **26.5%** |
| **Urban Bridges** | | | |
| Structurally Deficient | 11.0% | 9.9% | 9.2% |
| Functionally Obsolete | 21.5% | 22.0% | 21.9% |
| **Total Deficiencies** | **32.5%** | **31.9%** | **31.2%** |
| **All Bridges** | | | |
| Structurally Deficient | 16.0% | 14.8% | 13.7% |
| Functionally Obsolete | 13.6% | 13.8% | 13.8% |
| **Total Deficiencies** | **29.6%** | **28.5%** | **27.5%** |

Other indicators of bridge conditions, including the traffic carried on deficient bridges and the deck area on deficient bridges, are described in the body of Chapter 3 and in Chapter 15.

# System Conditions: Transit

U.S. transit system conditions depend on the quantity, age, and physical condition of the assets that make up the Nation's transit 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).

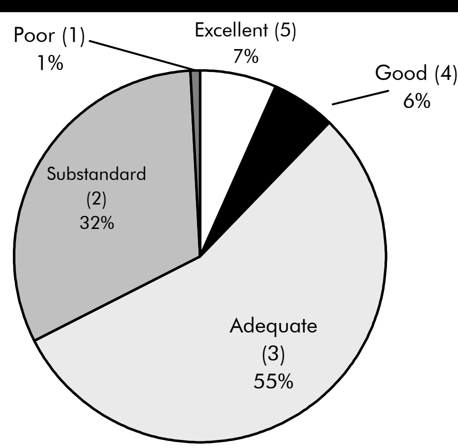
The Federal Transit Administration (FTA) has undertaken extensive engineering surveys and collected a considerable amount of data on the U.S. transit infrastructure to evaluate transit asset conditions. FTA uses a rating system of 1 "poor" to 5 "excellent" to describe asset conditions.

*Definitions of Transit Asset Condition*

| 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 increased from 3.05 in 2000 to 3.19 in 2002. The average condition of bus maintenance facilities increased from 3.23 in 2000 to 3.34 in 2002.** In 2002, 68 percent of bus maintenance facilities were in adequate or better condition.

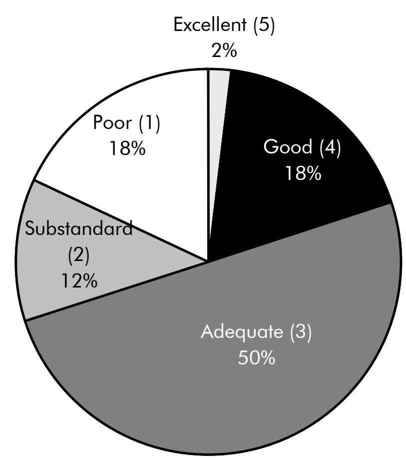
*Condition of Bus Maintenance Facilities, 2002*




**The average condition of rail vehicles increased from 3.38 in 2000 to 3.47 in 2002. The average age of rail vehicles declined from 21.8 years in 2000 to 20.4 years in 2002.** Commuter rail vehicle conditions have been revised using new deterioration schedules based on engineering surveys undertaken in 2002. As a result, the commuter rail conditions in this edition of the report are about 15 percent lower than those reported in earlier editions.

Additional data collected by FTA since the last edition of this report revealed that the percentage of rail maintenance facilities that are less than 10 years old is higher than previously estimated. This new information has led to an upward revision in the condition estimate of rail maintenance facilities from 3.18 in 2000 to 3.56 in 2002. In 2002, 80 percent of rail maintenance facilities were estimated to be in adequate or better condition.

*Condition of Rail Maintenance Facilities, 2002*




From 2000 to 2002, the conditions of track, substations, structures and third rail improved. The conditions of rail yards, overhead wire and stations declined. Station conditions fell from 3.4 in 2000 to 3.0 in 2002. This decrease was largely the result of new information collected directly from transit agencies rather than an actual change. Rail station conditions are, on average, considerably lower than bus station conditions.

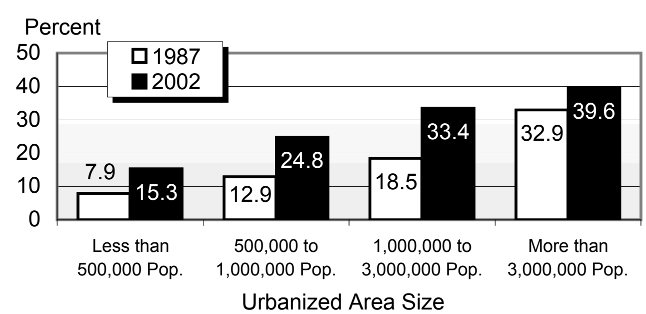
# Operational Performance: Highways

Three measures of congestion developed by the Texas Transportation Institute (TTI) clearly show con¬gestion is getting worse throughout the Nation. (Note that the values shown in this report are based on data for all urbanized areas. The values shown for these same measures in TTI's annual *Urban Mobility Study* are different, since that study is based on a subset of urbanized areas that is weighted towards the most heavily populated areas.)

### *Percent of Travel Under Congested Conditions:*

Percent of Travel Under Congested Conditions is an indicator of the portion of traffic on freeways and other principal arterials in an urbanized area that moves at less than free-flow speeds. Congested travel increased from 21.1 percent in 1987 to 30.4 percent in 2002. The length of the average congested period, or "rush hour," increased from 5.4 to 6.6 hours per day over these 15 years. For urban areas with populations greater than 3 million, 39.6 percent of daily travel in 2002 occurred under congested conditions.

*Percent of Travel Under Congested Conditions, 1987 Versus 2002*

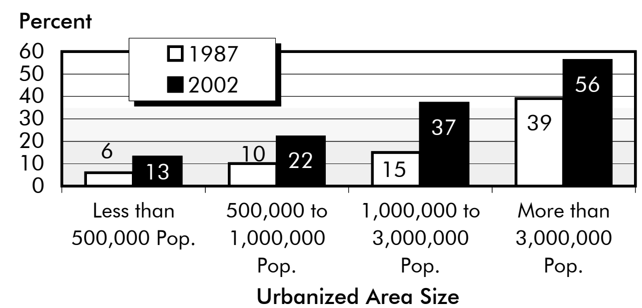



### *Percent of Additional Travel Time:*

Percent of Additional Travel Time is an indicator of the additional time required to make a trip during the congested peak travel period rather than at other times of the day. In 2002, an average peak period trip required 37.0 percent more time than the same trip under nonpeak, noncongested conditions. In 1987, a 20-minute trip during noncongested periods required 24.4 minutes under congested conditions. The same trip in 2002 required 27.4 minutes, or an additional 3 minutes.

Between 1987 and 2002, the percent of additional travel time grew fastest in urbanized areas with a population between 1 million and 3 million.

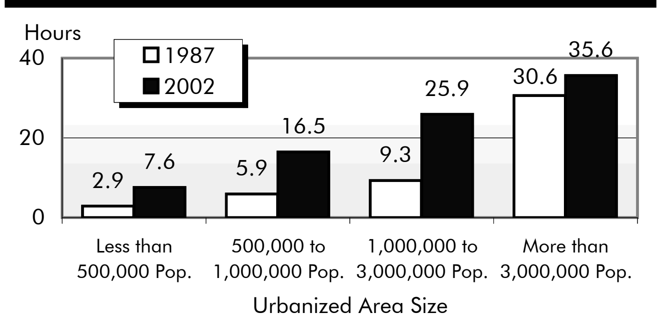
*Percent of Additional Travel Time, 1987 Versus 2002*




### *Annual Hours of Traveler Delay:*

Annual Hours of Traveler Delay is an indicator of the total time an individual loses due to traveling under congested conditions. Cities with populations between 500,000 and 1 million experienced the greatest percentage growth in the average annual delay experienced by drivers, from 5.9 hours in 1987 to 16.5 hours in 2002—an increase of nearly 180 percent.

*Annual Hours of Traveler Delay, 1987 Versus 2002*

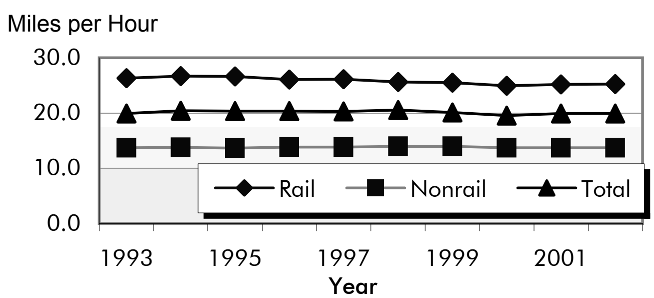


# Operational Performance: Transit

**Average operating speed in 2002 was higher than in 2000, but below its 10-year average. Average vehicle utilization levels were lower in 2002 than in 2000, but the utilization of rail vehicle modes remained high in 2002 relative to the 10-year averages. Buses had the smallest decline in vehicle utilization from 2000 to 2002.**

Average operating speed is the average speed that a passenger will travel on transit rather than the pure operational speed of transit vehicles. In 2002, the **average operating speed** for all transit modes was 19.9 miles per hour, up from 19.6 in 2000, but below the 10-year average of 20.1. The average speed for rail was 25.3 miles per hour in 2002, up from 24.9 in 2000, most likely due to a decline in vehicle utilization and shorter vehicle dwell times. The average speed of nonrail modes was 13.7 miles per hour in both 2000 and 2002.

*Transit Operating Speeds, 1993–2002*



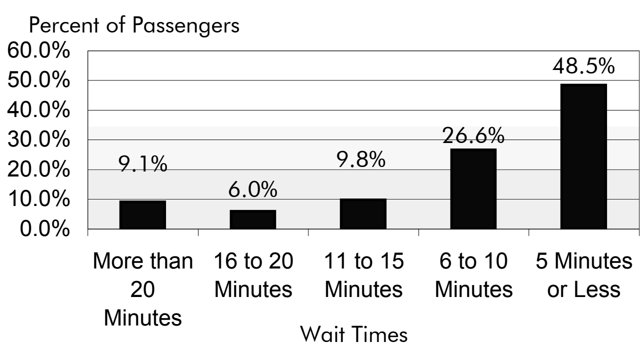

**Most passengers who ride transit wait in areas that have frequent service.** The 2001 National Household Travel Survey found that 49 percent of all passengers who ride transit wait for 5 minutes or less for a vehicle to arrive, and 75 percent wait 10 minutes or less. Nine percent of passengers wait 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.

**Vehicle utilization** is measured as passenger miles per vehicle adjusted to reflect differences in the passenger-carrying capacities of transit vehicles. Capacity-adjusted vehicle utilization levels in this edition of the report are based on revised capacity-equivalent factors, and, with the exception of buses, are not comparable to utilization levels reported in earlier editions. The revisions to capacity-equivalent factors did not affect year-to-year changes in utilization rates. 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*

| | Utilization | |
|---|---|---|
| **Mode** | **2000** | **2002** |
| Heavy Rail | 697 | 675 |
| Commuter Rail | 863 | 831 |
| Light Rail | 546 | 528 |
| Vanpool | 577 | 539 |
| Bus | 393 | 390 |
| Ferryboat | 305 | 294 |
| Trolleybus | 257 | 246 |
| Demand Response | 188 | 178 |

*Passengers by Waiting Times*

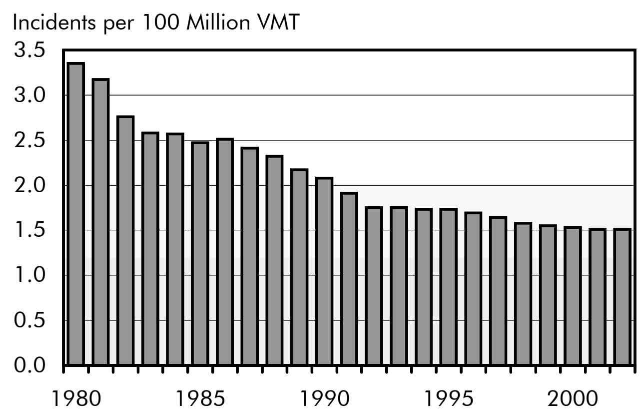


# Safety Performance: Highways

The U.S. Department of Transportation has established the goal of reducing the highway fatality rate to 1.00 per 100 million VMT by 2008. Federal safety initiatives intended to support the achievement of this goal are discussed in Chapter 11, while this chapter focuses on safety statistics.

Highway fatalities increased slightly between 1997 (42,013) and 2002 (43,005). 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 2002.

**Fatality Rate, 1980–2002**

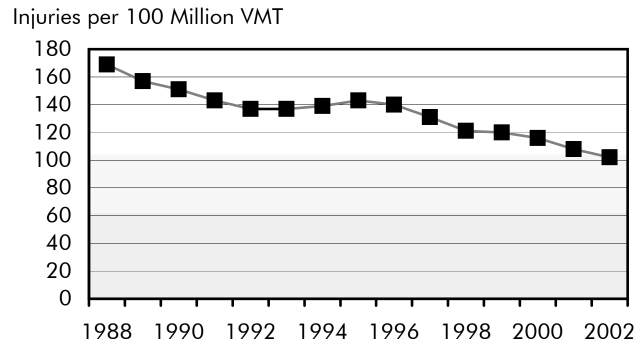



*Source: Fatality Analysis Reporting System.*

The fatality rate per 100 million VMT dropped from 1.64 in 1997 to 1.51 in 2002. This drop coincided with a significant increase in the number of VMT. Similarly, the fatality rate per 100,000 population was 14.93, a decrease from the 1997 fatality rate of 15.69.

The number of injuries declined from about 3.35 million in 1997 to 2.89 million in 2002. The injury rate per 100,000 people declined from 1,250 in 1997 to 1,016 in 2002, and the injury rate per 100 million VMT dropped from 131 in 1997 to 102 in 2002.

**Injury Rate, 1988–2002**




*Source: Fatality Analysis Reporting System.*

Alcohol-impaired driving is a serious public safety problem in the United States. The National Highway Traffic Safety Administration (NHTSA) estimates that alcohol was involved in 41 percent of fatal crashes and 6 percent of all crashes in 2002. The 17,524 fatalities in 2002 represent an average of one alcohol-related fatality every 30 minutes.

The number of alcohol-related fatalities dropped from 17,908 in 1993 to 17,524 in 2002, although the pattern of alcohol-related fatalities has been uneven—declining between 1996 and 1999, then increasing between 1999 and 2002.

**Alcohol-Related Fatalities, 1993–2002**

| 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|
| 17,908 | 17,732 | 16,711 | 16,572 | 17,380 | 17,524 |

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

The most common types of fatalities are those related to alcohol-impaired driving, single-vehicle run-off-the-road crashes, and speeding. There is a correlation between speeding, age, and alcohol consumption in fatal crashes. The NHTSA estimates that in 2002, 27 percent of underage **speeding** drivers involved in fatal crashes were intoxicated, while only 12 percent of underage **nonspeeding** drivers involved in fatal crashes were intoxicated.

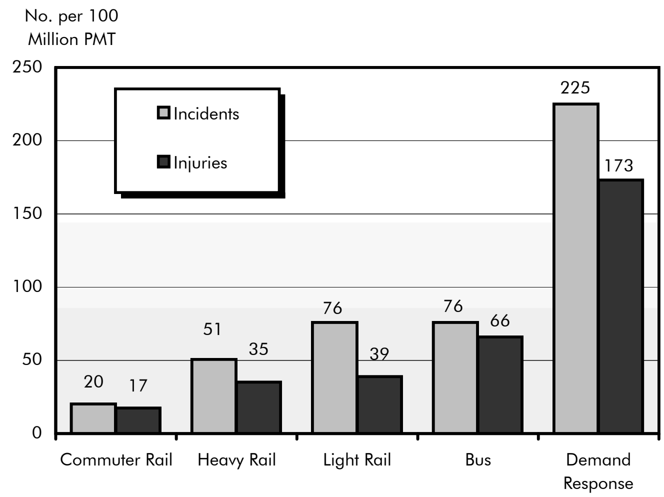
# Safety Performance: Transit

**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 reported by transit agencies for the vehicles they operate directly. Reportable safety incidents include collisions and any other type of occurrence (e.g., derailment) that result in injury or death, or fire 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. Injuries and fatalities may occur while traveling or while boarding, alighting, or waiting for a transit vehicle.

**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 2002 incident and injury statistics with those for earlier years. The definition of fatalities has remained the same. **Fatalities decreased from 292 in 2000 to 282 in 2002,** and fell from 0.69 per 100 million PMT in 2000, to 0.66 per 100 million PMT in 2002.

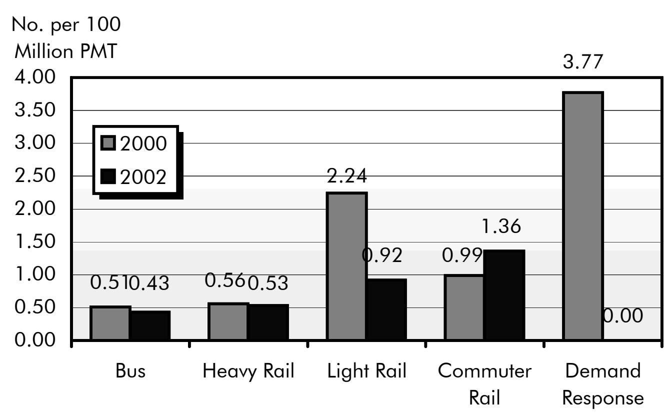
Transit vehicles that travel on roads have higher incident and injury rates than those that travel on fixed guideways. Incidents and injuries, when adjusted for PMT, are consistently the lowest for commuter rail and highest for demand response systems. Buses and demand response vehicles experienced the greatest fall in reported incidents and injuries from 2000 to 2002 as a result of the changes in definitions. While buses historically have had more incidents per PMT than light rail, the number of incidents reported by each of these modes was the same in 2002 under the new higher incident reporting threshold.

*Incidents and Injuries per 100 Million PMT, 2002*




Fatalities, adjusted for PMT, are lowest for buses and heavy rail systems. Fatality rates for commuter and light rail have, on average, been higher than fatality rates for heavy rail. Demand response vehicles have widely fluctuating fatality rates, well above those for other types of transit services. There were, however, no fatalities on demand response vehicles operated directly by public transit agencies in 2002.

*Fatalities per 100 Million PMT, 2000 and 2002*



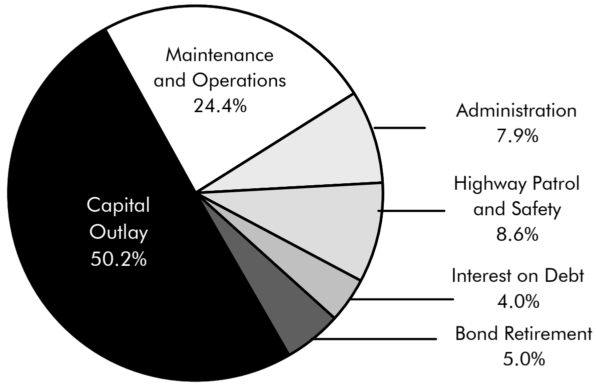
# Finance: Highways

Taken together, all levels of government spent $135.9 billion for highways in 2002. The Federal government funded $32.8 billion (24.1 percent). This figure reflects cash outlays by all Federal agencies combined for highway-related purposes, including amounts transferred to State and local governments for use on highways. States funded $69.0 billion (50.8 percent). Counties, cities, and other local government entities funded $34.1 billion (25.1 percent).

**Total highway expenditures by all levels of government increased 33.3 percent between 1997 and 2002.** Highway spending rose faster than inflation over this period, growing 18.4 percent in constant dollar terms.

Of the total $135.9 billion spent for highways in 2002, $68.2 billion (50.2 percent) went for capital outlay. 2001 was the first year since 1975 that this percentage exceeded 50 percent.

*Highway Expenditures by Type, 2002*



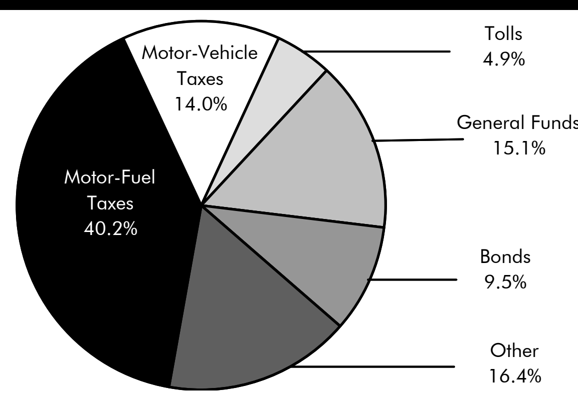

**Capital outlay grew by 41.0 percent between 1997 and 2002.** Federal cash expenditures for capital purposes rose 56.3 percent, while State and local capital investment increased by 29.7 percent.

From 1987 to 1997, the portion of total capital outlay funded by the Federal government varied within a range of 41 to 46 percent. This share dropped down to 37.1 percent in 1998, but has subsequently rebounded sharply to 46.1 percent in 2002, as the full effects of increased investment levels under the Transportation Equity Act for the 21st Century (TEA-21) have begun to take hold.

**State and local governments devoted more than half of their capital spending to the preservation of their existing roads and bridges in 2002.** All levels of government spent a combined $35.8 billion (52.6 percent) of capital funds for system preservation in 2002; $12.9 billion (18.9 percent) went for new roads and bridges; $13.6 billion (19.9 percent) went for adding new lanes to existing roads; and $5.9 billion (8.6 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—were $100.5 billion in 2002. Of this, $79.6 billion (79.2 percent) was spent on highways. This represented 59.1 percent of the total revenues generated by all levels of government in 2002 for use on highways.

*Revenue Sources for Highways, 2002*

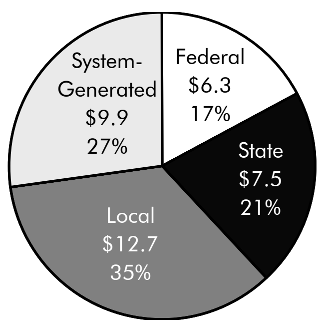



States are increasingly looking to the private sector as another potential source of highway and transit funding, either in addition to or in concert with new credit and financing tools. A number of States have taken legislative action to permit greater use of public-private partnerships.

# Finance: Transit

**In 2002, $36.5 billion was available from all sources to finance transit capital investments and operations.** 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 2002, Federal funds accounted for 17 percent of all transit revenue sources, State funds for 21 percent, local funds for 35 percent, and system-generated funds for 27 percent.

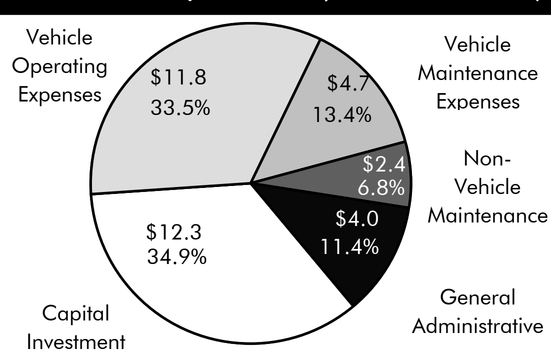
*2002 Transit Revenue Sources (Billions of Dollars)*



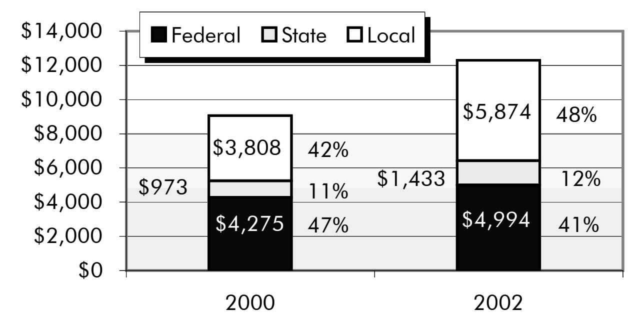

Eighty percent of the Federal funds allocated to transit are from a dedicated portion of the Federal motor-fuel tax receipts, and 20 percent are from general revenues. Federal funding for transit increased from $5.3 billion in 2000 to $6.3 billion in 2002, and State and local funding increased from $15.7 billion in 2000 to $20.3 billion in 2002.

**In 2002, $12.3 billion, or 34.9 percent of total available transit funds, was spent on capital investment.** Federal capital funding was $5.0 billion, or 40.6 percent of total capital expenditures; State capital funding was $1.4 billion, or 11.6 percent of total capital expenditures; and local capital funding was $5.8 billion, or 47.8 percent of total capital expenditures. Between 2000 and 2002, Federal capital funding increased by 17 percent and State and local capital funding by 53 percent.

*2002 Transit Expenditures (Billions of Dollars)*




*Sources of Transit Capital Investment Funding, 2000 and 2002 (Millions of Dollars)*




In 2002, $4.1 billion, or 33 percent of total capital expenditures, was for rolling stock; $3.2 billion, or 26 percent, was for guideway; $2.2 billion, or 18 percent of capital spending, was for facilities; and $1.0 billion, or 8 percent, was for other capital.

**In 2002, $24.2 billion was available for operating expenses and accounted for 65.1 percent of total available funds**. System-generated revenues provided $9.9 billion, or 41.0 percent of the total amount available for operating expenses; local governments provided $6.9 billion (28.4 percent), State governments provided $6.1 billion (25.3 percent), and the Federal government provided $1.3 billion (5.4 percent). Actual operating expenditures were $22.9 billion, slightly below the amount available. Vehicle operating expenses were $11.8 billion, or 51.5 percent of total operating expenses; vehicle maintenance expenses were $4.7 billion, or 20.3 percent of total operating expenses, nonvehicle maintenance expenses were $2.4 billion, or 10.6 percent of total operating expenses; and general administrative expenses were $4.0 billion, or 17.6 percent of total operating expenses.

# Investment/Performance Analysis

Chapters 7 through 10 present and analyze estimates of future capital investment requirements for highways, bridges, and transit.

The 20-year investment requirement projections identified in this report are the product of complex technical analyses that attempt to predict the impact that alternative levels of future capital investment may have on the future conditions and performance of the transportation system.

Separate estimates of investment requirements for highways, bridges, and transit are generated independently by separate models and techniques. **Cost to Maintain** and **Cost to Improve** scenarios are presented for each, but 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;** and, where practical, supplemental information has been included to describe the impacts of other possible investment levels. The highway, bridge, and transit scenarios are defined differently, based on the data available for analysis and the analytical model used.

The **Highway Economic Requirements System (HERS),** introduced in the 1995 C&P report, was used to generate estimates of investment requirements for highway preservation and highway/bridge capacity expansion. Recent changes to HERS are documented in Appendix A.

The **National Bridge Investment Analysis System (NBIAS)** was introduced in the 2002 C&P report, adding economic analysis into the bridge preservation modeling for the first time. The NBIAS is described in more detail in Appendix B.

The **Transit Economic Requirements Model (TERM)** has been used since the 1997 C&P report to generate estimates of investment requirements for transit. The TERM is discussed in Appendix C.

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 its users 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 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 health or property damage costs).

While the **Cost to Maintain** and **Cost to Improve** scenarios both assume that transportation improvements are selected for implementation based solely on their benefit-cost ratios, this is unlikely to be the case in reality. Other factors influence Federal, State, and local decisionmaking that may result in a different outcome. Consequently, increasing spending to the **Cost to Maintain** level would not guarantee that conditions and performance of the system would actually be maintained; additional funding could be required to the extent that some transportation improvements with lower benefit-cost ratios were implemented instead of ones with higher benefit-cost ratios. 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 guarantee that the full estimated benefits of that scenario would be attained. That result could be achieved only by modifying Federal program requirements and State and local government practices to ensure that no project would be implemented unless its estimated benefits exceeded its estimated costs.

# Investment/Performance Analysis

These 20-year investment requirement estimates also reflect the total capital investment required from **all sources**—Federal, State, local, and private—to achieve certain levels of performance. The analyses do not directly address which revenue sources might be used to finance the investment required by each scenario, nor do they identify how much might be contributed by each level of government. **This report makes no recommendations concerning future levels of Federal investment.**

It is important to recognize that the use of different revenue mechanisms to support transportation investments can have an impact on future investment requirements. For example, if investment in urban freeways were to be increased dramatically, more drivers would tend to use the newly improved routes. However, if fuel taxes were simultaneously increased to pay for the improvements, this would raise the cost of driving generally, causing some marginal trips to be deterred. If tolls were simultaneously imposed on urban freeways to pay for the improvements, this would likely discourage additional trips and encourage some drivers to switch to non-tolled routes.

**Congestion Pricing**—Some of the congestion problems facing the Nation's road network can be traced to imbalances between highway travel demand and supply, due to the "underpricing" of highway use. Under normal conditions, each individual driver's use of a road will not have an appreciable effect on the implicit costs (such as travel time and safety risks) faced by other users. As traffic volumes rise and a facility becomes congested, travel times for all users begin to rise, with each additional vehicle making the situation progressively worse. However, since individual travelers do not bear any of these costs that they impose on other drivers, their individual economically rational decisions can collectively result in an inefficiently high level of use of congested facilities.

In an ideal world, users of congested facilities would be levied charges precisely corresponding to the economic cost of the delay they impose on one another. This would reduce peak traffic volumes (but not necessarily eliminate all congestion delay) and increase total net benefits to highway users. While perfectly efficient pricing (which requires comprehensive knowledge of user demand and the ability to continuously adjust the fees that motorists are charged) may not be practical, it would be possible to make the current system more efficient through some form of variable road pricing on selected highways. Significant advances in tolling technology have reduced both the operating costs of toll collection and the delays experienced by users as a result of having to stop or slow down at collection points. Technology also has 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.

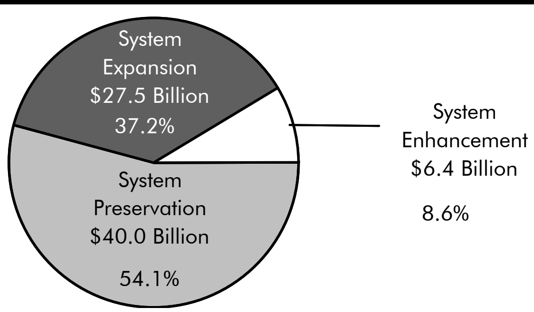
The implications of inefficient pricing for the highway investment requirements estimated in this report are difficult to quantify precisely. The Maximum Economic Investment (Cost to Improve) scenario reflects all economically efficient improvements given the current real-world highway financing structure, reflecting the costs that are currently borne by highway users. However, if efficient road pricing were widespread, the required level of investment would be reduced, with a stronger impact on capacity investment than on preservation improvements. Part V of this report includes a discussion of ongoing research relating to alternative financing mechanisms that should be available for use in the 2006 edition of this report.

**Uncertainty**—As in any modeling process, simplifying assumptions have been made to make analysis practical and to meet the limitations of available data. Chapter 10 examines the sensitivity of the estimates to changes in some of the key parameters underlying the analytical models.

# Capital Investment Requirements: Highway and Bridge

The **Cost to Maintain Highways and Bridges represents the investment required by all levels of government so that critical indicators of overall conditions and performance in the year 2022 will match their year 2002 values**. For bridge preservation, it represents the level of investment required to maintain the existing level of bridge deficiencies in constant dollar terms. For system expansion and pavement preservation, it represents the investment required to prevent average highway user costs (including travel time costs, vehicle operating costs, and crash costs) from rising in the future.

**Cost to Maintain Highways and Bridges Distribution by Improvement Type**




Agency costs, such as maintenance, and societal costs, such as emissions, are also considered in the analysis, but are not included in the calculation of the maintain user cost performance goal.

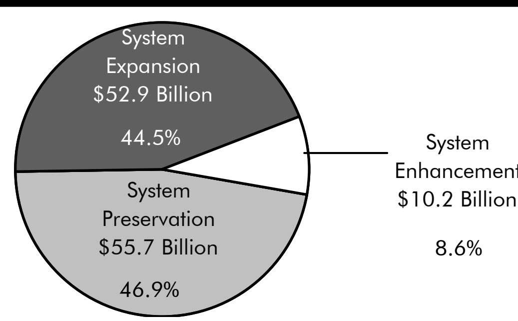
The average annual investment required over the 20-year period 2003–2022 for the Cost to Maintain Highways and Bridges is projected to be $73.8 billion. The two investment scenarios take into account the impact of existing trends in the deployment of operations strategies and technologies, including certain types of intelligent transportation systems investments. This has the primary effect of reducing the estimated level of investment required to reach a given performance target, such as maintaining user costs. As is noted on the previous page, the investment analyses do not account for the impact that broader adoption of congestion pricing could have on delaying or reducing future investment requirements.

**The Maximum Economic Investment (Cost to Improve) scenario represents the investment by all levels of government required to implement all cost-beneficial improvements on highways and bridges**. The average annual cost of this scenario is projected to be $118.9 billion. This level of investment would address the existing backlog of highway ($398 billion) and bridge ($63 billion) deficiencies, as well as new deficiencies as they arise during the 20-year period, when it is cost-beneficial to do so. Note that this projection implicitly assumes the continuation of current tax and fee structures. As pointed out on the preceding page, shifts in financing mechanisms could impact these results.

System preservation improvements make up 46.9 percent of the Maximum Economic Investment scenario. This includes all **capital** investment aimed at preserving the existing pavement and bridge infrastructure, such as resurfacing, rehabilitation, and reconstruction. This does not include the costs of routine maintenance.

Investment requirements for system expansion make up 44.5 percent of the Maximum Economic Investment scenario. The remaining 8.6 percent is not directly modeled; this represents the current share of capital spending on system enhancements such as safety, traffic control, and environmental investments.

**Maximum Economic Investment for Highways and Bridges Distribution by Improvement Type**



# Capital Investment Requirements: Transit

**Transit capital investment requirements to maintain conditions and performance and to improve conditions and performance are 5 percent and 16 percent higher, respectively, than in the 2002 report, principally as a result of new information collected on assets and asset prices.** Current estimates are for the period 2003-2022 for four scenarios. The "Maintain Conditions" scenario projects the level of capital investment necessary to maintain current average asset conditions over the 20-year period, and the "Improve Conditions" scenario projects the investment necessary to raise the average condition of each major transit asset type to at least a level of "good." The "Maintain Performance" scenario assumes investment in new capacity to maintain current vehicle occupancy levels as transit passenger travel increases, and the "Improve Performance" scenario assumes that additional investment will be undertaken to reduce average vehicle occupancy rates and increase average vehicle speeds. The "Improve Conditions and Performance" scenario is an upper limit of the economically justifiable level of transit investment.

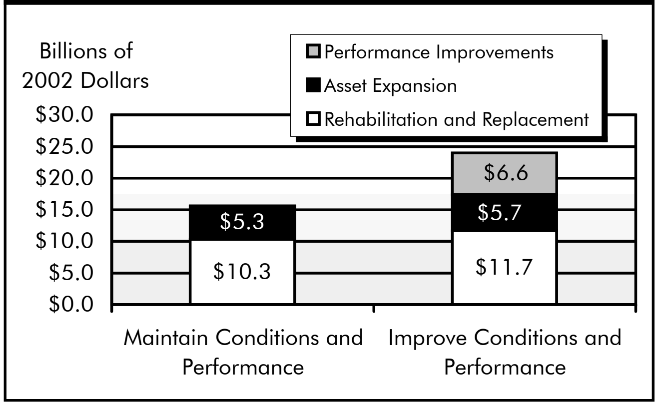
***Transit Average Annual Investment Requirements, 2001–2020 and 2003–2022***

(Billions of Dollars)

| Conditions | Performance | Average Annual Cost 2001-2020 2000 Dollars | 2003-2022 2002 Dollars |
|---|---|---|---|
| Maintain | Maintain | $14.8 | $15.6 |
| Improve | Maintain | $16.0 | $17.1 |
| Maintain | Improve | $19.5 | $22.5 |
| Improve | Improve | $20.6 | $24.0 |

**Average annual investment requirements are estimated to be $15.6 billion to maintain conditions and performance ($14.8 billion in 2000) and $24.0 billion to improve conditions and performance ($20.6 billion in 2000).** Under the "Maintain" scenario, $10.3 billion annually would be needed for asset rehabilitation and replacement and $5.3 billion for asset expansion. Under the "Improve" scenario, $11.7 billion would be needed annually for replacement and rehabilitation, $5.7 billion for asset expansion, and $6.6 billion for performance improvements.

***Annual Cost to Maintain and Improve Conditions and Performance by Investment Type, 2003–2022***




Vehicles account for the 45 percent of the investment required to maintain conditions and performance, $6.9 billion annually, and 39 percent of the investment needed to improve conditions and performance, $9.3 billion annually; guideway elements account for 17 percent of the investment to maintain conditions and performance, $2.7 billion annually, and 39 percent of the investment amount needed to improve conditions and performance, $4.3 billion annually. Facilities and stations each account for 10 to 15 percent of total investment requirements, systems for 7 to 8 percent, and other project costs for 6 to 12 percent.

***Average Annual Transit Investment Requirements by Asset Type, 2003–2022***

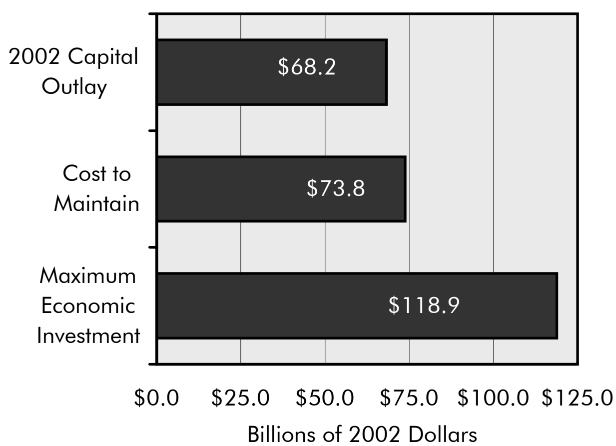
(Billions of 2002 Dollars)

| | Maintain | Improve |
|---|---|---|
| Vehicles | $6.9 | $9.3 |
| Guideway Elements | $2.7 | $4.3 |
| Facilities | $1.9 | $2.3 |
| Stations | $1.8 | $3.5 |
| Systems | $1.3 | $1.7 |
| Other Project Costs | $0.9 | $2.9 |

# Comparison of Spending and Investment Requirements: Highway and Bridge

While this report **does not recommend any specific level of investment**, a comparison of the investment requirement scenarios with current and projected spending levels provides some insights into the likelihood that the level of performance implied by the scenarios will be achieved.

**2002 Capital Outlay by All Levels of Government Versus Highway and Bridge Investment Requirements**

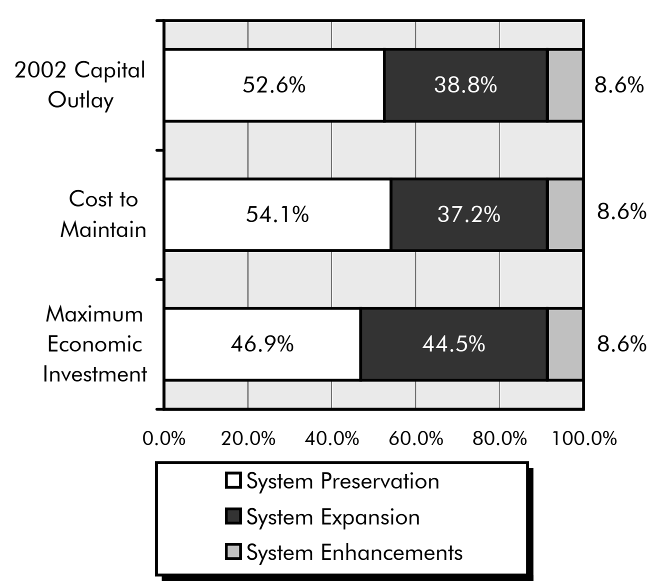



Federal, State, and local capital expenditures for highways and bridges totaled $68.2 billion in 2002. **Capital outlay by all levels of government would have to increase by 8.3 percent above this level to reach the projected $73.8 billion Cost to Maintain Highways and Bridges level**. The percentage gap is greatest for the highway pavement preservation component of the Cost to Maintain. Capital expenditures for bridge preservation were 21 percent higher than the estimated annual cost to maintain the current economic backlog of bridge improvements in constant dollar terms (though significant progress remains to be made in reducing the number of deficient bridges). **An increase in highway capital outlay of 74.3 percent above current levels would be required to reach the projected $118.9 billion Maximum Economic Investment (Cost to Improve Highways and Bridges) level**.

The distribution of funding by investment type suggested by the investment requirement scenarios developed using the HERS and NBIAS models depends on the level of available funding. In 2002, 38.8 percent of highway capital outlay went for system expansion, including the construction of new roads and bridges and the widening of existing facilities.

For the Cost to Maintain Highways and Bridges, 37.2 percent of the projected 20-year investment requirements is for system expansion, slightly lower than its share of current capital spending. The analysis indicates that modest increases in funding over current levels might best be directed more toward system preservation than is currently the case. However, 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 at the Maximum Economic Investment level, 44.5 percent of total investment requirements are for system expansion.

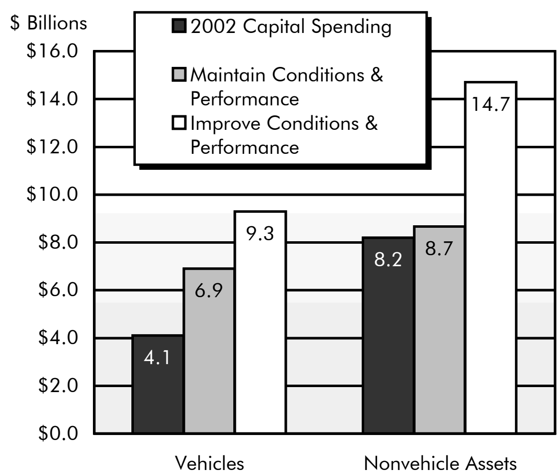
**Investment Requirements and 2002 Capital Outlay Distribution by Improvement Type**



# Comparison of Spending and Investment Requirements: Transit

Transit capital expenditures from Federal, State, and local governments totaled $12.3 billion in 2002. **The annual capital investment necessary to maintain conditions and performance for the 20 year period from 2003–2022 is estimated to be $15.6 billion, 27 percent above actual spending in 2002**; and the annual capital investment required to improve conditions and performance is estimated to be $24.0 billion, 95 percent above actual 2002 capital spending.

**A Comparison of 2002 Capital Investment Requirements with Average Annual Investment Requirements (Billions of Dollars)**




The difference between estimated requirements and actual expenditures in this report is smaller than reported in earlier editions. This decrease reflects an average annual growth of 16.5 percent in transit capital investment between 2000 and 2002, with total capital investment rising from $9.1 billion in 2000 to $12.3 billion in 2002. It also reflects a lower projected ridership growth of 1.5 percent compared with 1.6 percent in the 2002 report and the application of a more rigorous benefit-cost test.

**The annual amount estimated to be required to maintain the conditions and performance of the Nation's transit vehicle assets is $6.9 billion, 68 percent above actual spending of $4.1 billion in 2002**. To improve conditions and performance, investment in vehicles would need to be $9.3 billion, 127 percent above the 2002 investment.

Due to their natural rate of deterioration, the entire bus fleet and a considerable number of rail vehicles will need to be replaced at least once during the period 2003 to 2022. Furthermore, in 2002, approximately 16,500 bus vehicles and 6,980 rail vehicles were overage compared with 16,200 bus vehicles and 6,780 rail vehicles in 2000. In 2002, 68 percent of commuter rail self-propelled passenger coaches, 36 percent of heavy rail vehicles, and 34 percent of commuter rail passenger coaches were overage.

**The annual amount estimated to be needed to maintain the conditions and performance of the Nation's nonvehicle transit infrastructure is $8.7 billion, 6 percent above the $8.2 billion spent in 2002.** The annual amount estimated to be needed to improve the conditions and performance of the nonvehicle infrastructure is $14.7 billion, 79 percent above actual spending in 2002. In addition to meeting future needs as these assets deteriorate, 14 percent of all maintenance facilities, 20 percent of all yards, 6 percent of all substations, 19 percent of all overhead wire, 14 percent of third rail, 15 percent of track, 9 percent of elevated structures, 17 percent of underground tunnels, and 56 percent of stations were estimated to be in poor or substandard condition in 2002.

In addition to the continual replacement of existing transit assets, annual investment requirements will need to meet projected passenger growth by expanding the asset base. The passenger bus fleet will need to increase by almost 42,000 vehicles from 2002 to 2022, or by about 45 percent, and the rail fleet will need to increase by nearly 5,000 vehicles, or by about 26 percent.

# Impacts of Investment: Highway and Bridge

### *Linkage Between Recent Condition and Performance Trends and Recent Spending Trends*

Spending by all levels of government on system preservation increased by 56 percent between 1997 and 2002, from $23.0 to $35.8 billion. This increased investment in roadway and bridge rehabilitation and resurfacing is reflected in the improvements in pavement ride quality and reductions in bridge deficiencies that are described elsewhere in this report.

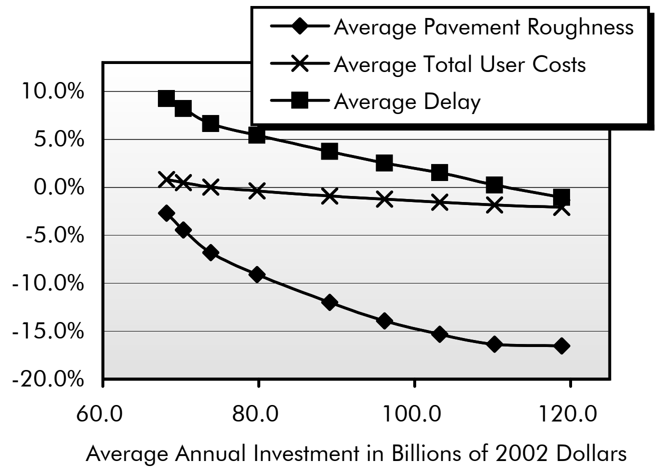
Investment in system expansion has also increased, but at a much lower rate relative to outlays for system preservation. While the rate of deterioration in various measures of operational performance has decreased, the level of investment has not stopped the overall growth in congestion levels.

### *Impact of Future Investment on Highway Conditions and Performance*

If average annual highway capital investment from 2003 to 2022 reaches the projected $118.9 billion Maximum Economic Investment level and is applied in the manner suggested by the analysis, shifting more investment toward system expansion to address increasing congestion problems, average pavement quality is projected to improve by 16.7 percent relative to year 2002 levels. Improvements in highway operational performance would cause average delay to decrease by 1.0 percent, while average highway user costs would decline by 2.1 percent. [Note these delay figures reflect average delay per vehicle miles traveled (VMT); total delay would be expected to increase as total VMT rises over time.]

If all levels of government combined invested at the Cost To Maintain projected level of $73.8 billion, and slightly increased the share of investment devoted to system preservation as suggested by the analysis, average pavement roughness would improve by 6.8 percent, while average delay would worsen by 6.6 percent. By definition, average highway user costs would remain at year 2002 levels.

**Projected Changes in 2022 Highway Condition and Performance Measures Compared to 2002 Levels, at Different Possible Funding Levels**




### *Impact of Investment on Travel Growth*

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 requirements in this report are dynamic, in the sense that they allow feedback between the level of future investment and future VMT growth.

If highway-user costs are maintained at current levels as they would be under the Cost to Maintain scenario, the analysis projects that urban VMT would grow by an average annual rate of 1.97 percent. If highway-user costs decline, as they would under the Maximum Economic Investment scenario, this rate would increase to 2.12 percent per year.

# Impacts of Investment: Transit

**Current capital spending reached its highest level relative to estimated rehabilitation and replacement needs in urban areas in 2002 ($12.3 billion in spending compared with $10.3 billion estimated for rehabilitation and replacement), 19 percent higher.** Since 1993, capital investment in transit assets has been equal to or slightly higher than the replacement and rehabilitation levels necessary to maintain conditions. Rehabilitation and replacement expenditures are always lower than total capital investment because a portion of the amount allocated to capital investment in each year is invested in new system capacity.

*Current Transit Capital Spending Levels Versus Rehabilitation and Replacement Needs, 1993 – 2002*

(Billions of Current Dollars)

| Analysis Year | Current Capital Spending | Estimated Replacement and Rehabilitation Needs |
|---|---|---|
| 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 |

Based on FTA's budget history, about half of FTA's capital assistance has been allocated to rehabilitation and replacement expenditures and about half has gone to asset expansion, i.e., new capacity, which also contributes to higher average condition levels through the purchase of new assets.

Funding levels between 2000 and 2002 have been sufficient to maintain conditions. If the amount spent is 10 percent lower than the amount estimated to be needed to maintain conditions in urban areas ($8.72 billion annually instead of $9.69 billion annually), the average condition of transit assets is estimated to fall from 3.7 in 2002 to 3.6 in 2022. If this amount is lowered by 30 percent to $6.78 billion annually, average asset conditions are estimated to fall to 3.4 in 2022.

*Effect of Capital Spending Constraints on Transit Conditions*

| | 2002 Condition | Percent of Recommended Rehabilitation and Replacement Expenditures to Maintain Conditions | | | |
|---|---|---|---|---|---|
| **Asset Type** | | **100%** | **90%** | **80%** | **70%** |
| Guideway Elements | 4.3 | 4.0 | 3.9 | 3.9 | 3.9 |
| Facilities | 3.4 | 3.3 | 3.1 | 3.1 | 3.1 |
| Systems | 4.1 | 4.0 | 3.8 | 3.7 | 3.6 |
| Stations | 3.0 | 3.6 | 3.6 | 3.6 | 2.9 |
| Vehicles | 3.4 | 3.4 | 3.3 | 3.1 | 3.0 |
| **All Assets** | **3.7** | **3.7** | **3.6** | **3.5** | **3.4** |
| **Rehabilitation and Replacement Expenditure Scenarios** [1] | | $9.69 | $8.72 | $7.75 | $6.78 |

[1] *Excludes rural vehicles and facilities.*

Funding levels between 2000 and 2002 have also been sufficient to maintain performance as measured by passenger travel time and vehicle occupancy. TERM estimates that for urban areas $5.3 billion annually will be needed to maintain current performance if PMT increases annually at the projected rate of 1.5 percent, or about 158 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 comprised 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.

TERM estimates that $6.52 billion annually is required to improve transit performance in urban areas, $1.65 billion annually for asset expansion in new rail or BRT service to increase speed and $4.87 billion annually for asset expansion in new vehicles to reduce occupancy levels. The average ridership estimated to result from increasing speed is 22.2 million passengers annually; the average annual ridership estimated to result from decreasing occupancy levels is 36.7 million passengers annually.

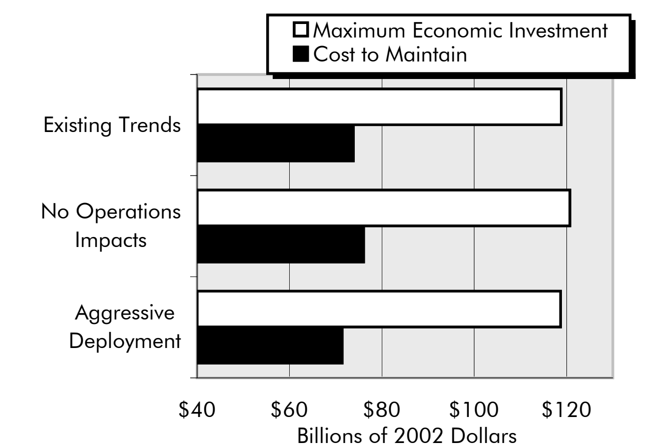
# Sensitivity Analysis: Highway and Bridge

The usefulness of any investment requirements 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 estimated Maximum Economic Investment (Cost to Improve Highways and Bridges) and Cost to Maintain Highways and Bridges to changes in these assumptions. [See also "Congestion Pricing" on page ES-13.]

### Operations Improvements

The baseline estimates of future investment requirements reflect the impacts of existing trends in the deployment of operations strategies and intelligent transportation systems technologies on highway performance. Had such impacts not been considered, the Cost to Maintain conditions and performance on highways would have been 3.0 percent higher. If the deployment of operations improvements were to accelerate significantly in future years, the projected Cost to Maintain Highways and Bridges might decrease by 3.3 percent.

*Impact of Operations Improvements on Average Annual Investment Requirements*



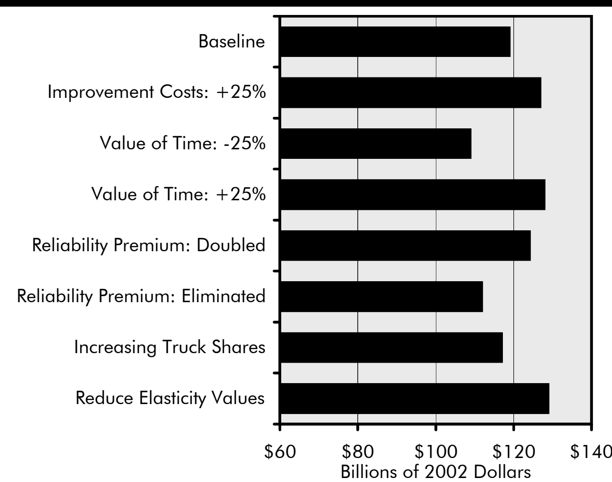

### Value of Time

The value of time in the Highway Economic Requirements System (HERS) was developed using a standard methodology adopted by the Department, but other values are used inside and outside the Federal government. Increasing the value of time by 25 percent would increase the Maximum Economic Investment level by 7.6 percent. Cutting it by the same margin would reduce the Maximum Economic Investment level by 8.4 percent.

### Construction Costs

If currently unforeseen circumstances were to cause future highway construction costs to unexpectedly rise by 25 percent in constant dollar terms, this would increase the Maximum Economic Investment level by 6.6 percent. The increased cost of individual projects would be partially offset in this scenario by some projects that would no longer be cost-beneficial.

*Individual Impact of Alternate Assumptions on the Average Annual Maximum Economic Investment for Highways and Bridges*




**Note:**

The impacts of alternative model parameters and procedures shown above for the Maximum Economic Investment scenario are more ambiguous for the Cost to Maintain, as many of these parameters are used in the calculation of baseline user costs. By changing these parameters, the target user cost level being maintained under the scenario is also changed, so in essence, the definition of what is being "maintained" would be different.

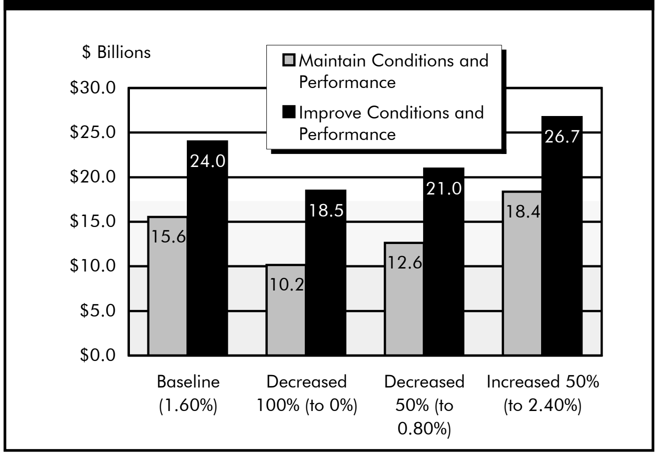
# Sensitivity Analysis: Transit

Chapter 10 examines the sensitivity of projected transit investment requirements to variations in the values of the following exogenously determined model inputs: 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 the amount of investment that will be needed by the Nation's transit systems to maintain performance (i.e., current levels of passenger travel speeds and vehicle utilization rates) as ridership increases, and to improve these performance indicators.

*The Effect of Variations in PMT Growth on Transit Annual Investment Requirements*




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 1.5 percent used in this report is a weighted average of the most recent MPO forecasts available from 76 of the Nation's largest metropolitan areas. Investment requirements in the 2002 report were based on a projected PMT growth rate of 1.6 percent, based on projections from 33 MPOs. (PMT increased at an average annual rate of 2.7 percent between 1993 and 2002, and by 0.9 percent between 2000 and 2002.)

Varying the assumed rate of growth in PMT affects estimated transit investment requirements. 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 12 to 13 percent. Investment requirements decrease significantly if PMT remains 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 higher capital costs on the cost of projected transit investment requirements. A 25 percent increase in capital costs increases the amount necessary to maintain conditions and performance by 14 percent and increases the amount necessary to improve conditions and performance by 9 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 investment requirements, 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 has almost no effect on projected investment requirements.

# Federal Safety Initiatives

Safety remains the U.S. Department of Transportation's (DOT's) highest priority. The Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA) and the Federal Transit Administration (FTA) are sponsoring a variety of initiatives to address highway and transit safety issues.

The DOT has established a goal to reduce the national highway fatality rate from the 2002 level of 1.5 deaths per 100 million vehicle miles traveled to 1.0 deaths per 100 million vehicle miles traveled by the year 2008.

Major improvements in highway safety require a comprehensive and coordinated approach that addresses driver behavior, vehicle design, and the roadway. Many of the safety-related activities currently being carried out by DOT are a result of a national Strategic Highway Safety Plan. This plan includes 22 emphasis areas and 90 strategies to improve highway safety.

Rather than adopting a single policy to improve safety, DOT partners with both the public and private sectors in using a variety of strategies and approaches.

The FHWA addresses roadway infrastructure improvements in three high fatality crash areas (roadway departure crashes—59 percent of all fatalities, intersection crashes—21 percent, pedestrian related crashes—11 percent) by providing roadway improvement programs and working with States to implement these programs to prevent crashes and save lives.

The NHTSA has worked to improve safety through regulatory action, by implementing Federal laws that cover safety belt and child safety seat performance requirements, air bags, and intoxicated driving standards. These efforts are estimated to have saved thousands of lives.

*Estimated Number of Lives Saved by Restraint Systems, 1993 and 2002*

| Restraint Type | 1993 | 2002 |
|---|---|---|
| Safety Belts | 7,773 | 14,164 |
| Air Bags | 190 | 2,248 |
| Child Restraints | 313 | 376 |

Source: *Fatality Analysis Reporting System (FARS).*

The NHTSA's public awareness campaigns such as "Drunk Driving Prevention" and "Click it or Ticket" have helped shape public opinion on the critical issues of drunk driving and safety belt use.

The DOT partners with industries and public interest groups on safety-related issues. Such a partnership has helped reduce the number of alcohol-related driving fatalities. The DOT also works to improve safety through engineering and technological research.

FMCSA's enforcement authority extends to interstate motor carriers and motor coaches. FMCSA enforcement operations help ensure compliance with the Federal Motor Carrier Safety Regulations, and their proven effectiveness in reducing crashes and fatalities on the highways has been borne out in the findings of the Roadside Inspection and Traffic Enforcement Intervention Model and Compliance Review Impact Assessment Model.

The FTA has six programs designed to improve the safety and security of the Nation's transit systems. They address modal safety, information sharing and technical assistance, training education, substance abuse, security, and data collection and analysis. Additionally, FTA works to improve safety through the DOT's Intelligent Vehicle Initiative.

As part of these programs, FTA demonstrates, evaluates, and deploys innovative safety technologies; shares technical guidance; and issues regulations stating the safety operational requirements for public transportation systems.

## 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; identifying recurring and nonrecurring traffic bottlenecks; 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. [See also "Congestion Pricing" on page ES-13.]

Without greater attention to operations, travelers and goods moving on our 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.



## Freight

Freight transportation enables economic activity, and trucking is a key element of freight transportation. **The condition and performance of the highway system are crucial to the efficiency and effectiveness of trucking.** Recent growth in truck traffic is placing greater burdens on the highway system.

The economic vitality of the Nation relies on the U.S. transportation network. It supports local businesses, interstate commerce, and international trade. At the same time, the American public relies on freight transportation to provide access to goods and services produced by businesses both here and abroad.

Although commercial vehicles currently account for less than 10 percent of all vehicle-miles of travel, **truck traffic is growing faster than passenger vehicle traffic and is having major effects on intercity highways.** Trucks already account for more than 30 percent of traffic on about 20 percent of Interstate System mileage. This share is projected to significantly increase based on a projection that the demand for freight transportation will double over the next 20 years. This growth in trucking is stimulated by economic growth as well as factors such as increased demand for just-in-time deliveries, major reductions in railroad track mileage and decentralization of business establishments.

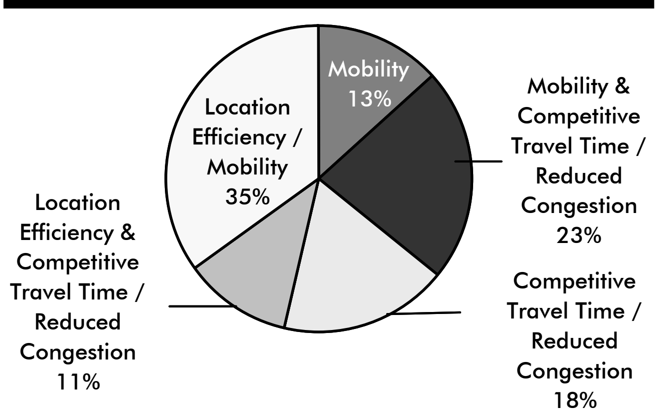
Trucking may be seen by the traveling public as an unwanted competitor for space on congested highways, but that same public depends on trucking to meet the logistics needs of businesses and households. Highway condition and performance, including congestion, have a significant effect on the costs and efficiency of trucking. The importance of freight transportation in general and trucking in particular is increasingly recognized by agencies at all levels of government and will be the subject of extensive analyses and policy considerations in the years ahead.

## The Importance of Transit

Transit enhances the quality of life of the American people. It offers basic mobility to people who either do not own or have access to a car, convenient and efficient mobility to people who live and work in densely populated areas where travel by car does not make sense, and competitive travel times and reduced road congestion for people traveling to and from work along major transportation corridors in large metropolitan areas. Chapter 14 draws on two surveys of transit riders— The National Household Travel Survey (NHTS), a national survey, and the Transit Performance Monitoring System (TPMS) a snapshot of smaller systems with more transit-dependent riders.

The NHTS found that 44 percent of nationwide transit riders come from households without cars; TPMS found that 70 percent of trips were made by riders from households without cars. Getting to and from work accounts for the highest percentage of transit trips. Transit also is used to obtain educational, medical, personal business, and recreational services. The following pie chart shows shares of mobility, location efficiency, competitive travel time, and reduced congestion benefits provided by transit to TPMS riders. In many cases, trips provide more than one benefit. Transit also provides environmental and other benefits not captured by onboard passenger surveys.

*The Benefits of Transit*

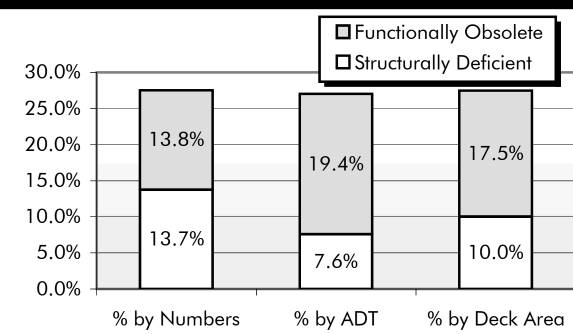





## Bridges

Bridges are critical elements within the highway transportation network, supporting commerce, economic vitality, and personal mobility. There are 591,707 bridges over 20 feet in length located on public roads in the United States, carrying nearly 4 billion vehicles per day. Of this total, 27.5 percent are classified as structurally deficient or functionally obsolete. Structural deficiencies result primarily from deteriorated conditions on the primary components of a bridge. These structures typically require significant maintenance and repair to remain in service. While 13.7 percent of bridges are structurally deficient, these bridges constitute only 10.0 percent of total bridge deck area and carry only 7.6 percent of bridge traffic. A functionally obsolete bridge generally is one that no longer meets current geometric and structural standards for the highway on which it is located.

*Bridge Deficiencies by Numbers, by ADT, and by Deck Area*




*Source: National Bridge Inventory.*

The Nation's highway bridges have remained safe as a result of the development of the National Bridge Inspection Standards and associated funding programs of the bridge programs, and progress has been made in reducing deficiencies. However, with an ever-aging population of highway structures and increasing traffic demands, it is important to examine transportation system preservation strategies, such as preventative maintenance, and improved bridge inspection and management techniques to continue to ensure the safety of the motoring public and effective stewardship of the public trust.

## Interstate System

The Interstate System serves as the backbone of transportation and commerce in the United States. Interstate route miles increased from 46,675 in 2000 to 46,747 in 2002. About 70.8 percent were in rural areas, 3.9 percent were in small urban areas, and 25.3 percent were in urbanized areas. In 2002 the Interstate System included 55,245 bridges, 27,316 rural bridges, and 27,929 urban bridges.

In 2002, Americans traveled approximately 282 billion vehicle miles on rural Interstates, 23 billion vehicle miles on small urban Interstates, and in excess of 389 billion vehicle miles on urban Interstates. Interstate vehicle miles traveled (VMT) grew at an average annual rate of approximately 3.1 percent between 1993 and 2002.

About 26.3 percent of all urban Interstate bridges were deficient in 2002, and 15.8 percent of all rural interstate bridges were deficient. In 2002, 97.8 percent of rural Interstate pavements met the standard for "Acceptable" ride quality, compared to 95.3 percent for Interstates in small urban areas and 91.7 for Interstates in urbanized areas.

To maintain the current level of user costs on urban Interstates, an average annual investment level of $10.96 billion would be required. For all Interstates, an average annual investment in bridge preservation of $2.13 billion would be required so that the bridge investment backlog would not increase above its current level.

The 2002 level of rural and urban Interstate bridge preservation investment would be adequate to address the economic backlog of bridge deficiencies if that level of investment could be sustained. However, 2002 appears to have been an unusually high year for rural Interstate capital spending, especially for rural bridges. On urban Interstates, significant increases in funding for preservation and expansion above current levels would be required to prevent both average physical conditions and operational performance from becoming degraded.



## National Highway System

The National Highway System (NHS) consists of the most important routes for commerce and trade in the United States and includes the Interstate System and the Strategic Highway Network (STRAHNET), as well as critical intermodal connectors to passenger and freight facilities. The NHS includes 84.0 percent of rural other principal arterials and 87.1 percent of urban other freeways and expressways. Only 4.1 percent of the Nation's total road mileage is on the NHS, but it carries 44.4 percent of the total VMT.

In 2002, 93.7 percent of NHS route miles had acceptable ride quality, while 90.6 of VMT on the NHS was on pavements classified as acceptable. Since 1997, the percent of rural NHS route miles with acceptable ride quality has risen from 94.5 percent to 97.1 percent. The comparable percentages for the urban NHS have remained relatively flat, rising from 83.9 to 84.1 percent.

Between 2000 and 2002, daily vehicle miles traveled per lane mile grew by 3.0 percent on the rural NHS and 2.1 percent on the urban NHS.

The 114,587 structures on the NHS constitute 19.4 percent of all bridges in terms of numbers, but carry 71.0 percent of the total daily traffic volume serviced by the total bridge inventory. Of the total NHS bridges, 23.0 percent were deficient in 2002.

Rural NHS average ride quality could be maintained at 2002 levels at a sustained funding level of $6.33 billion annually. For the urban NHS, this would be between $12.82 and $13.42 billion annually. An average annual investment in bridge preservation of $3.79 billion would be needed so the NHS bridge investment backlog would not increase.

On the urban portion of the NHS, current funding levels for preservation and expansion can be expected to provide improved pavement quality, but a loss in overall operational performance.

## Strategic Highway Network

The Strategic Highway Network (STRAHNET) is a 62,791-mile system of roads deemed necessary for emergency mobilization and peacetime movement of heavy armor, fuel, ammunition, repair parts, food, and other commodities to support U.S. military operations. STRAHNET Connectors (about 1,700 miles) are additional highway routes linking over 200 important military installations and ports to STRAHNET. These routes are typically used when moving personnel and equipment during a mobilization or deployment.

*STRAHNET Mileage, 2002*

| | |
|---|---|
| Interstate | 46,749 |
| Non-Interstate | 16,042 |
| Total | 62,791 |

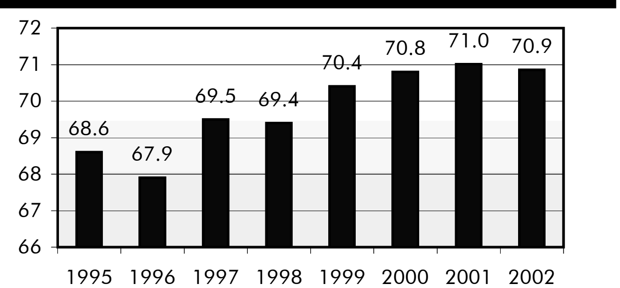
*Source: Highway Performance Monitoring System*

In 2002, 96.1 percent of all mileage in STRAHNET had a measured pavement roughness that met the standard for acceptable ride quality on the National Highway System cited in the FHWA Performance Plan.

There were 79,852 bridges on STRAHNET in 2002. About 20.6 percent of STRAHNET bridges were considered deficient.

In 2002, about 70.9 percent of bridges over STRAHNET routes had vertical clearances greater than 16 feet, up from 68.6 percent in 1995. This measure is important because military convoys and emergency response vehicles need to be able to clear structures on the STRAHNET system.

*Percent of STRAHNET Routes Under Bridges With Clearance Greater Than 16 Feet, 1995–2002*

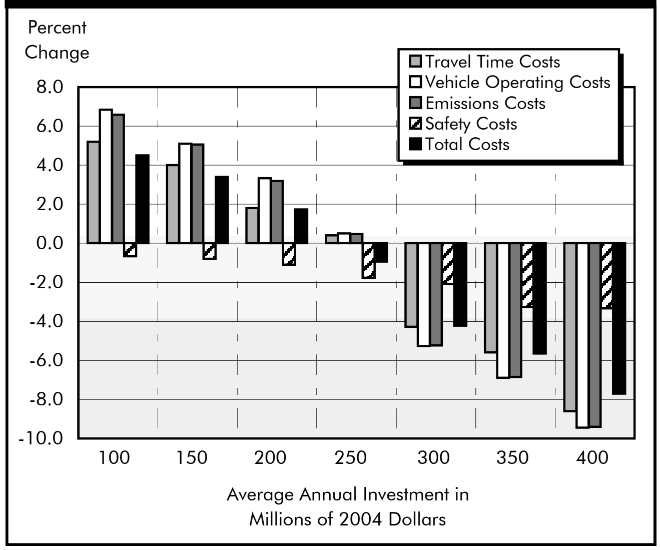



*Source: FY 2003 FHWA Performance Plan.*

## Highway-Rail Grade Crossings

An analysis of highway-rail grade crossings on the Federal-aid highway system by the Federal Railroad Administration finds that **all categories of highway users could face delay costs of up to $8.8 billion at grade crossings over the next 20 years.** Auto users could spend 86.5 million more hours delayed at crossings and truckers could log an additional 10.7 million hours behind closed gates in 2024, compared with 2004. Bus delay could increase by 8.9 million hours over the next 20 years.

*Costs Compared to 2004 Levels for Different Possible Funding Levels*




An estimated $250 million annual investment in grade separation over the next 20 years could maintain highway user costs at grade crossings at 2004 levels. A projected annual investment of $400 million would be sufficient to separate all grade crossings on the Federal-aid highway system where estimated highway user costs exceed capital investment requirements.

These two investment levels are comparable to the "Maintain User Costs" and "Maximum Economic Investment" scenarios for highways discussed in Chapter 7. Some grade separation improvements also are reflected in the estimates of the "Cost to Maintain Highways and Bridges" and "Cost to Improve Highways and Bridges" scenarios presented in Chapter 7.

## Transit on Federal Lands

Federal lands account for approximately 27 percent of the land area of the United States, principally in the western part of the country. These lands are composed of the National Park Service (NPS), the Bureau of Land Management (BLM), and the U.S. Fish and Wildlife Service (USFWS), which are part of the Department of the Interior (DOI), and the U.S. Forest Service (USFS), which is part of the Department of Agriculture. Transit services are already in place in more heavily visited Federal land areas. As it becomes more difficult to expand roads and parking lots at a reasonable cost and without harming the environment in these areas, transit investment could help accommodate increases in recreational visits to these areas.

In 2004, a joint FTA and FHWA study was completed, which estimated transit and transit enhancement investment needs—or alternative transportation systems (ATS)—on USFS lands. This study was under-taken to expand the results of a 2001 study of ATS needs on DOI lands. The 2004 study identified 30 USFS sites that would benefit from new or supplemental ATS investments. Six of these sites are located in Alaska and the rest in the lower 48 States. The report estimates that, between 2003 and 2022, these ATS needs will total approximately $698 million in 2003 dollars ($687 million or $34.35 million per year in 2002 dollars). Seventy-five percent of this investment is estimated to be required for surface transit, 17 percent for water transit, and 8 percent for transit enhancements. Twenty-six percent of this investment will be needed for existing systems and 74 percent for new systems.

Total ATS needs for the 20-year period (2001 to 2020) for DOI lands from the 2001 FTA and FHWA study were estimated to be $1.71 billion in 1999 dollars ($1.82 billion in 2002 dollars). Ninety-one percent of these needs were estimated to be for the NPS, 7 percent for the USFWS, and 2 percent for the BLM. (See Chapter 27 of the 2002 C&P report.)

## Afterword: A View to the Future

The data and analyses presented in this report are based on tools and techniques that have been refined over time, evolving to reflect changing priorities and incorporating the latest relevant surface transportation research to the extent possible. At the same time, there is considerable room for improvement in our understanding of the physical conditions, operational performance, and investment requirements for the Nation's surface transportation infrastructure.

This Afterword is intended to discuss the gap between the current state of knowledge and the type of information that would be necessary and desirable to make significant leaps forward in the comprehensiveness of the C&P report analyses. In some cases, significant improvements to the analysis would have to be predicated on changes or improvements in data collection, recognizing that such changes would need to be balanced against the costs of collecting such data. This section also describes some ongoing research initiatives to bridge some of the knowledge gaps described.

Highway operational performance is currently modeled rather than measured, but advances in ITS technology might make it feasible to collect speed information directly. Improved data and modeling would assist analyses of highway and transit physical conditions, safety issues, and environmental impacts.

At its core, transportation investment involves balancing the demand for transportation services with the supply of those services. Areas in need of further exploration include the full social costs of adding capacity, the modeling of transportation demand, the impact of ITS on increasing effective capacity, linkages between financing mechanisms and investment requirements, and the impact of congestion pricing on bringing demand into closer balance with supply. Multimodal analysis, lifecycle cost analysis, and the impacts of investment on productivity also warrant further study.

# Description of Current System

# Part I

# 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

The typical U.S. resident may consciously consider transportation only when he or she faces an obstacle to his or her safety and mobility: That unexpected accident that delays the single parent in picking up his or her children from the day care center; the business proposal that is mistakenly delivered a day after the deadline causing the company to lose 10 percent of its annual profit; the pothole, obscured by a sudden rainfall, that flattens the commuter's tire; the transit vehicle that does not adhere to its published schedule when the jobseeker needs to arrive on time for the interview; or the sad news that the teenage son of a neighbor has been injured in a car accident.

Such obstacles often present a direct but temporary negative impact on individuals. But transportation, on the whole, serves as an often-overlooked asset for both individuals and the Nation. America's transportation system, despite its imperfections, is the essential element facilitating the movement of goods and people within the country. It forms the generally unheralded backbone of local, regional, national, and international trade, making most economic activity critically dependent upon this resource. The Nation's urban, intercity, intrastate, and interstate transportation systems bring America's cities, States, and regions together, linking farmers and manufacturers to markets, raw material suppliers to processors, businesses to clients, and tourists to recreational and cultural destinations.

These transportation functions are served by a wide variety of modes. Airways and airports provide rapid, long-distance transportation services for travelers and freight, such as mail. On the surface, freight moves by water, rail, highways, and pipelines, while people move by passenger rail, buses, ferries, and private vehicles.

The surface transportation system serving the United States today reflects investment and location decisions made by both governments and private enterprise since the beginning of the Nation. Early settlement and transportation patterns were determined primarily by geography, with waterborne and horse-drawn transportation the dominant modes. Over the years, technological improvements and investments have greatly expanded both the speed and flexibility of transportation movements, allowing economic activity to concentrate in cities and spread more freely across the country.

## The Role of Highway Transportation

Highways form the backbone of America's transportation system, connecting all regions and States to one another. Moving people and goods across this network is critical to meeting the everyday needs of our Nation's people. Highway transportation depends on both public and private inputs and investment. In the United States, most vehicles used on highways are owned and operated by private individuals and firms, while most highway infrastructure is funded and maintained by the public sector. 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 owned and operated by public agencies, 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.

Highway transportation in the United States plays a significant role in two major areas: providing personal mobility to households and facilitating freight movement.

### *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 the average U.S. household owns or has access to 1.9 personal vehicles. The NHTS also found that 87 percent of daily trips were taken by personal vehicle.

**Q.** Where can I go for more information on highways?

**A.** The Federal Highway Administration (FHWA) has produced or sponsored numerous reports and publications regarding surface transportation in general and Federal transportation programs in particular. Some of these publications include:

- *Financing Federal-aid Highways*

  http://www.fhwa.dot.gov/reports/finfedhy.htm
- *Highway History Web Site*

  http://www.fhwa.dot.gov/infrastructure/history.htm
- *America's Highways 1776-1976*

  Update to be published by FHWA in early 2006
- *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

### *Freight Movement*

Highways are the keystone of the U.S. freight transportation system, and the national economy supported by that system. Trucks carried 71 percent of the 15 billion tons of goods shipped in 1998, and accounted for about two-thirds the value-added to the economy by all transportation services. 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 will play an increasingly important role as businesses depend increasingly on 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; it provides broader transportation choices to people with cars, as well as reduced travel times and road congestion in major transportation corridors. It also facilitates economic growth and development, and supports environmentally sustainable and safe 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 to obtain the health care that they require. 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 with incomes sufficient to own a car and use transit because it offers them a more convenient, reliable, and less expensive transportation alternative. Some live in a densely developed area with highly accessible and frequent transit service or in a suburb with access to a transit system that offers a cheaper, more comfortable, or more convenient way of traveling to and from a downtown city center.

**Q.** Where can I go for more information on transit?

**A.** The Federal Transit Administration (FTA) produces and sponsors numerous reports and publications on transit issues. These publications include:

- *Annual Report on New Starts*

  http://www.fta.dot.gov/library/policy/ns/ns2005/nscover.html

- *Statistical Summaries-Grants Assistance Programs*

  http://www.fta.dot.gov/transit_data_info/reports_publications/publications/statistical_summaries/15972_ENG_HTML.htm

- *National Transit Summaries and Trends*

  http://www.ntdprogram.com/NTD/ntdhome.nsf/Docs/NTDPublications?OpenDocument#

- *The Benefits of Transit 2000*

  http://www.fta.dot.gov/transit_data_info/reports_publications/reports/transit_benefits_2000/2262_2253_ENG_HTML.htm

- *The Transit Performance Monitoring System*

  http://www.fta.dot.gov/16053_ENG_HTML.htm

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

  http://www.fta.dot.gov/library/legal/49uscc53.html

## *Economic Growth and Development*

Private sector development gravitates to location efficient areas offering accessible and frequent transit services. This development in turn leads to increased employment opportunities and higher property values. Higher density housing and attractive retail, entertainment, and business options create thriving communities in transit corridors.

## *Environmentally Friendly and Safe Communities*

Transit helps the Nation and communities protect the environment, conserve energy, and ensure the safety and security of our citizens. Each trip that is shifted from a car to a transit vehicle helps to reduce automotive emissions and meet local air quality goals. Transit is also available and can be used to cope with natural or man-made emergency situations, transporting emergency workers to the scene, evacuating people from the affected area, and even serving as temporary shelters and medical shelters.

## Q. Where can I find more information about trends in travel behavior?

**A.** The *National Household Travel Survey* (NHTS) is the nation's inventory of personal travel, both daily and long-distance. 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. The 2001 NHTS report may be found at http://nhts.ornl.gov/2001/index.shtml. Some findings from the 2001 NHTS include:

- **Trip lengths continue to increase.** 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 is also on the rise.** Since 1990 the average time spent behind the wheel is up from 49 minutes a day to 61, a 24 percent increase. While congestion has worsened over that period, some of that additional time was spent in traveling additional miles.
- **Transit principally serves those who can access it easily.** 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.
- **The number of daily trips has remained essentially unchanged in recent years.** Average daily person trips per person grew from 2.0 in 1969 to 4.3 in 1995, with leveling off to 4.1 in 2001. Daily vehicle trips per driver increased from 2.3 in 1969 to 3.6 in 1995, with a similar leveling off to 3.4 in 2001.
- **Trip chaining is a significant consideration.** Approximately 20 percent of all workers chain trips (i.e., make stops, such as child care drop-offs, on their way to and from work). This phenomenon impacts travel mode, route, and travel time and often dictates departure time.
- **Vehicle ownership continues to rise.** Between 1983 and 1995, 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.
- **A large percentage of transit trips are 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.
- **Commuting to work has decreased relative to other trip purposes.** 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.
- **Walking is still a significant mode of travel.** Americans spend 15 percent of their daily travel time in non-privately-owned vehicle (POV) modes, primarily walking.
- **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 is particularly important to people with limited incomes.** In 2001, 43 percent of all transit users lived in households with incomes of less than $20,000.

Chapter 14 includes additional information on transit ridership characteristics drawn from the 2001 NHTS, and from the Transit Performance Monitoring System based on on-board survey information collected directly from 30 transit systems.

## The Complementary Roles of Highways and Transit

Highways and transit serve distinct but overlapping markets in our national transportation system and complement each other in many ways. For example, bus transit systems rely upon roads to move their passengers. Transit may serve the basic mobility needs of riders for whom car ownership is not a viable option, while highways and autos may best meet the needs of residents and firms whose trip patterns are not readily met by transit. 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 choose what best meets 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 lifestyle. Highways provide people with their principal means of intercity travel and shippers with an alternative to rail and air and the means to reach the majority of final destinations for shipments in the Nation, which are accessible by no other means.

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 attract private vehicle drivers, freeing up road capacity. Transit can also increase the effectiveness of highways by encouraging and supporting carpooling, and as a backup mode for riders in both formal and informal arrangements when carpools don't meet their needs.

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

**A.** 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 and integrated approach to modeling transit and highway investments, are discussed in the Introduction to Part II and in the Afterword found in Part V of this report.

Highway investment encourages transit usage and improves 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. Good accessibility by road near transit stations facilitates transit use. Good highway access to 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.

## The Evolving Federal Role in Surface Transportation

The success of our transportation network is fundamental to America's economic growth and well-being. Over the years, from the early postal roads to the highway and transit networks that we have today, America has demonstrated a long-standing public commitment to transportation. State and local governments and businesses are full partners in the development and operation of our transportation system, with the Federal government balancing diverse needs and interests in order to systematically and cohesively address transportation concerns affecting the Nation as a whole. 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 through 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 in 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.

In order 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 initiative will accelerate the integration of proven innovations into routine practice by demonstrating and promoting the use of elevated performance standards, state-of-the-art tools and technologies, and new business practices in the highway construction process to achieve improved safety, reduced congestion from construction, improved quality, and faster construction. 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, cost savings, and improve system performance.

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. FHWA also provides leadership in establishing national standards for 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, and 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 and 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 2000 values shown in the 2002 Conditions and Performance (C&P) Report. Some of the 2000 values have subsequently been revised, which is reflected in the second column as appropriate. The third column contains comparable values based on 2002 data.

**Exhibit 2-1** *Comparison of System and Use Characteristics with Those in the 2002 C&P Report*

| | 2000 Data | | |
|---|---|---|---|
| **Statistic** | **2002 C&P Report** | **Revised as of 12/23/04** | **2002 Data** |
| Percentage of Total Highway Miles Owned by Local Governments | 77.4% | | 77.5% |
| Percentage of Total Highway Miles Owned by State Governments | 19.6% | | 19.5% |
| Percentage of Total Highway Miles Owned by the Federal Government | 3.0% | | 3.0% |
| Local Transit Operators in Urbanized Areas | 614 | | 610 |
| Rural and Specialized Transit Service Providers | 4,888 | | 6,051 |
| Total Rural Highway Miles (Population under 5,000) | 3.09 million | | 3.08 million |
| Total Urban Highway Miles (Population equal to or above 5,000) | 0.86 million | | .90 million |
| Total Highway Miles | 3.95 million | | 3.98 million |
| Transit Route Miles (Rail) | 9,221 | 9,222 | 9,484 |
| Transit Route Miles (Nonrail) | 163,303 | 196,858 | 225,820 |
| Total Transit Route Miles | 172,524 | 206,080 | 235,304 |
| Total Rural Highway Lane Miles (Population under 5,000) | 6.32 million | | 6.31 million |
| Total Urban Highway Lane Miles (Population equal to or above 5,000) | 1.93 million | | 2.02 million |
| Total Highway Lane Miles | 8.25 million | | 8.33 million |
| Urban Transit Capacity-Equivalent Miles (Rail) | 1.87 billion | 2.08 billion | 2.18 billion |
| Urban Transit Capacity-Equivalent Miles (Nonrail) | 1.90 billion | 1.9 1billion | 2.03 billion |
| Urban Transit Capacity-Equivalent Miles (Total) | 3.77 billion | 3.99 billion | 4.21 billion |
| Vehicle Miles Traveled on Rural Highways (Population under 5,000) | 1.09 trillion | 1.09 trillion | 1.13 trillion |
| Vehicle Miles Traveled on Urban Highways (Population equal to or above 5,000) | 1.67 trillion | 1.67 trillion | 1.74 trillion |
| Vehicle Miles Traveled on All Highways | 2.68 trillion | 2.76 trillion | 2.87 trillion |
| Transit Passenger Miles (Rail) | 24.60 billion | | 24.6 billion |
| Transit Passenger Miles (Nonrail) | 20.50 billion | | 21.3 billion |
| Transit Passenger Miles (Total) | 45.10 billion | | 45.9 billion |

There were almost 3.98 million miles of public roads in the United States in 2002, of which nearly 3.08 million miles were in rural areas (rural areas are defined as locations with less than 5,000 residents, and urban communities are defined as those areas with 5,000 or more people). Local governments controlled over 77 percent of total highway miles in 2002; States controlled nearly 20 percent; and the Federal Government owned about 3 percent. Hence, the Nation's highway system is overwhelmingly *rural* and *local.*

**Q. Is the increase in urban lane mileage entirely due to new construction?**

**A.** 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. This process is likely to continue through 2006 and therefore a continuing trend of increases in small urban and urbanized mileage coupled with a decline in rural mileage is very likely to continue in the next edition of the C&P report.

**Q. Are the 2002 HPMS data cited in this report fully consistent with those reported in the *Highway Statistics 2002* publication?**

**A.** No. The data reflected in this report represents the latest available data as of the date the chapters were written. Certain States had revised their data following the publication of the *Highway Statistics 2002*. 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 website: http://www.fhwa.dot.gov/policy/ohpi/hpms/index.htm

Total highway lane mileage was almost 8.33 million in 2002. Lane miles have increased at an average annual rate of about 0.2 percent since 1993, mostly in urban areas. Urban lane mileage grew to more than 2.0 million by 2002, while rural lane mileage decreased slightly, but was still approximately 6.3 million.

The number of vehicle miles traveled (VMT) between 1993 and 2002 grew by an average of 2.5 percent annually. About 1.1 trillion VMT were on rural highways, and over 1.7 trillion were on urban roads. Traffic has increased in metropolitan areas, but it has also grown in rural areas where there is increased truck traffic and visits by tourists to recreation centers.

There are 591,707 bridges in excess of 6 meters (20 feet) in total length carrying public roads in the United States. These structures carry nearly 4 billion vehicles daily and, with over 300 million square meters of total deck area, represent a sizeable investment. Information on the composition and conditions of these structures is maintained by the Federal Highway Administration (FHWA) in the National Bridge Inventory (NBI) database.

The majority of the bridges are located in rural areas (77 percent); however, the majority of traffic (73 percent of the total daily traffic volume) is carried by the urban structures. In terms of the total number of structures, 58 percent of the bridges carry local roadways, either in a rural or urban setting. Considering the higher functional classifications, 22 percent of the structures carry principal arterials, including rural and urban interstates and other expressways. Bridges carrying local roadways, however, service less than 5 percent of the total daily traffic volume; bridges carrying principal arterials service 78 percent of the daily traffic. Thus, the bridge inventory, like the road network, is predominantly rural and local when considering numbers of bridges; however, when traffic impact is considered, the importance of bridges in urban areas and bridges carrying higher functional classifications cannot be understated.

Responsibility for and ownership of bridges is split primarily between State agencies (47 percent) and local governments (51 percent). Federal agencies own less than 10,000 bridges nationwide (2 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.

Transit system coverage, capacity, and use in the United States continued to increase between 2000 and 2002. In 2002, there were 610 transit operators serving urbanized areas compared with 614 operators in 2000. In 2000, the most recent year for which information is available, there were 1,215 transit operators serving rural areas and in 2002, there were an estimated 4,836 providers of special service transit services to the elderly and disabled in both urban and 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 2002, transit agencies in urban areas operated 114,564 vehicles, of which 87,295 were in areas of more than 1 million people. Rail systems had 10,722 miles of rail track and 2,862 rail stations, compared with 10,572 miles of track and 2,825 stations in 2000. The number of bus and rail maintenance facilities in urban areas increased from 759 in 2000 to 769 in 2002. 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 2002, transit systems operated 235,304 directional route miles, of which 225,820 were nonrail and 9,484 were rail route miles. Total route miles increased by 14.2 percent in total between 2000 and 2002. Nonrail route miles increased by 14.7 percent, and rail route miles increased by 2.8 percent.

Transit system capacity as measured by capacity-equivalent vehicle revenue miles (VRM) increased by 5.6 percent in total between 2000 and 2002. 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 motor bus representing the baseline. The capacity of rail modes increased by 5.2 percent between 2000 and 2002 in total, and the capacity of nonrail modes by 7.8 percent. In 2002, 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 2000 and 2002, reflecting New Starts openings and extensions, increasing in total by 16.2 percent.

Transit passenger miles increased by 1.9 percent in total between 2000 and 2002, from 45.1 billion to 45.9 billion. Passenger miles traveled on nonrail modes increased from 20.5 billion in 2000 to 21.3 billion in 2002, or by total of 4.0 percent. Passenger miles on rail transit modes were unchanged at 24.6 billion. The lack of growth in aggregate passenger miles traveled on rail transit modes reflects a decrease in heavy rail ridership, particularly in the New York City and surrounding areas, most likely resulting from the terrorist attacks on September 11, 2001.

Vehicle occupancy of transit vehicles, adjusted to the capacity of a bus, fluctuated between 10.6 persons and 11.3 persons per vehicle between 1993 and 2002. In 2002, vehicle occupancy was 10.9 persons compared with 11.3 persons in 2000.

# 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

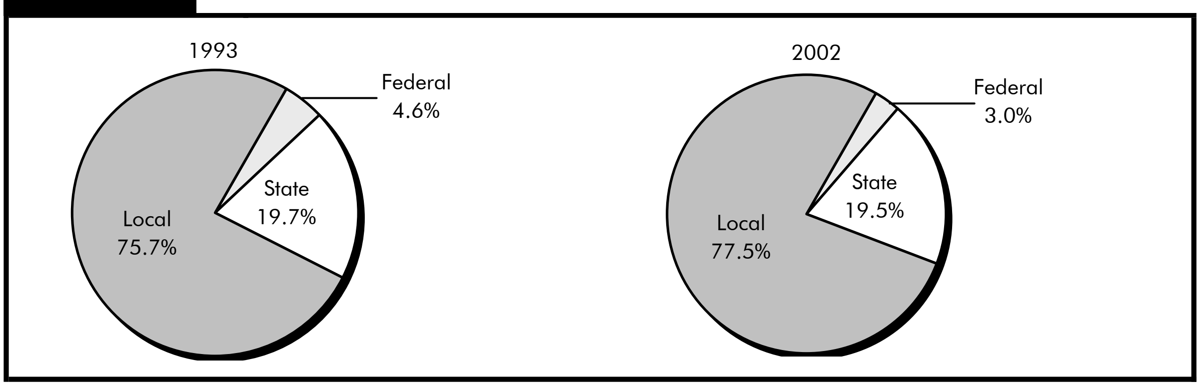
Ownership is largely split among the Federal, State, and local governments. Roads owned by these governments are considered "public."

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.

Over 77 percent of American roads are locally owned, although some intergovernmental agreements may authorize States to construct and maintain locally owned highways. About 1,050 counties in the United States have at least 1 mile of public roads owned by the Federal Government. Most of these counties are in the Western United States. Apache County, Arizona, has the highest percentage of Federal ownership (80 percent), followed by California's Siskiyou County and Montana's Lincoln County (70 percent each).

As *Exhibit 2-2* demonstrates, the share of locally owned roads has grown over the past decade. The share of local public road mileage increased from 75.7 to 77.5 percent between 1993 and 2002. During that same period, the share of State-owned public road mileage declined slightly, from 19.7 to 19.5 percent.

**Exhibit 2-2** *Highway Mileage by Owner, 1993 and 2002*




*Source: Highway Performance Monitoring System.*

**Q.** Why has Federally owned mileage increased substantially in urban areas since the last report?

**A.** Federally owned mileage in urban areas nearly doubled between 2000 and 2002. This is a result of an emphasis that FHWA has placed on complete reporting of Federally owned mileage by agencies that are not primarily transportation oriented. In every case of a large mileage increase within a State, the data change results from more accurate reporting of Department of Defense mileage on military bases within urban areas, rather than from an increase in the mileage or roadways under Federal ownership.

The dramatic decline in Federally owned public road mileage noted in the previous C&P report has leveled off, and the mileage is actually slightly higher for 2002 than it was for 2000. Yet, between 1993 and 2002 the share of Federal road mileage declined from 4.6 to 3.0 percent. Federal road mileage reached a peak in 1984, when 7 percent of all public roads were owned by the Federal Government, and had steadily decreased since then, until reaching the current 3 percent in 1999. As was noted in the previous C&P report, much of the change occurred as a result of Federal land management agencies reclassifying some of their mileage from public to nonpublic status.

A continuing trend is the increase in urban highway mileage. This is depicted in *Exhibit 2-3,* which shows that mileage in small urban areas grew by an average annual rate of 1.3 percent between 1993 and 2002. In larger urbanized areas with at least 50,000 residents, the annual growth rate was slightly smaller.

**Exhibit 2-3** *Highway Mileage by Owner and by Size of Area, 1993–2002*

| | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | | | | |
| Federal | 179,603 | 170,574 | 167,368 | 116,707 | 117,775 | -4.6% |
| State | 660,241 | 660,666 | 661,473 | 663,763 | 664,814 | 0.1% |
| Local | 2,257,002 | 2,259,064 | 2,280,042 | 2,308,842 | 2,295,006 | 0.2% |
| **Subtotal Rural** | **3,096,846** | **3,090,304** | **3,108,883** | **3,089,312** | **3,077,595** | -0.1% |
| **Small Urban Areas (5,000–49,999 in population)** | | | | | | |
| Federal | 355 | 494 | 482 | 458 | 980 | 11.9% |
| State | 27,160 | 27,442 | 27,455 | 27,596 | 27,639 | 0.2% |
| Local | 136,538 | 139,825 | 143,848 | 148,094 | 154,869 | 1.4% |
| **Subtotal Small Urban Areas** | **164,053** | **167,761** | **171,785** | **176,148** | **183,488** | 1.3% |
| **Urbanized Areas (50,000 or more in population)** | | | | | | |
| Federal | 943 | 982 | 980 | 1,026 | 1,840 | 7.7% |
| State | 80,747 | 83,016 | 83,428 | 83,944 | 84,135 | 0.5% |
| Local | 566,125 | 574,319 | 587,426 | 597,837 | 632,025 | 1.2% |
| **Subtotal Urbanized Areas** | **647,815** | **658,317** | **671,834** | **682,807** | **718,000** | 1.1% |
| **Total Highway Miles** | | | | | | |
| Federal | 180,901 | 172,050 | 168,830 | 118,191 | 120,595 | -4.4% |
| State | 768,148 | 771,124 | 772,356 | 775,303 | 776,588 | 0.1% |
| Local | 2,959,665 | 2,973,208 | 3,011,316 | 3,054,773 | 3,081,900 | 0.5% |
| **Total** | **3,908,714** | **3,916,382** | **3,952,502** | **3,948,267** | **3,979,083** | 0.2% |
| **Percent of Total Highway Miles** | | | | | | |
| Federal | 4.6% | 4.4% | 4.3% | 3.0% | 3.0% | |
| State | 19.7% | 19.7% | 19.5% | 19.6% | 19.5% | |
| Local | 75.7% | 75.9% | 76.2% | 77.4% | 77.5% | |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | |

*Source: Highway Performance Monitoring System.*

**Q.** Does the decrease in rural mileage signify roadway abandonment?

**A.** 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.

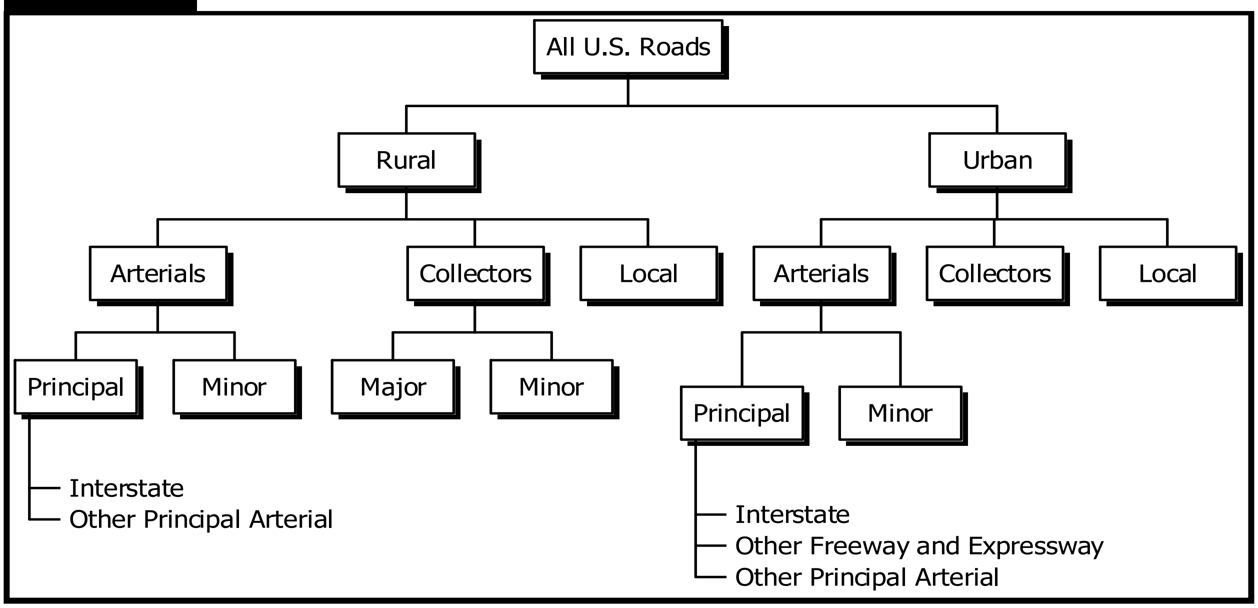
# Highways by Purpose

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.

## *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).

**Exhibit 2-4** *Highway Functional Classification Hierarchy*




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 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*

In 2002, the rural principal arterial system accounted for about 3.3 percent of total miles in the United States, but carried 47.6 percent of rural travel, or 18.8 percent of total travel, in the United States. Rural minor arterials represented 3.5 percent of total U.S. miles while carrying 15.6 percent of rural travel, or 6.2 percent of total travel, in the United States.

In 2002, the urban principal arterial system accounted for 1.8 percent of total miles in the United States. However, this network carried 58.2 percent of urban travel, or 35.4 percent of total travel, in the United

States. The urban minor arterial network represented 2.3 percent of total U.S. mileage. This system carried 19.6 percent of urban travel, or 11.9 percent of total travel, in the United States.

Rural major collectors accounted for 10.8 percent of total U.S. miles in 2002. They carried 18.9 percent of rural travel, or 7.5 percent of total travel, in the United States. The rural minor collector system accounted for 6.8 percent of total U.S. mileage in 2002. These roads carried 5.5 percent of rural travel, or 2.2 percent of total travel, in the United States.

In 2002, the urban collector network accounted for 2.2 percent of U.S. road mileage. It carried 8.2 percent of urban travel, or 4.9 percent of total travel, in the United States.

In 2002, rural local roads represented 52.9 percent of total U.S. road mileage. Local roads carried only 12.3 percent of rural travel, or 4.9 percent of total travel, in the United States. Urban local roads accounted for 16.2 percent of total U.S. road mileage and 13.9 percent of urban travel, or 8.4 percent of total travel, in the United States.

*Exhibit 2-5* summarizes the *percentage* of highway miles, lane miles, and VMT stratified by functional system. The share of mileage on rural highways has decreased slightly since 2000, dropping from 78.2 to 77.3 percent, a trend shown earlier in Exhibit 2-3. The share of lane miles on rural highways also decreased slightly, from 76.6 to 75.7 percent; however, the share of VMT in rural areas remained constant at 39.4 percent from 2000 to 2002.

**Exhibit 2-5** *Percentage of Highway Miles, Lane Miles, and VMT by Functional System and by Size of Area, 2002*

| Functional System | Miles | Lane Miles | VMT |
|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | |
| Interstate | 0.8% | 1.6% | 9.8% |
| Other Principal Arterial | 2.5% | 3.1% | 9.0% |
| Minor Arterial | 3.5% | 3.5% | 6.2% |
| Major Collector | 10.8% | 10.4% | 7.5% |
| Minor Collector | 6.8% | 6.5% | 2.2% |
| Local | 52.9% | 50.6% | 4.9% |
| **Subtotal Rural** | **77.3%** | **75.7%** | **39.4%** |
| **Small Urban Areas (5,000–49,999 in population)** | | | |
| Interstate | 0.0% | 0.1% | 0.8% |
| Other Freeway and Expressway | 0.0% | 0.1% | 0.4% |
| Other Principal Arterial | 0.3% | 0.5% | 2.1% |
| Minor Arterial | 0.5% | 0.5% | 1.6% |
| Collector | 0.5% | 0.5% | 0.7% |
| Local | 3.2% | 3.0% | 1.2% |
| **Subtotal Small Urban Area** | **4.6%** | **4.7%** | **6.7%** |
| **Urbanized Areas (50,000 or more in population)** | | | |
| Interstate | 0.3% | 0.8% | 13.6% |
| Other Freeway and Expressway | 0.2% | 0.5% | 6.3% |
| Other Principal Arterial | 1.0% | 1.8% | 12.2% |
| Minor Arterial | 1.8% | 2.3% | 10.3% |
| Collector | 1.7% | 1.8% | 4.2% |
| Local | 13.0% | 12.4% | 7.2% |
| **Subtotal Urbanized Areas** | **18.0%** | **19.6%** | **53.9%** |
| **Total** | **100.0%** | **100.0%** | **100.0%** |

*Source: Highway Performance Monitoring System.*

The share of urban mileage increased slightly between 2000 and 2002, from 21.8 to 22.6 percent. Urban lane mileage also increased, from 23.4 to 24.3 percent. Since the percentage of rural travel remained constant, that of urban travel did perforce, remaining at 60.6 percent from 2000 to 2002.

*Exhibit 2-6* shows the total public road route mileage in the United States. In 2002, there were nearly 4 million route miles in the United States. About 77.3 percent of this mileage, or just under 3.1 million route miles, was in rural areas. The remaining 22.7 percent of route mileage, or 901,913 miles, was in urban communities. Overall route mileage increased by an average rate of about 0.2 percent between 1993 and 2002. On an average annual basis, mileage decreased by 0.1 percent in rural America and increased by 1.2 percent in metropolitan communities from 1993 to 2002.

**Exhibit 2-6** *Highway Route Miles by Functional System and by Size of Area, 1993–2002*

| Functional System | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | | | | |
| Interstate | 32,795 | 32,703 | 32,919 | 33,152 | 33,107 | 0.1% |
| Other Principal Arterial | 97,127 | 98,039 | 98,358 | 99,023 | 98,945 | 0.2% |
| Minor Arterial | 137,755 | 137,440 | 137,791 | 137,863 | 137,855 | 0.0% |
| Major Collector | 432,993 | 432,492 | 433,500 | 433,926 | 431,754 | 0.0% |
| Minor Collector | 282,853 | 274,750 | 273,043 | 272,477 | 271,371 | -0.5% |
| Local | 2,123,895 | 2,125,054 | 2,141,111 | 2,115,293 | 2,106,725 | -0.1% |
| **Subtotal Rural** | **3,107,418** | **3,100,478** | **3,116,722** | **3,091,733** | **3,079,757** | **-0.1%** |
| **Small Urban Areas (5,000–49,999 in population)** | | | | | | |
| Interstate | 1,694 | 1,731 | 1,744 | 1,794 | 1,808 | 0.7% |
| Other Freeway and Expressway | 1,261 | 1,282 | 1,253 | 1,219 | 1,227 | -0.3% |
| Other Principal Arterial | 12,570 | 12,432 | 12,477 | 12,474 | 12,590 | 0.0% |
| Minor Arterial | 19,200 | 19,538 | 19,635 | 19,800 | 19,926 | 0.4% |
| Collector | 20,973 | 21,301 | 21,338 | 21,535 | 21,813 | 0.4% |
| Local | 108,440 | 111,566 | 115,420 | 119,342 | 126,140 | 1.7% |
| **Subtotal Small Urban Areas** | **164,138** | **167,850** | **171,867** | **176,163** | **183,503** | **1.2%** |
| **Urbanized Areas (50,000 or more in population)** | | | | | | |
| Interstate | 11,313 | 11,569 | 11,651 | 11,729 | 11,832 | 0.5% |
| Other Freeway and Expressway | 7,656 | 7,740 | 7,864 | 7,977 | 8,150 | 0.7% |
| Other Principal Arterial | 40,434 | 40,622 | 40,993 | 41,084 | 41,090 | 0.2% |
| Minor Arterial | 68,102 | 69,475 | 70,050 | 70,502 | 70,996 | 0.5% |
| Collector | 64,407 | 66,623 | 67,312 | 67,263 | 68,033 | 0.6% |
| Local | 456,134 | 462,537 | 474,044 | 484,650 | 518,309 | 1.4% |
| **Subtotal Urbanized Areas** | **648,046** | **658,566** | **671,914** | **683,205** | **718,410** | **1.2%** |
| **Total Highway Route Miles** | **3,919,602** | **3,926,894** | **3,960,503** | **3,951,101** | **3,981,670** | **0.2%** |

*Source: Highway Performance Monitoring System.*

*Exhibit 2-7* shows the number of highway lane miles by functional system. In 2002, 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 1993, mostly in urban areas (lane mileage in rural areas having decreased overall by 0.1 percent per year during the same time period). In small urban areas (those with between 5,000 and 49,999 residents) and in urbanized areas (those with 50,000 or more residents), lane mileage grew at approximately equal rates, which was about 1.3 percent annually between 1993 and 2002.

**Exhibit 2-7** *Highway Lane Miles by Functional System and by Size of Area, 1993–2002*

| Functional System | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | | | | |
| Interstate | 132,559 | 132,346 | 133,573 | 135,000 | 135,032 | 0.2% |
| Other Principal Arterial | 240,714 | 245,164 | 248,921 | 253,586 | 256,458 | 0.7% |
| Minor Arterial | 286,860 | 288,222 | 288,872 | 287,750 | 288,391 | 0.1% |
| Major Collector | 873,988 | 872,767 | 875,393 | 872,672 | 868,977 | -0.1% |
| Minor Collector | 565,705 | 549,500 | 546,085 | 544,954 | 542,739 | -0.5% |
| Local | 4,247,239 | 4,250,107 | 4,282,222 | 4,230,588 | 4,213,448 | -0.1% |
| **Subtotal Rural** | **6,347,065** | **6,338,106** | **6,375,066** | **6,324,550** | **6,305,044** | **-0.1%** |
| **Small Urban Areas (5,000–49,999 in population)** | | | | | | |
| Interstate | 7,141 | 7,269 | 7,365 | 7,626 | 7,776 | 1.0% |
| Other Freeway and Expressway | 4,741 | 4,828 | 4,747 | 4,627 | 4,685 | -0.1% |
| Other Principal Arterial | 36,768 | 37,135 | 37,618 | 37,806 | 38,275 | 0.4% |
| Minor Arterial | 42,937 | 44,390 | 44,982 | 45,212 | 45,682 | 0.7% |
| Collector | 43,491 | 43,755 | 44,216 | 44,525 | 45,095 | 0.4% |
| Local | 216,881 | 223,132 | 230,839 | 238,684 | 252,279 | 1.7% |
| **Subtotal Small Urban Areas** | **351,959** | **360,509** | **369,767** | **378,482** | **393,793** | **1.3%** |
| **Urbanized Areas (50,000 or more in population)** | | | | | | |
| Interstate | 62,754 | 64,865 | 65,603 | 67,020 | 68,088 | 0.9% |
| Other Freeway and Expressway | 34,864 | 35,705 | 36,655 | 37,428 | 38,782 | 1.2% |
| Other Principal Arterial | 130,769 | 143,572 | 146,585 | 149,224 | 150,250 | 1.6% |
| Minor Arterial | 176,130 | 183,595 | 185,273 | 184,199 | 187,512 | 0.7% |
| Collector | 136,305 | 143,517 | 145,927 | 145,313 | 147,020 | 0.8% |
| Local | 912,267 | 925,073 | 948,087 | 969,300 | 1,036,619 | 1.4% |
| **Subtotal Urbanized Areas** | **1,453,089** | **1,496,327** | **1,528,130** | **1,552,484** | **1,628,271** | **1.3%** |
| **Total Highway Lane Miles** | **8,152,113** | **8,194,942** | **8,272,963** | **8,255,516** | **8,327,108** | **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 2.5 percent between 1993 and 2002. By the end of that period, Americans were traveling almost 2.9 trillion vehicle miles annually. More than 1.13 trillion vehicle miles were on rural highways, and about 1.74 trillion vehicle miles were on urban roads.

While highway mileage is mostly rural, a majority of highway travel (over 60 percent) occurred in urban areas in 2002. Since 1993, however, rural travel has grown at a slightly faster average annual rate (2.8 percent) than overall urban travel (2.4 percent).

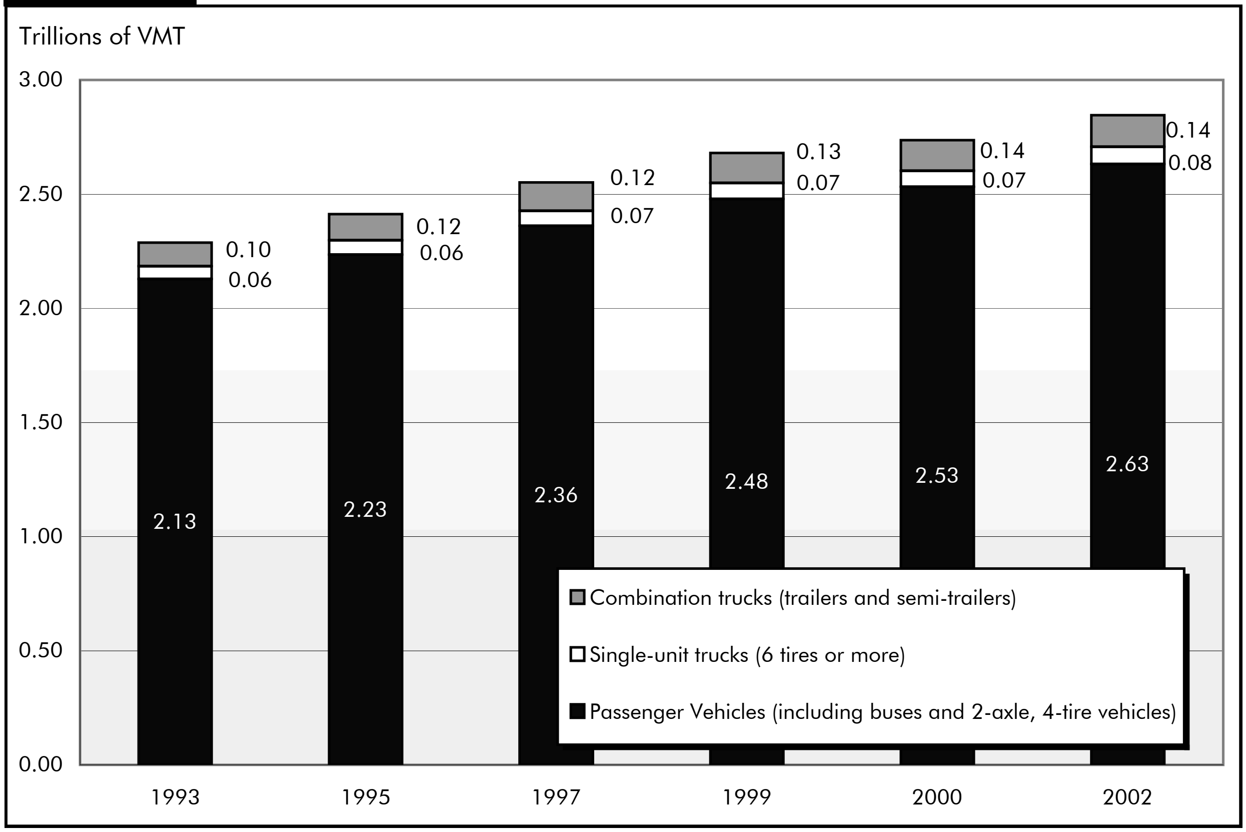
**Exhibit 2-8** *Vehicle Miles Traveled (VMT) and Passenger Miles Traveled (PMT), 1993–2002*

| (Millions of Miles)<br>Functional System | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Rural (under 5,000 in population)** | | | | | | |
| Interstate | 209,470 | 224,705 | 241,451 | 269,533 | 281,461 | 3.3% |
| Other Principal Arterial | 203,149 | 215,988 | 229,133 | 249,177 | 258,009 | 2.7% |
| Minor Arterial | 148,023 | 156,253 | 164,129 | 172,772 | 177,139 | 2.0% |
| Major Collector | 185,611 | 194,420 | 202,588 | 210,595 | 214,463 | 1.6% |
| Minor Collector | 48,579 | 50,386 | 52,809 | 58,183 | 62,144 | 2.8% |
| Local | 102,948 | 105,819 | 113,248 | 127,560 | 139,892 | 3.5% |
| **Subtotal Rural** | **897,779** | **947,571** | **1,003,358** | **1,087,820** | **1,133,107** | **2.6%** |
| **Small Urban Area (5,000–49,999 in population)** | | | | | | |
| Interstate | 16,297 | 17,310 | 18,393 | 21,059 | 22,578 | 3.7% |
| Other Freeway and Expressway | 8,353 | 8,854 | 9,251 | 9,892 | 10,442 | 2.5% |
| Other Principal Arterial | 51,088 | 53,202 | 55,359 | 58,170 | 59,490 | 1.7% |
| Minor Arterial | 36,464 | 39,270 | 40,845 | 43,035 | 44,566 | 2.3% |
| Collector | 17,282 | 18,710 | 19,749 | 20,412 | 21,492 | 2.5% |
| Local | 25,919 | 27,970 | 30,368 | 33,277 | 34,241 | 3.1% |
| **Subtotal Small Urban Area** | **155,403** | **165,317** | **173,965** | **185,845** | **192,808** | **2.4%** |
| **Urbanized Areas (50,000 or more in population)** | | | | | | |
| Interstate | 303,324 | 327,329 | 346,376 | 375,088 | 389,903 | 2.8% |
| Other Freeway and Expressway | 132,344 | 141,980 | 151,231 | 167,833 | 180,199 | 3.5% |
| Other Principal Arterial | 298,558 | 313,676 | 332,448 | 342,249 | 351,436 | 1.8% |
| Minor Arterial | 236,815 | 251,470 | 263,296 | 283,078 | 297,393 | 2.6% |
| Collector | 96,102 | 104,453 | 111,874 | 116,277 | 122,129 | 2.7% |
| Local | 175,917 | 179,392 | 176,268 | 202,220 | 207,480 | 1.9% |
| **Subtotal Urbanized Areas** | **1,243,060** | **1,318,300** | **1,381,495** | **1,490,819** | **1,548,540** | **2.5%** |
| **Total VMT** | **2,296,243** | **2,431,188** | **2,558,818** | **2,764,484** | **2,874,455** | **2.5%** |
| **Total PMT** | **3,772,492** | **3,868,070** | **4,089,366** | **4,390,076** | **4,733,824** | **2.6%** |

*Source: Highway Performance Monitoring System and National Household Travel Survey.*

*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, 1993–2002*




*Source: Highway Statistics, Summary to 1995, Table VM-201; Highway Statistics, Table VM-1, various years.*

Exhibit 2-10 shows that, in rural areas, travel grew the fastest on the interstate among all vehicle types and, in urban areas, travel grew the fastest regardless of system among single-unit and combination trucks. Between 1993 and 2002, for example, combination truck traffic grew by 3.7 percent per year on rural interstates and 4.4 percent per year on urban interstates. Overall, passenger vehicle travel grew by an average annual rate of 2.4 percent between 1993 and 2002. Single-unit and combination truck travel grew by 3.3 percent per year.

# 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 on the highway network. ITS uses advanced technology to improve highway safety and efficiency. The deployment of ITS for operations and freight management are discussed more fully in Chapters 12 and 13.

**Exhibit 2-10** *Highway Travel by System and Vehicle Type, 1993–2002*

| Functional System<br>Vehicle Type | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| | (Millions of VMT) | | | | | |
| **Rural Interstate** | | | | | | |
| PV | 168,282 | 178,973 | 189,869 | 214,532 | 224,375 | 3.2% |
| SU | 5,982 | 6,708 | 7,671 | 8,236 | 8,745 | 4.3% |
| Combo | 32,827 | 36,643 | 41,665 | 44,248 | 45,633 | 3.7% |
| **Other Arterial** | | | | | | |
| PV | 312,924 | 330,029 | 351,313 | 377,270 | 389,758 | 2.5% |
| SU | 11,375 | 12,980 | 13,688 | 13,644 | 14,606 | 2.8% |
| Combo | 23,725 | 24,076 | 25,505 | 28,005 | 27,818 | 1.8% |
| **Other Rural** | | | | | | |
| PV | 302,986 | 314,158 | 341,323 | 366,433 | 383,724 | 2.7% |
| SU | 12,510 | 12,948 | 13,698 | 13,722 | 14,963 | 2.0% |
| Combo | 11,941 | 12,676 | 12,471 | 12,555 | 14,090 | 1.9% |
| **Total Rural** | | | | | | |
| PV | 784,192 | 823,160 | 882,505 | 958,235 | 997,857 | 2.7% |
| SU | 29,867 | 32,636 | 35,057 | 35,602 | 38,314 | 2.8% |
| Combo | 68,493 | 73,395 | 79,641 | 84,808 | 87,541 | 2.8% |
| **Urban Interstate** | | | | | | |
| PV | 293,045 | 314,422 | 331,343 | 359,592 | 373,957 | 2.7% |
| SU | 6,513 | 7,148 | 7,906 | 8,716 | 9,106 | 3.8% |
| Combo | 16,183 | 18,491 | 20,643 | 23,465 | 23,887 | 4.4% |
| **Other Urban** | | | | | | |
| PV | 1,049,710 | 1,097,161 | 1,146,289 | 1,213,109 | 1,259,859 | 2.0% |
| SU | 20,403 | 22,921 | 23,930 | 26,182 | 28,467 | 3.8% |
| Combo | 18,450 | 23,565 | 24,300 | 26,747 | 27,215 | 4.4% |
| **Total Urban** | | | | | | |
| PV | 1,342,755 | 1,411,583 | 1,477,632 | 1,572,701 | 1,633,816 | 2.2% |
| SU | 26,916 | 30,069 | 31,836 | 34,898 | 37,573 | 3.8% |
| Combo | 34,633 | 42,056 | 44,943 | 50,212 | 51,102 | 4.4% |
| **Total** | | | | | | |
| PV | 2,126,947 | 2,234,743 | 2,360,137 | 2,530,936 | 2,631,673 | 2.4% |
| SU | 56,783 | 62,705 | 66,893 | 70,500 | 75,887 | 3.3% |
| Combo | 103,126 | 115,451 | 124,584 | 135,020 | 138,643 | 3.3% |

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

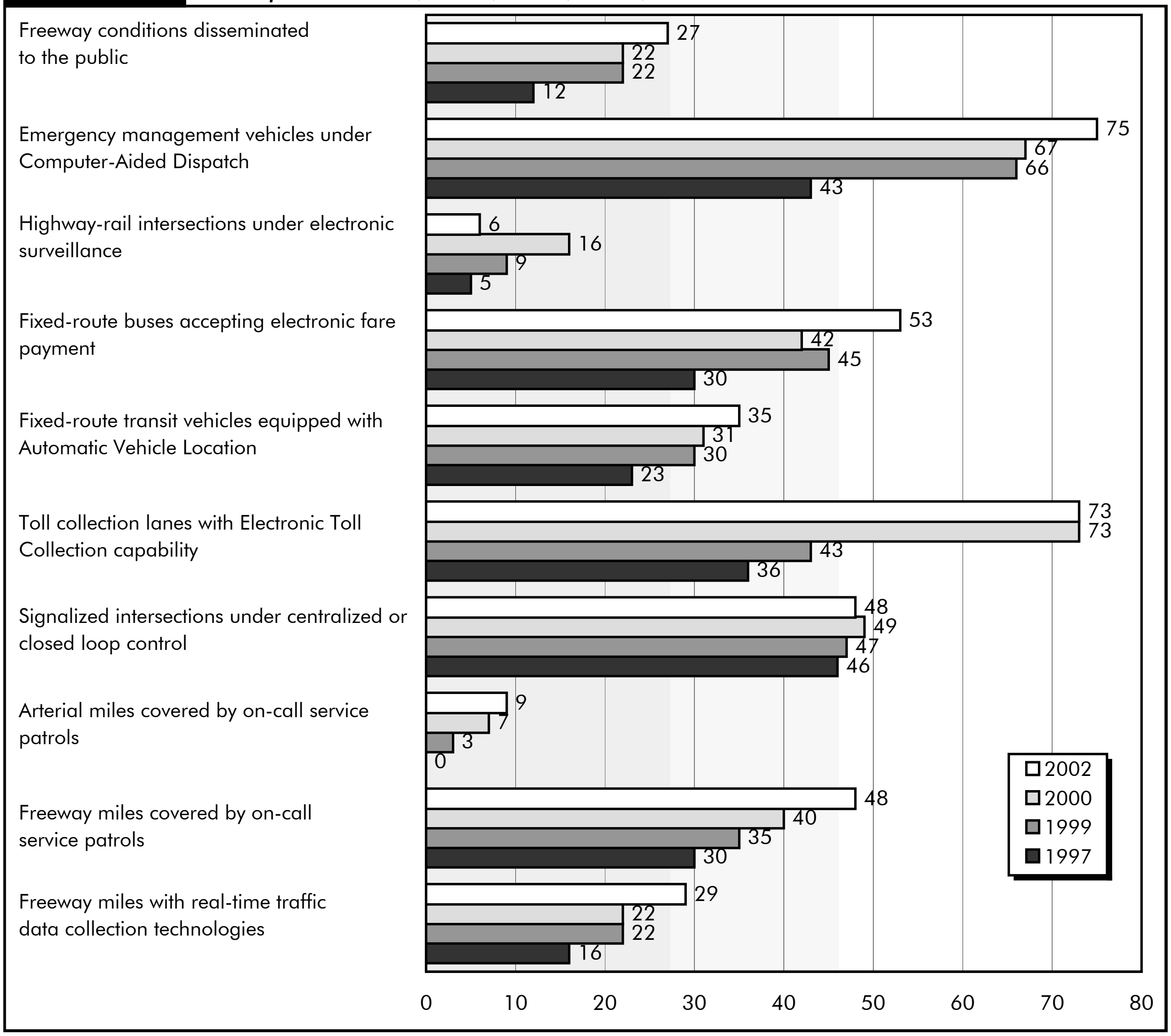
SU=Single-Unit Trucks (6 tires or more)

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

*Source: Highway Statistics, Summary to 1995, Table VM-201; Highway Statistics, Table VM-1, various years.*

*Exhibit 2-11* describes the deployment of ITS devices in 78 metropolitan regions, based on a survey by the FHWA Intelligent Transportation Systems Joint Program Office. More regions are using computer-aided emergency management vehicles (75 percent) followed by electronic tolling (73 percent in 2002). While Intelligent Transportation Systems continue to grow in acceptance and use, the number of arterial miles covered by on-call service patrols remains low at 9 percent in 2002.

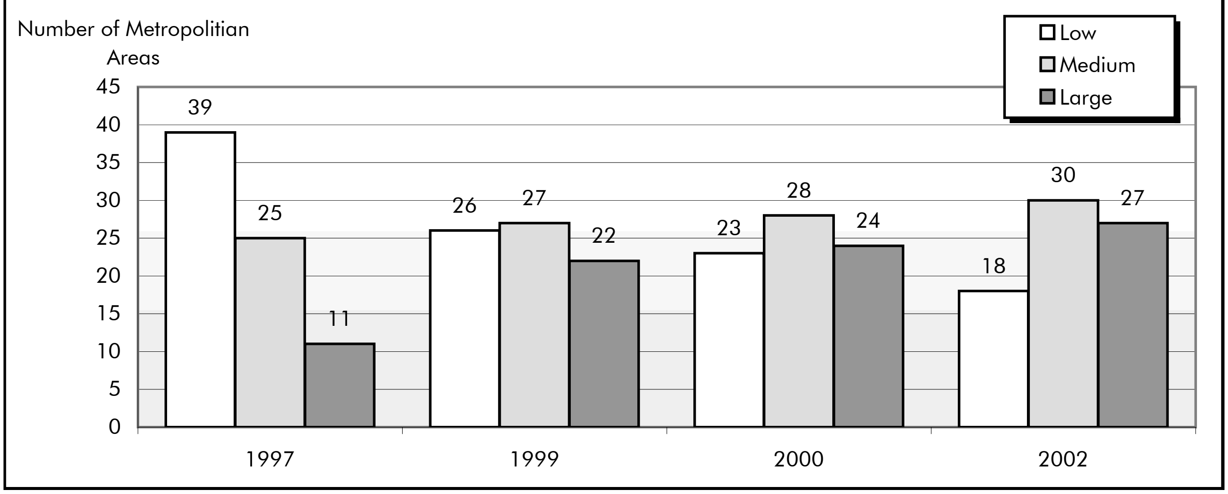
**Exhibit 2-11** *Deployment of Intelligent Transportation Systems (ITS) in 78 Largest Metropolitan Areas, 1997, 1999, 2000, and 2002*




*Source: "Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 2002 Results, April 2004."*

*Exhibit 2-12* shows the level of ITS deployment in 75 of the nation's largest metropolitan areas. Progress has been made in the number of cities with medium or high level ITS. The number of cities with high or medium level ITS has increased from 36 in 1997 to 57 in 2002.

**Exhibit 2-12** *Integrated Metropolitan Deployment Progress*




*Source: "Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 2002 Results, April 2004."*

# Bridge System Characteristics

## Bridges by Owner

*Exhibit 2-13* shows the number of highway bridges by owner from 1996 to 2002. 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. Ownership percentages have remained relatively constant over time, as shown in Exhibit 2-13.

**Q. Is information on railroad bridge inspections included in the NBI?**

**A.** 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. There are a small number of railroad-owned highway bridges in excess of 6 meters in total length in the inventory: 1,016 nationally. 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.

A simple tabulation of the number of bridges by ownership does not take into account the traffic carried by the structure or the size of the structure. *Exhibit 2-14* compares the ownership percentages based on the actual number of bridges with percentages based on average daily traffic on bridges and bridge deck area, respectively. Bridges owned by State agencies carry significantly higher cumulative traffic volumes than bridges owned by local agencies. State-owned bridges also tend to have greater deck area than locally owned bridges.

**Exhibit 2-13** *Bridges by Owner, 1996–2002*

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

*Source: National Bridge Inventory.*

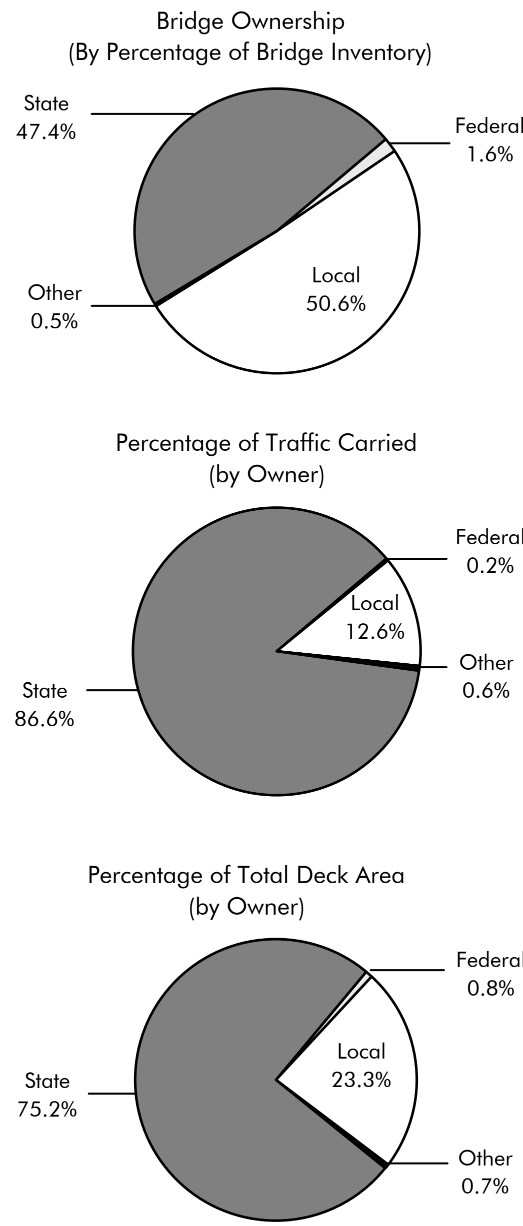
**Q.** How do the bridge ownership percentages compare with the road ownership percentages?

**A.** The majority of bridges and roadways are owned by State and local agencies. The vast majority of roadways, however, are owned by local agencies. Bridge ownership is nearly equally divided between State ownership and local ownership. 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.

**Q.** If an agency owns a bridge, is it responsible for the maintenance and operation of the structure?

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

***Exhibit 2-14*** ***Percent Bridge Inventory, Traffic, and Deck Area by Owner***




*Source: National Bridge Inventory.*

# Bridges by Functional Classification

Highway functional classifications are maintained with the NBI according to the hierarchy used for highway systems previously shown. 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.

**Exhibit 2-15** *Number of Bridges by Functional System, 1996–2002*

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

*Source: National Bridge Inventory.*

*Exhibit 2-16* gives additional detail on bridges from the 2002 NBI dataset by cross tabulating the number of bridges by owner and functional classification. There are 378 structures (less than 0.1 percent) that do not have accurately coded functional classifications. These bridges are not included in the 2002 tabulation. Nearly all of the Interstate bridges are owned by State agencies (99.3 percent) with small numbers of Interstate bridges owned by other agencies, primarily in urban areas. Likewise, most of the bridges functionally classified as local (82.4 percent) are owned by cities, counties, townships, and other local agencies.

State agencies own the majority of bridges at the higher functional classifications and also own sizeable numbers of bridges across all functional classifications. Approximately 125,000 of the 280,000 State-owned bridges carry principal arterials including Interstates and other freeways and expressways. The remaining structures carry minor arterials, collectors, and local roadways. Of the nearly 300,000 locally owned bridges, the majority carry local roadways and collectors (93 percent). The majority of federal bridges (97 percent) are located in rural areas and carry either local or collector roadways (94 percent).

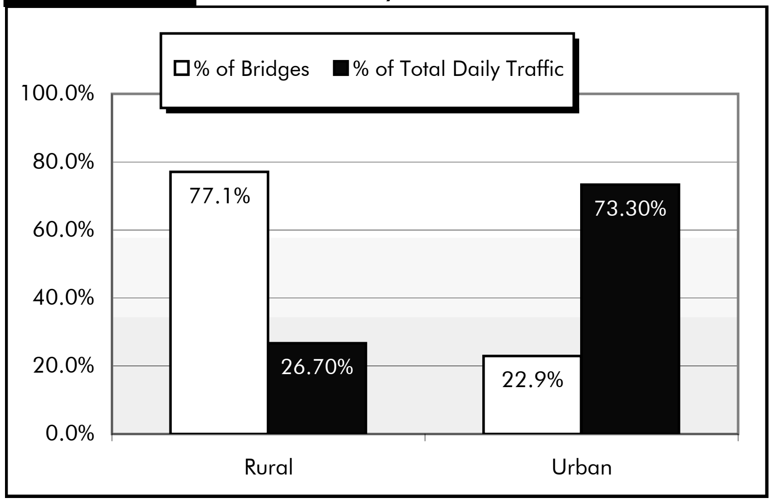
**Exhibit 2-16** *Bridges by Functional Classification and Owner, 2002*

| Functional Classification | State | Local | Federal | Private/ Railroad | Other/ Unclassified | All Owners |
|---|---|---|---|---|---|---|
| **Rural** | | | | | | |
| Interstate | 27,283 | 10 | 18 | 4 | 1 | 27,316 |
| Other Principal Arterials | 34,686 | 300 | 55 | 29 | 157 | 35,227 |
| Minor Arterial | 36,682 | 2,414 | 402 | 49 | 40 | 39,587 |
| Major Collector | 52,737 | 41,742 | 179 | 85 | 38 | 94,781 |
| Minor Collector | 16,602 | 31,423 | 1,178 | 89 | 28 | 49,320 |
| Local | 28,177 | 173,578 | 7,255 | 564 | 148 | 209,722 |
| **Rural Total** | **196,167** | **249,467** | **9,087** | **820** | **412** | **455,953** |
| **Urban** | | | | | | |
| Interstate | 27,601 | 307 | 2 | 9 | 10 | 27,929 |
| Other Freeway and Expressway | 15,429 | 970 | 2 | 47 | 396 | 16,844 |
| Other Principal Arterial | 18,785 | 5,317 | 17 | 80 | 108 | 24,307 |
| Minor Arterial | 11,939 | 12,288 | 42 | 146 | 101 | 24,516 |
| Collector | 5,086 | 9,850 | 20 | 114 | 101 | 15,171 |
| Local | 4,956 | 21,096 | 195 | 282 | 80 | 26,609 |
| **Urban Total** | **83,796** | **49,828** | **278** | **678** | **796** | **135,376** |
| Unclassified | 303 | 59 | 6 | 4 | 6 | 378 |
| **TOTAL** | **280,266** | **299,354** | **9,371** | **1,502** | **1,214** | **591,707** |

*Source: National Bridge Inventory.*

*Exhibit 2-17* presents a summary of bridges and traffic carried by rural/urban status. Of all structures, 77.1 percent are located in rural areas. Though only 22.9 percent of the bridges are located in urban areas, these structures carry three-quarters of all daily traffic.

**Exhibit 2-17** *Rural and Urban Bridges by Number and Percent of Daily Traffic, 2002*




*Source: National Bridge Inventory.*

# Transit System Characteristics

## Transit Services, Jurisdiction, and Use

Prior to 1960, the Federal Government was not focused on public transit issues. But, by the end of the 1950s, it was becoming clear to all levels of government that developing and sustaining transit services was an important national, as well as local, concern. Studies undertaken by State and local governments in major cities, including Chicago, Philadelphia, San Francisco, and Washington, highlighted the need for creating or improving transit facilities and programs. Since the 1960s, the ownership and operation of most transit systems in the United States have been transferred from private to public hands. This transformation occurred with the large influx of Federal funding following the passage of the Urban Mass Transportation Act of 1964, which specified that Federal funds for transit were to be given to local or metropolitan-level public agencies, and not to private firms or State governments. The Act also required local governments to contribute local matching funds for the provision of transit services in order to receive Federal aid.

As local governments have come to understand the regional nature of transportation problems, metropolitan planning organizations have assumed more responsibility for formulating local transit policy. Regional planning allows local officials to consider the effects of the transportation system on other characteristics of the urban environment, including land use, the location and creation of employment, and accessibility, i.e., the ease with which local residents and visitors can reach locations for business, medical, educational, and recreational purposes. It also allows local decision makers to choose the best way to invest their scarce transportation resources, including choosing among modes.

Transit operations have increasingly become the subject of State initiatives in the form of financial support and performance oversight, as well as outright ownership and operation of services. Five states—Connecticut, Delaware, Maryland, New Jersey, and Rhode Island—own and operate transit systems. Ballot initiatives dedicating specific taxes to transit were passed in 10 States—Arizona, California, Colorado, Florida, Michigan, Nevada, Ohio, South Carolina, Utah, and Washington—between 2000 and 2002.

A transit provider can be an independent agency with either an elected or appointed Board of Governors. It may also be the unit of a regional transportation agency, or a State, county, or city government. Services may be provided directly or under contract. Transit services must be open to the general public, i.e., to anyone who pays the proscribed fare. They must also meet accessibility requirements, such as the Americans with Disabilities Act of 1990 (ADA).

In 2002, there were 610 providers of transit services in both large and small urbanized areas, compared with 614 in 2000. Of these 610 providers, 538 were public agencies. The remaining 72 providers were private providers under contract to public agencies, private brokerage systems, or agencies in special categories such as private entities providing dial-a-ride services. In 2000, the most recent year for which information is available, there were 1,215 operators serving rural areas. In spring 2004, it was estimated that there were 4,836 providers of special services to the elderly and disabled in both urban and rural areas.

Increases in population coupled with investment in transit infrastructure have led to transit ridership increases. The total number of miles traveled on transit, or passenger miles traveled (PMT), increased from 35.1 billion miles in 1980 to 45.9 billion miles in 2002. PMT growth was particularly strong in the latter half of the 1990s, increasing at an average annual rate of 3.5 percent between 1995 and 2000. By comparison PMT was virtually the same in 1995 as in 1990 and increased at a much more gradual pace (1.7 percent on average annually) between 1980 and 1990. The fast growth in transit use in the latter part of the 1990s most likely resulted from the strong economy and, in part, from the expansion of commuter benefits, including transit benefits and parking cash-out programs. The introduction of fares cards in New York City in 1997, which enabled transfers, and the introduction of volume discounts and unlimited-ride one-day, 7-day, and 30-day passes in New York City in 1999, also very likely contributed to ridership increases. Nationwide PMT increased in between 2000 and 2001, falling back to 2000 levels in 2002, reflecting a decrease in ridership in New York City as a result of the terrorist attacks on September 11, 2001.

## *Transit Fleet and Infrastructure*

The Nation's transit system continues to grow. In 2002, urban transit systems operated 114,564 vehicles, of which 87,295 were in urbanized areas of more than 1 million people and 27,269 were in urbanized areas under 1 million. In 2000, the most recent year for which information is available and as reported in the last edition of this report, there were 19,185 rural vehicles, i.e., vehicles serving rural areas operated by agencies receiving FTA funds. FTA estimates that there are currently (2004) 37,720 special service vehicles, of which 16,219 were funded by FTA. (No estimate of special service vehicles is available for 2002.) In 2002, transit providers operated 10,722 miles of track and served 2,862 stations, compared with 10,572 miles of track and 2,825 stations in 2000. Between 2000 and 2002, the number of urban transit vehicles increased by 7.7 percent, track mileage grew by 1.4 percent, and the number of stations increased by 1.3 percent. There were also 769 maintenance facilities in urban areas, compared with 759 in 2000, an increase of 1.3 percent [*Exhibit 2-18*].

**Q.** What is demand response?

**A.** Demand response is a transit service composed of passenger cars, vans, or small buses dispatched directly in response to requests for service. Demand response vehicles do not operate over fixed routes or to fixed schedules except on a temporary basis to satisfy a special need. Typically, the vehicle may be dispatched to pick up several passengers at different locations before taking them to their respective destinations.

## *System Network (Urban Route Miles)*

The number of the Nation's transit directional route miles is a measure of the coverage or the extensiveness of the U.S. transit system. Directional route miles are counted for vehicles traveling in a particular direction. They measure the distance covered by a transit route independent of the number of vehicles that serve that route. When routes overlap, the mileage is counted separately for each route. Routes may be along fixed guideways (as in the case of rail modes) or separated bus guideways, or they may share city streets with other vehicles (as with most bus routes).

In the United States in 2002, there were 235,304 transit directional route miles (route miles), of which 225,820 were provided by bus modes and 9,484 by rail modes. Total route miles increased at an average annual rate of 2.1 percent between 1993 and 2002 and 6.9 percent between 2000 and 2002.

Changes in total route miles are driven almost exclusively by changes in bus route miles, which, in 2002, accounted for 96 percent of total route mileage. The National Transit Database (NTD) reports that route miles for buses increased rapidly between 2000 and 2002 at an average annual rate of 7.1 percent. Light rail route miles exhibited the most rapid growth between 1993 and 2002, at an average annual rate of 6.7 percent, and between 2000 and 2002, at an average annual rate of 7.2 percent. The rapid pace in growth of light rail route miles reflects new and extensions to existing New Starts rail systems that have become operational during this period. Route miles for remaining transit modes have also increased, although less rapidly. Commuter rail route miles increased at an average annual rate of 1.8 percent between 1993 and 2002, and trolleybus route miles by 1.6 percent. Heavy rail and ferryboat route miles each increased at an average annual rate of 0.9 percent over the same period. Route miles are not collected for demand response, vanpool, jitney, and publico services, since these transit modes do not travel along specific predetermined routes [*Exhibit 2-19*]. [Publico is a jitney service that operates in Puerto Rico. See Q & A on page 2-26.]

**Q. Why are directional route miles higher for nonrail modes than they were in previous editions of this report?**

**A.** Directional route miles for bus and ferryboat services performed under contract were not included in earlier editions of this report. These route miles are now included.

## System Capacity

The Nation's transit system's capacity is measured with capacity-equivalent vehicle revenue miles (VRM). Capacity-equivalent VRM are a measure of the distance traveled by transit vehicles in revenue service, adjusted by the passenger-carrying capacity of each transit vehicle type, with the average passenger-carrying capacity of buses representing the baseline.

**Exhibit 2-18** *Transit Active Fleet and Infrastructure, 2002*

| | Areas Over 1 Million | Areas Under 1 Million[1] | Total |
|---|---|---|---|
| **Vehicles** | | | |
| Buses | 49,159 | 19,259 | 68,418 |
| Heavy Rail | 10,946 | 0 | 10,946 |
| Light Rail | 1,373 | 84 | 1,457 |
| Self-Propelled Commuter Rail | 2,383 | 0 | 2,383 |
| Commuter Rail Trailers | 2,838 | 78 | 2,916 |
| Commuter Rail Locomotives | 624 | 68 | 692 |
| Vans | 13,602 | 6,165 | 19,767 |
| Other (including Ferryboats) | 6,370 | 1,615 | 7,985 |
| **Vehicle Subtotal** | **87,295** | **27,269** | **114,564** |
| Rural Service Vehicles [2] | 0 | 19,185 | 19,185 |
| Special Service Vehicles [3] | 10,107 | 27,613 | 37,720 |
| **Total Active Vehicles** | **97,402** | **74,067** | **171,469** |
| **Infrastructure** | | | |
| Track Mileage | | | |
| Heavy Rail | 2,179 | 0 | 2,179 |
| Commuter Rail | 7,070 | 283 | 7,353 |
| Light Rail | 1,052 | 61 | 1,114 |
| Other Rail [4] | 23 | 53 | 76 |
| **Total Track Mileage** | **10,325** | **397** | **10,722** |
| **Stations** | | | |
| Heavy Rail | 1,017 | 0 | 1,017 |
| Commuter Rail | 1,138 | 18 | 1,156 |
| Light Rail | 572 | 68 | 640 |
| Other Rail [4] | 36 | 13 | 49 |
| **Total Transit Rail Stations** | **2,763** | **99** | **2,862** |
| **Maintenance Facilities [5]** | | | |
| Heavy Rail | 53 | 0 | 53 |
| Commuter Rail | 62 | 0 | 62 |
| Light Rail | 27 | 5 | 32 |
| Ferryboat | 6 | 1 | 7 |
| Buses | 296 | 219 | 516 |
| Demand Response | 28 | 63 | 91 |
| Other Rail [4] | 3 | 5 | 8 |
| **Total Urban Maintenance Facilities** | **476** | **293** | **769** |
| Rural Maintenance Facilities [2] | | 510 | 510 |
| **Total Maintenance Facilities** | **476** | **803** | **1,279** |

[1] Note that all numbers in this column refer to urbanized areas under 1 million except for rural vehicles, rural maintenance facilities, and special service vehicles. The numbers for rural vehicles and rural maintenance facilities comprise those that serve rural areas only. Special service vehicles comprise those that operate in urbanized areas under 1 million and in rural areas.

[2] Owned by operators receiving funding from FTA as directed by 49USC 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, CTAA, April 2001.)

[3] FTA, Fiscal Year Trends Report on the Use of Section 5310 Elderly and Persons with Disabilities Program Funds, 2002. FTA funded 16,219 of these vehicles.

[4] Includes Alaska Railroad which was not reported to the NTD in 2000.

[5] Includes owned and leased facilities; directly operated service only.

*Source: National Transit Database.*

**Exhibit 2-19** *Transit Directional Route Miles, 1993–2002*

| | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 | Average Annual Rate of Change 2002/1993 | Average Annual Rate of Change 2002/2000 |
|---|---|---|---|---|---|---|---|---|
| **Rail** | **7,888** | **8,211** | **8,602** | **9,170** | **9,222** | **9,484** | **2.1%** | **1.4%** |
| Commuter Rail [1] | 5,875 | 6,162 | 6,393 | 6,802 | 6,802 | 6,923 | 1.8% | 0.9% |
| Heavy Rail | 1,452 | 1,458 | 1,527 | 1,540 | 1,558 | 1,572 | 0.9% | 0.5% |
| Light Rail | 537 | 568 | 659 | 802 | 834 | 960 | 6.7% | 7.2% |
| Other Rail [2] | 24 | 24 | 24 | 27 | 29 | 30 | 2.5% | 1.6% |
| **Nonrail [3]** | **187,215** | **187,757** | **185,164** | **195,984** | **196,858** | **225,820** | **2.1%** | **7.1%** |
| Bus | 186,334 | 186,856 | 184,248 | 195,022 | 195,884 | 224,838 | 2.1% | 7.1% |
| Ferryboat | 476 | 490 | 496 | 533 | 505 | 513 | 0.9% | 0.8% |
| Trolleybus | 405 | 412 | 420 | 430 | 469 | 468 | 1.6% | -0.1% |
| **Total** | **195,102** | **195,968** | **193,766** | **205,154** | **206,080** | **235,304** | **2.1%** | **6.9%** |
| Percent Nonrail | 96.0% | 95.8% | 95.6% | 95.5% | 95.5% | 96.0% | | |

[1] Includes Alaska Rail.

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

[3] Excludes jitney, publico, and vanpool.

*Source: National Transit Database.*

VRM, unadjusted by passenger-carrying capacity, are reported in *Exhibit 2-20.* These numbers are of interest because they show the actual number of miles traveled by each mode in revenue service. Unadjusted VRM for each mode are multiplied by a capacity-equivalent factor in order to calculate capacity-equivalent VRM. Rail's share of total unadjusted transit VRM remained relatively constant between 1993 and 2002, ranging between 27 and 28 percent. As subsequent paragraphs will show, the share of VRM on rail modes, adjusted for capacity equivalency, are considerably higher than the share of VRM on rail modes unadjusted for capacity equivalency. The share of unadjusted VRM provided by bus services has declined from 61 percent in 1993 to 54 percent in 2002.

**Exhibit 2-20** *Transit Unadjusted Vehicle Revenue Miles (VRM), 1993–2002*

| (Millions) | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| **Rail** | **737** | **775** | **811** | **849** | **880** | **925** |
| Commuter Rail [1] | 203 | 218 | 230 | 243 | 248 | 259 |
| Heavy Rail | 505 | 522 | 540 | 561 | 578 | 603 |
| Light Rail | 27 | 34 | 40 | 42 | 51 | 60 |
| Other Rail [2] | 2 | 2 | 2 | 2 | 2 | 2 |
| **Nonrail** | **1,855** | **1,957** | **2,042** | **2,257** | **2,322** | **2,502** |
| Bus | 1,578 | 1,591 | 1,606 | 1,719 | 1,764 | 1,864 |
| Demand Response | 243 | 297 | 350 | 418 | 452 | 525 |
| Ferryboat | 2 | 2 | 2 | 2 | 2 | 3 |
| Trolleybus | 13 | 13 | 13 | 14 | 14 | 13 |
| Vanpool | 19 | 22 | 40 | 60 | 62 | 71 |
| Other Nonrail [3] | 0 | 31 | 31 | 44 | 28 | 26 |
| **Total** | **2,592** | **2,732** | **2,853** | **3,106** | **3,202** | **3,427** |
| Percent Rail | 28.4% | 28.4% | 28.4% | 27.3% | 27.5% | 27.0% |

[1] Includes Alaska Rail.

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

[3] Publico and jitney.

*Source: National Transit Database.*

The capacity-equivalent factors used in earlier reports and the resulting capacity-equivalent VRM have been revised. New capacity-equivalent factors are equal to the ratio of the average full-seating and full-standing capacities of vehicles in active revenue service for each transit mode to the average full-seating and full-standing capacity of all bus vehicles in active revenue service as reported by the NTD for each year from 2000 to 2002. For vehicles in service that prohibit standing, often the case with commuter rail, standing capacity is assumed to be 0. These revised capacity-equivalent factors are shown in *Exhibit 2-21.*

**Exhibit 2-21** *Capacity-Equivalent Factors Mode, Full-Seating and -Standing Capacities Combined*

| Base = Average Bus Capacity | | | |
|---|---|---|---|
| Automated Guideway | 1.43 | Jitney | 0.57 |
| Alaska Rail | 0.40 | Light Rail | 2.52 |
| Cable Car | 0.87 | **Bus** | **1.00** |
| Commuter Rail | 2.33 | Monorail | 1.85 |
| Demand Response | 0.18 | Publico | 0.26 |
| Ferryboat | 12.05 | Trolleybus | 1.46 |
| Heavy Rail | 2.36 | Vanpool | 0.19 |
| Inclined Plane | 0.84 | | |

*Source: National Transit Database.*

Capacity-equivalent VRM reported in *Exhibit 2-22* are based on the new capacity-equivalent factors. In 2002, all transit modes combined provided the equivalent of 4.2 billion miles of bus service loaded to full-seating and full-standing capacity. Slightly more than half of these capacity-equivalent VRM were provided by rail modes of service, and slightly less than half by nonrail modes. Total capacity-equivalent VRM increased at an average annual rate of 2.4 percent between 1993 and 2002 and 2.8 percent between 2000 and 2002. Between 1993 and 2002, capacity-equivalent VRM grew most rapidly for vanpool, at an average annual rate of 17.9 percent, although vanpool accounts for only a very small percentage of total transit services. Capacity-equivalent VRM for light rail also grew rapidly, at an average annual rate of 9.3 percent between 1993 and 2002 and 8.0 percent between 2000 and 2002, reflecting New Starts openings and extensions. Capacity-equivalent VRM for demand response also exhibited substantial growth, increasing

**Exhibit 2-22** *Transit Urban Capacity-Equivalent Vehicle Revenue Miles, 1993–2002*

| | (Millions) | | | | | | Average Annual Rate of Change | |
|---|---|---|---|---|---|---|---|---|
| | **1993** | **1995** | **1997** | **1999** | **2000** | **2002** | **2002/ 1993** | **2002/ 2000** |
| **Rail** | **1,736** | **1,827** | **1,912** | **2,013** | **2,075** | **2,182** | **2.6%** | **2.6%** |
| Commuter Rail [1] | 474 | 507 | 535 | 567 | 578 | 604 | 2.7% | 2.2% |
| Heavy Rail | 1,192 | 1,231 | 1,274 | 1,324 | 1,365 | 1,424 | 2.0% | 2.2% |
| Light Rail | 68 | 85 | 100 | 119 | 130 | 151 | 9.3% | 8.0% |
| Other Rail [2] | 2 | 2 | 3 | 3 | 3 | 3 | 4.9% | 3.3% |
| **Nonrail** | **1,669** | **1,699** | **1,728** | **1,867** | **1,914** | **2,030** | **2.2%** | **3.0%** |
| Bus | 1,578 | 1,591 | 1,606 | 1,719 | 1,764 | 1,864 | 1.9% | 2.8% |
| Demand Response | 44 | 54 | 63 | 75 | 81 | 95 | 8.9% | 7.7% |
| Ferryboat | 24 | 23 | 24 | 30 | 30 | 32 | 3.2% | 4.1% |
| Trolleybus | 19 | 19 | 20 | 20 | 20 | 19 | 0.2% | -2.3% |
| Vanpool | 4 | 4 | 8 | 11 | 12 | 13 | 17.9% | 7.0% |
| Other Nonrail [3] | 0 | 8 | 8 | 11 | 7 | 7 | -2.6% | -3.8% |
| **Total** | **3,405** | **3,526** | **3,640** | **3,880** | **3,989** | **4,213** | **2.4%** | **2.8%** |
| Percent Rail | 51.0% | 51.8% | 52.5% | 51.9% | 52.0% | 51.8% | | |

[1] Includes Alaska Rail.

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

[3] Jitney and publico. Capacity-equivalent VRM were 16.7 thousand in 1993.

*Source: National Transit Database.*

at an average annual rate of 8.9 percent between 1993 and 2002 and 7.7 percent between 2000 and 2002, as transit agencies continued to fulfill their responsibilities under the ADA. Capacity-equivalent VRM for bus, commuter rail, and heavy rail, which combined account for the bulk of transit services, increased more slowly between 1993 and 2002, at average annual rates of 1.9 percent, 2.7 percent, and 2.0 percent, respectively.

**Q.** What is a jitney service, and what is a publico service?

**A.** Jitney is composed of passenger cars or vans operating on fixed routes, with some minor deviations. Jitney services operate without a fixed schedule or stops and as warranted by demand. There is only one jitney service in the United States, which has been operating in Long Beach, California, since 1914. A newspaper reporter coined the name "jitney" because the service charged a jitney or five cents a ride. At that time, independent operators provided jitney services using a wide range of automobiles. In 1914, the first ordinance regulating jitney bus traffic was adopted.

Publico is the name of the jitney service that operates in San Juan, Puerto Rico. Publico is composed of passenger vans or small buses operating with fixed routes, but not fixed schedules. Publico vehicles are privately owned, unsubsidized, but regulated through a public service commission or state or local government. Vehicle capacities vary from eight to 30 or more passengers. Vehicles may be owned or leased by the operator.

## *Passenger Travel*

As previously mentioned in the beginning of this chapter, PMT, or the total number of miles traveled by passengers in transit vehicles, measures the Nation's transit use. Percentage changes in PMT closely follow percentage changes in unlinked trips. *Exhibit 2-23* provides PMT for selected years between 1993 and 2002. PMT increased at an average annual rate of 2.7 percent between 1993 and 2002 and 0.9 percent between 2000 and 2002. PMT on all rail modes combined increased at an average annual rate of 3.6 percent between 1993 and 2002, more than double the 1.7 percent average annual growth rate on all nonrail modes combined. Starting from an extremely low level of ridership, PMT on vanpool grew the mostly rapidly between 1993 and 2002, at an average annual rate of 11.1 percent. PMT on vanpool remains a tiny fraction of the Nation's total. PMT on light rail also grew at a fast pace, at an average annual rate of 8.2 percent between 1993 and 2002, as new light rail systems and extensions were opened, but slowed to an average annual rate of 3.4 percent between 2000 and 2002. PMT on demand response systems also grew briskly at an average annual rate of 5.9 percent between 1993 and 2002. In addition to serving disabled persons, demand response services are effective at meeting ridership demand in sparsely populated areas where fixed route service does not make economic sense. PMT on commuter rail increased moderately at an average annual rate of 3.6 percent between 1993 and 2002, but more slowly at 0.5 percent between 2000 and 2002.

**Q.** When are vanpools considered to be transit service?

**A.** Vanpools that are operated, owned, or leased by a public entity are considered to be transit. They must comply with transit rules, including the ADA provisions and be open to the public.

**Exhibit 2-23** *Transit Urban Passenger Miles, 1993–2002*

| | (Millions) | | | | | | Average Annual Rate of Change | |
|---|---|---|---|---|---|---|---|---|
| | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 | 2002/ 1993 | 2002/ 2000 |
| **Rail** | **17,867** | **19,682** | **21,138** | **22,875** | **24,603** | **24,616** | **3.6%** | **0.0%** |
| Commuter Rail | 6,912 | 8,244 | 8,037 | 8,764 | 9,400 | 9,500 | 3.6% | 0.5% |
| Heavy Rail | 10,231 | 10,559 | 12,056 | 12,902 | 13,844 | 13,663 | 3.3% | -0.7% |
| Light Rail | 704 | 859 | 1,024 | 1,190 | 1,340 | 1,432 | 8.2% | 3.4% |
| Other Rail [1] | 20 | 21 | 21 | 19 | 20 | 20 | -0.1% | 0.1% |
| **Nonrail** | **18,354** | **18,288** | **19,042** | **20,404** | **20,498** | **21,328** | **1.7%** | **2.0%** |
| Bus | 17,360 | 17,024 | 17,509 | 18,684 | 18,807 | 19,527 | 1.3% | 1.9% |
| Demand Response | 389 | 397 | 531 | 559 | 588 | 651 | 5.9% | 5.3% |
| Ferryboat | 240 | 243 | 254 | 295 | 298 | 301 | 2.5% | 0.5% |
| Trolleybus | 188 | 187 | 189 | 186 | 192 | 188 | 0.0% | -1.1% |
| Vanpool | 177 | 185 | 310 | 413 | 407 | 455 | 11.1% | 5.7% |
| Other Nonrail [2] | - | 252 | 249 | 267 | 205 | 206 | -2.8% | 0.1% |
| **Total** | **36,220** | **37,971** | **40,180** | **43,279** | **45,101** | **45,944** | **2.7%** | **0.9%** |
| Percent Rail | 49.3% | 51.8% | 52.6% | 52.9% | 54.6% | 53.6% | | |

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

[2] Jitney and Publico. Ninety-eight percent or more are PMT on Publico. Average annual percentage change is between 1995 and 2002.

*Source: National Transit Database.*

While PMT on heavy rail also increased moderately at an average annual rate of 3.3 percent between 1993 and 2002, it declined by 0.7 percent on an average annual basis between 2000 and 2002, reflecting a decrease in ridership in New York City following the terrorist attacks on September 11, 2001. If heavy rail is excluded, PMT increased at an average annual rate of 1.6 percent between 2000 and 2002. (Note that PMT on heavy rail increased by 2.4 percent between 2000 and 2001.) Some heavy rail systems, however, had rapid increases in PMT over the 2000 to 2002 period. PMT on the Los Angeles County Metro increased at an average annual rate of 48 percent between 2000 and 2002, reflecting the opening of the North Hollywood extension in 2000. PMT on the Washington Metro Green line increased at an average annual rate of 21 percent between 2000 and 2002, reflecting the opening of a 6.5-mile extension in January 2001. Both projects were supported by FTA's New Starts capital investment program.

## Q. What affects transit ridership?

**A.** Transit ridership is measured by PMT or unlinked passenger trips. PMT for each system by mode are calculated as the number of unlinked trips multiplied by an estimate of average trip length. Transit ridership is higher in densely developed areas with more extensive and frequent service and lower in sprawling developments where the service is less extensive and frequent.

The largest increases in transit ridership generally come from expanding transit services into areas where there is significant latent ridership demand. Investments that enhance riders' comfort levels, such as benches and shelters at transit stops and walkways with safer pedestrian access, have been found to promote ridership. Riders are attracted by more frequent service, reduced vehicle crowding and, in some cases, changes in service routes. However, bus ridership may be adversely affected by road congestion. Special programs targeting students, human service agency clientele, and tourists can also build ridership as can the reduction of parking subsidies and provision of transit checks.

A statistical analysis by FTA found a positive relationship between changes in employment and transit use, and provided an indication that the level of employment was the most important factor affecting transit use. Research in this area is ongoing, and additional linkages are under examination.

## *Vehicle Occupancy*

### Unadjusted for Vehicle Capacities

Vehicle occupancy, or the average number of passengers that a transit vehicle carries, measures the level of utilization of the transit infrastructure and compares the level of transit use with the level of transit service. *Exhibit 2-24* shows average unadjusted vehicle occupancies for transit modes on a mode-by-mode basis. Since the average carrying capacities of the vehicles in each mode are different, differences in these occupancy rates reflect the size of the vehicle and not the extent to which the vehicle is being utilized. Automated guideway, inclined plane, cable car, and monorail have been grouped together as other rail and jitney and Publico as other nonrail.

Average unadjusted vehicle occupancies are not calculated for all rail modes combined or for all nonrail modes combined because the passenger-carrying capacities of vehicles within each mode are not comparable. In 2002, on average a commuter rail vehicle carried 37 passengers, a heavy rail vehicle carried 23 passengers, and a bus carried 11 passengers.

**Exhibit 2-24** *Unadjusted Vehicle Occupancy Passengers per Transit Vehicle, 1993–2002*

| | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| **Rail** | | | | | | |
| Commuter Rail [1] | 34.0 | 37.9 | 35.0 | 36.0 | 37.9 | 36.7 |
| Heavy Rail | 20.2 | 20.2 | 22.3 | 23.0 | 23.9 | 22.6 |
| Light Rail | 26.1 | 25.3 | 25.7 | 28.1 | 26.1 | 23.9 |
| Other Rail [2] | 11.8 | 10.7 | 9.5 | 8.7 | 8.4 | 8.0 |
| **Nonrail** | | | | | | |
| Bus | 11.0 | 10.7 | 10.9 | 10.9 | 10.7 | 10.5 |
| Demand Response | 1.6 | 1.3 | 1.5 | 1.3 | 1.3 | 1.2 |
| Ferryboat | 118.3 | 125.3 | 126.2 | 119.0 | 120.1 | 112.1 |
| Trolleybus | 14.4 | 14.2 | 14.1 | 13.7 | 13.8 | 14.1 |
| Vanpool | 9.2 | 8.3 | 7.7 | 6.9 | 6.6 | 6.4 |
| Other Nonrail [3] | 0.0 | 8.0 | 8.1 | 6.1 | 7.3 | 7.9 |

[1] Includes Alaska Rail

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

[3] Jitney and publico.

*Source: National Transit Database.*

### Adjusted for Vehicle Capacities

To provide a better indication of actual capacity utilization, vehicle occupancies can be adjusted to reflect differences in vehicle-carrying capacities among modes by taking the ratio of PMT to capacity-equivalent VRM. This enables the comparison of vehicle occupancy levels across modes. Adjusted vehicle occupancy levels are based on capacity-equivalent VRM and provide the average number of people that a mode would carry if it were operating vehicles equal to the size of the average U.S. bus. Note that these adjusted capacity-equivalent occupancy levels differ from what were reported in previous editions of this report because they have been revised to reflect the revisions in capacity-equivalent factors and capacity-equivalent VRM discussed earlier in this chapter under "System Capacity" on page 2-24. The slight downward adjustment in the estimates of capacity-adjusted vehicle occupancy levels for rail vehicles has resulted from a slight increase in the estimated average adjusted capacity of these vehicles [*Exhibit 2-25*].

**Exhibit 2-25** *Adjusted Vehicle Occupancy[1]*
*Passengers per Capacity-Equivalent Public Transit Vehicle Mile, 1993–2002*

| | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| **Rail** | 10.3 | 10.8 | 11.1 | 11.4 | 11.9 | 11.3 |
| Commuter Rail [2] | 14.6 | 16.2 | 15.0 | 15.5 | 16.3 | 15.7 |
| Heavy Rail | 8.6 | 8.6 | 9.5 | 9.7 | 10.1 | 9.6 |
| Light Rail | 10.4 | 10.0 | 10.2 | 10.0 | 10.3 | 9.5 |
| Other Rail [3] | 9.2 | 8.3 | 7.3 | 6.6 | 6.3 | 5.9 |
| **Nonrail** | **11.0** | **10.8** | **11.0** | **10.9** | **10.7** | **10.5** |
| Bus | 11.0 | 10.7 | 10.9 | 10.9 | 10.7 | 10.5 |
| Demand Response | 8.9 | 7.4 | 8.4 | 7.4 | 7.2 | 6.9 |
| Ferry Boat | 9.8 | 10.4 | 10.5 | 9.9 | 10.0 | 9.3 |
| Trolley Bus | 9.9 | 9.7 | 9.7 | 9.4 | 9.4 | 9.7 |
| Vanpool | 48.6 | 43.6 | 40.7 | 36.3 | 34.7 | 33.9 |
| Other Nonrail [4] | - | 30.8 | 31.0 | 23.3 | 28.0 | 30.3 |
| **Total** | **10.6** | **10.8** | **11.0** | **11.2** | **11.3** | **10.9** |

[1] Recalculated since the last report based on new capacity-equivalent factors in Exhibit 2-21.

[2] Includes Alaska Rail.

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

[4] Jitney and publico.

*Source: National Transit Database.*

Between 1993 and 2002, adjusted vehicle occupancy levels remained relatively constant. The adjusted vehicle occupancy for all modes combined was 10.9 passengers in 2002, compared with a high of 11.3 passengers in 2000 and a low of 10.6 passengers in 1993. These occupancy levels show that on average transit vehicles were operating at a capacity equivalent to 11 persons per bus.

Adjusted vehicle occupancy levels for all rail modes combined was 11.3 passengers in 2002, and ranged from a high of 15.7 passengers for commuter rail to a low of 5.9 passengers for other rail modes (automated guideway, inclined plane, cable car, and monorail). The higher adjusted vehicle occupancy level for commuter rail reflects the fact that many commuter rail systems do not allow passengers to stand so that the capacity of commuter rail vehicles is lower in relationship to the capacity of bus vehicles than if standing on all commuter rail systems were allowed. Adjusted vehicle occupancy levels for heavy rail and light rail in 2002 were 9.6 passengers and 9.5 passengers, respectively, slightly lower than in the immediately preceding years.

In 2002, adjusted vehicle occupancy for all nonrail vehicles combined was 10.5 passengers. Vanpool had the highest adjusted vehicle occupancy level in 2002 (33.9 passengers) and demand response systems the lowest (6.9 passengers). Transit agencies are not mandated to provide vanpool services. These services are likely to be made available only when higher occupancy levels are assured. Alternatively, demand response vehicles are generally used either to provide services to the elderly or disabled or to persons in sparsely settled areas. These riders are more likely to have unique trip requirements, making it difficult to operate demand response services at higher occupancy rates. Occupancy levels for both vanpool and demand response services were lower in 2002 than in the preceding years, particularly in comparison with 1993. Bus occupancy remained almost constant between 1993 and 2002, although marginally lower in 2002 than in earlier years—10.5 passengers in 2002, compared with 10.7 passengers in 2000 and 11.0 passengers in 1993.

## *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*, April 2001, prepared for FTA. These data have not been updated since the last edition of this report. They are 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 were combined for purposes of analysis.

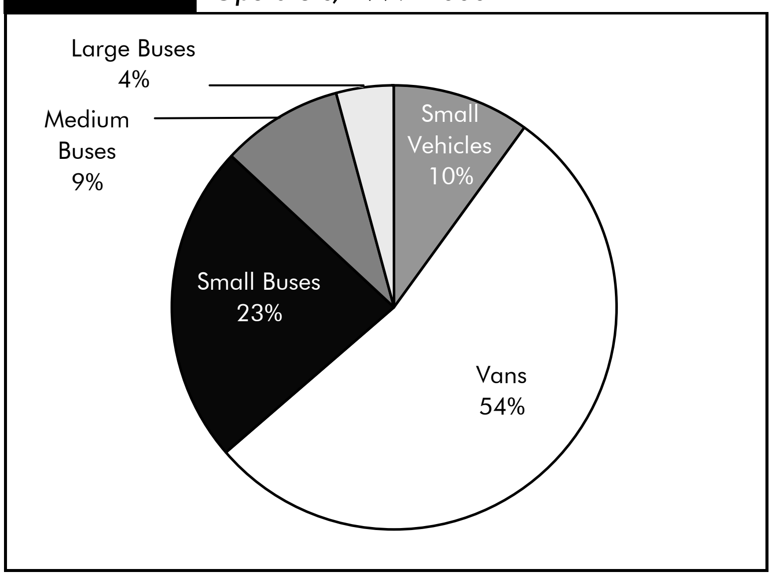
**Q.** How are transit route miles and ridership located in rural areas, but served by an agency that also services an urbanized area, classified?

**A.** Transit agencies that operate in both urbanized and rural areas report data on their operations for both areas combined.

In 1997, 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 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 [*Exhibit 2-26*].

**Exhibit 2-26** *Fleet Composition of Rural Transit Operators, 1997–2000*




*Source: Community Transportation Association of America, Status of Rural Public Transportation 2000, April 2001.*

Rural systems provide both traditional fixed route and demand response services. About half of all rural transit providers offer various forms of route- or point-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 (Section 5310 Providers)*

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. Since its passage in 1990, transit operators have been working toward upgrading their regular vehicle fleets to accommodate the disabled. The ADA requires that public entities that purchase or lease new vehicles for transit purposes make "demonstrated good faith efforts to purchase or lease" vehicles that are accessible to persons with disabilities. Department of Transportation (DOT) regulations provide minimum guidelines and accessibility standards for buses, vans, and heavy, light, and commuter rail vehicles. 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 services to disabled individuals that are inferior to those provided to nondisabled individuals. Paratransit must be used to provide persons with disabilities with a level of service comparable to the level provided to nondisabled persons who use a fixed route system.

The percentage of transit vehicles that are ADA compliant is increasing. In 2002, 79 percent of all transit vehicles included in the NTD were ADA compliant, compared with 73 percent in 2000 [*Exhibit 2-27*].

In addition to the services provided by urban transit operators, there were about 483,673 private and nonprofit agencies that received FTA Section 5310 funding for the provision of "special" transit services to persons with disabilities and the elderly. A recent survey by the University of Montana, which concluded in the spring of 2004, found that there were 4,836 private and nonprofit agencies that received FTA Section 5310 funding, compared with 3,673 agencies reported by a CTAA survey in 1993. These providers include religious organizations, senior citizen centers, rehabilitation centers, the American Red Cross, nursing homes, community action centers, sheltered workshops, and coordinated human services transportation providers. In FY 2002, approximately 62 percent of these special service providers were in rural areas and 38 percent were in urbanized areas.

**Exhibit 2-27** *Urban Transit Operators' ADA Vehicle Fleets, 2002*

| | Active Vehicles | ADA Compliant Vehicles | ADA as a Percentage of Active Vehicles |
|---|---|---|---|
| **Rail** | | | |
| Automated Guideway | 49 | 49 | 100% |
| Commuter Rail [1] | 5,991 | 2,923 | 49% |
| Heavy Rail | 10,946 | 10,377 | 95% |
| Inclined Plane | 8 | 6 | 75% |
| Light Rail | 1,457 | 997 | 68% |
| Monorail | 8 | 8 | 100% |
| **Total Rail** | **18,459** | **14,360** | **78%** |
| **Nonrail** | | | |
| Cable Car | 40 | - | 0% |
| Demand Response | 24,926 | 17,347 | 70% |
| Ferryboat | 110 | 94 | 85% |
| Motor Bus | 62,331 | 58,359 | 94% |
| Publico | 2,845 | - | 0% |
| Trolleybus | 656 | 345 | 53% |
| Vanpool | 5,191 | 102 | 2% |
| **Total Nonrail** | **96,099** | **76,247** | **79%** |
| **Total** | **114,558** | **90,607** | **79%** |

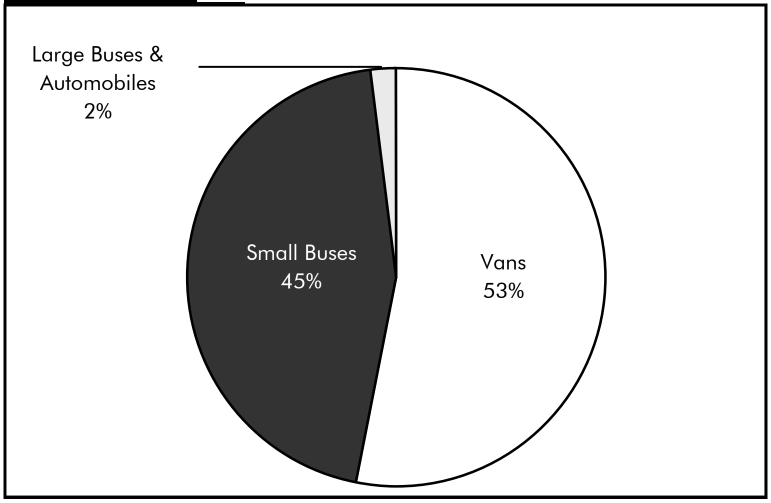
[1] Includes Alaska Rail.

*Source: National Transit Database.*

In 2002, there were estimated to be 37,720 special service vehicles of which 16,219 were funded by FTA [Exhibit 2-18]. Data collected by FTA show that vehicle size of special service transportation providers grew between 1993 and FY 2002. By FY 2002, only 53 percent of the special service vehicles purchased were vans (compared with 75 percent in 1993), 45 percent were buses less than 30 feet in length (compared with 13 percent in 1993), and 2 percent were large buses and automobiles (compared with 12 percent in 1993)

[*Exhibit 2-28*]. Approximately 76 percent of the vehicles purchased in FY 2002 were wheelchair accessible, about the same as in the previous few years.

**Exhibit 2-28** *Composition of Special Service Vehicles, FY 2002*




*Source: FTA, Fiscal Year 2002 Trends Report on the Use of Section 5310 Elderly and Persons with Disabilities Program Fund.*

In 2002, 77 percent (or 5,216) of total transit stations were ADA compliant and 23 percent (or 1,555) were not. The ADA requires that new transit facilities and alterations to existing facilities be accessible to the disabled.

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. Although ADA legislation required all key stations to be accessible by July 26, 1993, the DOT ADA regulation at 49 CFR 37.47(c)(2) permitted the FTA Administrator to grant an extension up to July 26, 2020, for stations requiring extraordinarily expensive structural modifications to bring them into compliance. Currently, there are 138 stations under FTA-approved time extensions.

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.

The number of key rail stations that are ADA accessible is increasing. In 2002, 423 of 585 key rail stations, or 77 percent, were ADA accessible. By comparison, in 2000, 52 of 689 key rail stations were accessible; in 1997, 29 of 689 key rail stations were accessible; and, in 1994, 13 of 700 key rail stations were accessible. The number of key rail stations has decreased over the years as a result of rail station closings, renovations, relocations, and merges. There were also instances where initially some stations were double counted because the location of the station connected two different lines in a system.

# CHAPTER 3

# System Conditions

# Summary

*Exhibit 3-1* highlights the key highway and transit statistics discussed in this chapter, and compares them with the values from the last report. The first data column contains the values reported in the 2002 C&P report, based on 2000. Data revisions are shown in the next column.

**Exhibit 3-1** *Comparison of System Conditions Statistics with Those in the 2002 C&P Report*

| Statistic | Condition | 2000 Data<br>2002 C&P Report | 2000 Data<br>Revised as of 12/23/04 | 2002 Data |
|---|---|---|---|---|
| Total System Pavement | Good (% of miles) | 43.5% | 43.2% | 46.6% |
| | Acceptable (% of miles) | **86.0%** | | **87.4%** |
| Rural Interstate Pavement | Good (% of miles) | 68.5% | | 71.9% |
| | Acceptable (% of miles) | **97.8%** | | **97.8%** |
| Small Urban Intestate Pavement | Good (% of miles) | 61.6% | | 64.9% |
| | Acceptable (% of miles) | **95.8%** | **95.7%** | **95.3%** |
| Urbanized Interstate Pavement | Good (% of miles) | 48.2% | | 48.7% |
| | Acceptable (% of miles) | **93.0%** | | **91.7%** |
| National Highway System Pavement | Good (% of miles) | 54.6% | 54.5% | 57.4% |
| | Acceptable (% of miles) | **93.5%** | | **93.7%** |
| Deficient Bridges | | 167,566 | | 162,869 |
| Deficient Bridges On Interstates | | 55,679 | | 55,245 |
| Deficient Bridges On Other Arterials | | 137,973 | | 140,481 |
| Average Urban Bus Vehicle Condition * | | 3.07 | 3.05 ** | 3.19 ** |
| Average Rail Vehicle Condition* | | 3.55 | 3.77 ** | 3.72 ** |
| Urban Bus Maintenance Facilities | Excellent | 9% | | 7% |
| | Good | 8% | | 6% |
| | Adequate | 54% | | 55% |
| Rail Maintenance Facilities | Excellent | 0% | | 3% |
| | Good | 21% | | 41% |
| | Adequate | 43% | | 43% |
| Rail Maintenance Yards | Excellent | 0% | | 1% |
| | Good | 50% | | 31% |
| | Adequate | 50% | | 48% |
| Rail Stations | Excellent | 1% | 7% | 3% |
| | Good | 33% | | 22% |
| | Adequate | 50% | 17% | 18% |
| Rail Track | Excellent | 26% | | 40% |
| | Good | 45% | | 34% |
| | Adequate | 12% | | 12% |

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

** New Condition Classification System.

# Highway Conditions

The pavement conditions reported in this chapter include all functional classifications except rural minor collectors and local roads. Pavement conditions are presented for three population groupings: rural (population less than 5,000), small urban (population 5,000 to 50,000), and urbanized (population greater than 50,000). The overall pavement conditions are presented based on the terminology used in the annual Federal Highway Administration (FHWA) Performance Plan and other FHWA reports. Pavement is classified as having either "acceptable" or "not acceptable" ride quality; and, within the "acceptable" category, some pavement is classified as "good." 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.

In 2002, 87.4 percent of measured road miles had acceptable ride quality, while 85.3 percent of the vehicle miles traveled (VMT) occurred on pavements in acceptable condition. Included within these figures are 46.6 percent of the miles of pavement that met the standard for good condition and 43.8 percent of the VMT that occurred on pavements in good condition. Since 2000, there has been an increase in the percentage of miles in the good category, as well as an increase in the percentage of VMT on pavements in good condition. There also has been an increase in the percentage of miles in acceptable condition, but a slight decrease in the percentage of VMT on pavements in acceptable condition. Pavement conditions on the Interstate System have varied since 2000. The percentage of miles of rural, small urban, and urbanized Interstates with acceptable ride quality decreased by 0.4 percentage points to 96.2 percent between 2000 and 2002, while the percentage of miles with good ride quality increased by 2.7 percentage points to 65.8 percent. The percentages based on VMT show changes in the same direction.

# Bridge Conditions

The number of deficient bridges is the most common measure used to evaluate the condition of the Nation's bridges. This measure considers all bridges equivalently. Weighting bridges according to the average daily traffic incorporates traffic demands on the structure. Weighting bridges according to the total deck area includes the size of the structure in the analysis.

These metrics are used to evaluate structural deficiencies and functional obsolescence within the bridge network. Structural deficiencies result from deterioration of conditions and the reductions in load-carrying capacity appraisals. Functional obsolescence results from changing demands on the structure and includes appraisals on clearance adequacy, deck geometry, and alignment.

The number of deficient bridges on our highway system has been steadily declining. Since 1995, the percentage of deficient bridges decreased from 31.4 percent to 27.5 percent. Decreases have been seen on all other functional classes for all different owners. As demonstrated, the progress has occurred primarily due to reducing the percentage of structurally deficient bridges with little overall change in the percentage of functionally obsolete bridges.

# 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 2002 C&P Report, condition information for approximately 70 percent of the Nation's transit assets has been updated in TERM.

The estimated condition of transit vehicles improved between 2000 and 2002, and the average age of transit vehicles declined. On a scale of 1 (poor) to 5 (excellent), bus vehicles had an average condition of 3.19 in 2002, up from 3.05 in 2000. The improvement in bus vehicle condition reflects a decrease in the average age of the bus vehicle fleet from 6.8 years in 2000 to 6.2 years in 2002. The average condition of the rail fleet increased from 3.38 in 2000 to 3.47 in 2002. The average age of rail vehicles declined from 21.8 years in 2000 to 20.4 years in 2002. 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 commuter rail vehicles has been lowered since the 2002 report, based on engineering surveys that found that commuter rail vehicles deteriorate more rapidly in earlier years than previously estimated.

The average condition of bus and rail maintenance facilities was higher in 2002 than in 2000; however, about one-third of all bus and one-fifth of all rail maintenance facilities are in unacceptable condition. In addition to reflecting actual condition changes, these estimates reflect updated data on asset conditions collected from transit agencies. The average condition of urban bus maintenance facilities (including facilities for vans and demand response vehicles) improved, increasing from 3.23 in 2002 to 3.34 in 2002. In 2002, 55 percent of urban bus maintenance facilities was in adequate condition, 6 percent was in good condition, and 7 percent was in excellent condition, for a combined total of 68 percent in adequate or better condition. The conditions of rail maintenance facilities increased from 3.20 in 2000 to 3.56 in 2002. Eighty percent of all rail maintenance facilities are estimated to be in adequate or better condition and 20 percent in poor or substandard condition. Data collected since the last edition of this report revealed that a much larger percentage of rail facilities than previously estimated was 10 years old or less. In contrast to facilities, the condition of vehicle storage yards has declined. In 2002, 32 percent of all storage yards was estimated to be in good or excellent condition, compared with 50 percent in 2002.

About 46 percent of the nonvehicle data collected from earlier transit asset studies has been updated since the last report. This information revealed that the condition of stations was much worse than previously estimated. The condition of rail stations declined from 3.44 in 2000 to 2.99 in 2002. Nonrail stations are, on average, in better condition than rail stations. From 2000 to 2002, the conditions of track, substations, structures and third rail improved. The conditions of rail yards, overhead wire and stations declined. Changes in the condition of power systems are mixed, depending on the particular asset type. In 2002, power systems were, on average, estimated to be in good condition. These changes in conditions also reflect updated asset information.

# 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. *Exhibit 3-2* contains a description of the PSR system.

**Exhibit 3-2** *Present Serviceability Rating (PSR)*

| PSR | Description |
|---|---|
| **4.0 - 5.0** | Only new (or nearly new) superior pavements are likely to be smooth enough and distress free (sufficiently free of cracks and patches) to qualify for this category.<br>Most pavements constructed or resurfaced during the data year would normally be rated in this category. |
| **3.0 - 4.0** | Pavements in this category, although not quite as smooth as those described above, give a first-class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracking and spalls. |
| **2.0 - 3.0** | The riding qualities of pavements in this category are noticeably inferior to those of the new pavements and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements may have a few joint fractures, faulting and/or cracking, and some pumping. |
| **1.0 - 2.0** | Pavements have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement may have large potholes and deep cracks. Distress includes raveling, cracking, and rutting and occurs over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, faulting, patching, cracking, and scaling and may include pumping and faulting. |
| **0.0 - 1.0** | Pavements are in extremely deteriorated conditions. The facility is passable only at reduced speed and considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface. |

**Q. Do other measures of pavement condition exist?**

**A.** 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.

States are required to report IRI data for the Interstate system, other principal arterials, rural minor arterials, and the National Highway System (NHS) regardless of functional classification. IRI reporting is recommended for all functional classifications. For those sections of rural major collectors for which ride quality data were reported, the use of IRI as the reporting method has decreased from 63.7 percent in 2000 to 62.7 percent in 2002. For every other functional classification for which a ride quality was reported, the percentage of miles for which it was reported in IRI increased between 2000 and 2002. The Federal Highway Association's (FHWA's) *Highway Performance Monitoring System (HPMS) Field Manual* requires rural roadway sample sections that are functionally classified higher than major collectors to have a ride quality reported in IRI. Compliance with this requirement varies from 99.75 percent on the Interstate to 99.47 percent on minor arterials. The *HPMS Field Manual* requires a ride quality of one form or another to be reported for all standard sample sections, including rural major collectors. A similar requirement exists within urban areas where roadway sections functionally classified higher than minor arterials are required to have a ride quality reported in IRI. Compliance in the urban areas varies from 99.10 percent on other freeways and expressways to 93.56 percent on other principal arterials. Reporting of ride quality in IRI drops to 53.91 percent for the urban minor arterials. The urban minor arterials and the rural major collectors classifications have increased their respective percentage of reporting using IRI between 2000 and 2002.

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 3-3* 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.

**Exhibit 3-3** *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 the 2004 C&P 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."

Since the translation between PSR and IRI is imprecise, caution should be used when making comparisons with older data from earlier editions of this report that relied more heavily on PSR data.

**Q.** What is FHWA's current target for NHS ride quality?

**A.** *The FHWA Fiscal Year 2005 Performance Plan* includes a goal to have 93.5 percent of all VMT on the NHS to be on pavements with acceptable ride quality. Additional details can be found in Chapter 17.

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 IRI value less than or equal to 170 inches per mile. This goal was accomplished in 1999. The FHWA subsequently revised this metric to be based on the percentage of vehicle miles traveled (VMT) on NHS pavements with acceptable ride quality. This revised metric places more emphasis on the benefits of ride quality to highway users and presents a more challenging performance target, since in recent years the percentage of VMT on NHS pavements with an IRI of less than or equal to 170 has been lower than the percentage of mileage meeting that standard. In 2002, while 93.7 percent of NHS pavements had an IRI of less than or equal to 170, only 90.6 percent of VMT on the NHS was on pavements with acceptable ride quality. The physical condition of the NHS is discussed in more detail in Chapter 17.

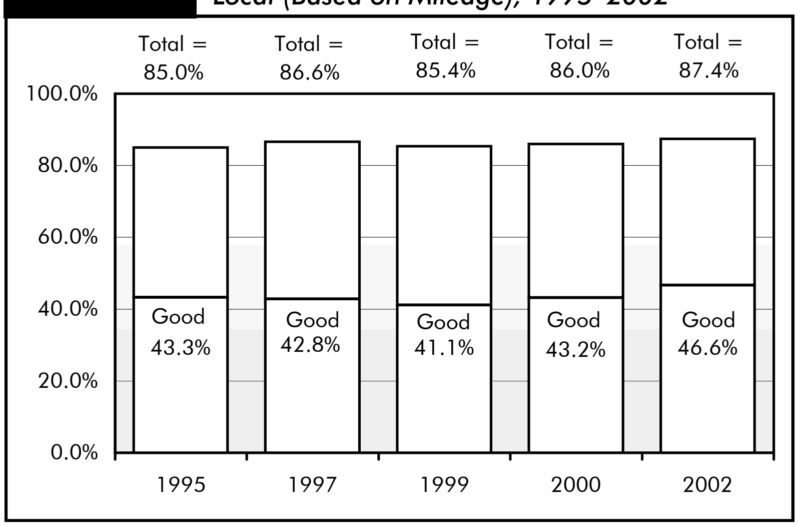
Some previous editions of the annual FHWA Performance plan also included targets for "good ride quality," which represented a subset of acceptable ride quality. For ride quality to be rated as good, it must occur on pavements with an IRI value of less than 95 inches per mile. In this chapter, overall ride quality is presented based on the qualitative condition terms: good, acceptable, and not acceptable.

Previous editions of the C&P report have focused mainly on pavement conditions in terms of mileage. This edition retains exhibits of that nature to maintain continuity, but also adds a number of parallel exhibits based on the percentage of VMT occurring on pavements with acceptable ride quality. This increased emphasis on the impacts of system conditions in highway conditions is intended to make this chapter more consistent with the approaches used in the operational performance and future investment requirement analyses included in Chapters 4 and 7, respectively. This approach is also intended to make this chapter more logically consistent with the revised NHS ride quality metric that has been adopted in the annual FHWA performance plans.

## Overall Pavement Condition

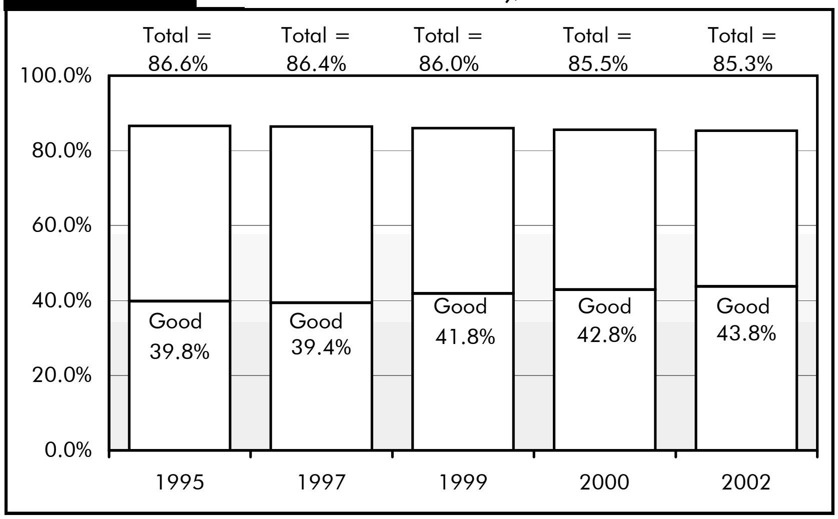
The highway systems covered in this chapter include all mileage except rural minor collectors and local functional classifications. In 2002, 87.4 percent of total road mileage evaluated was rated acceptable including 46.6 percent that met the standard for good [*Exhibit 3-4*], and 85.3 percent of VMT occurred on pavements rated acceptable, including 43.8 percent that occurred on pavements rated as good [*Exhibit 3-5*].

**Exhibit 3-4** *Acceptable Pavement, All Functional Systems except Rural Minor Collectors and Local (Based on Mileage), 1995–2002*



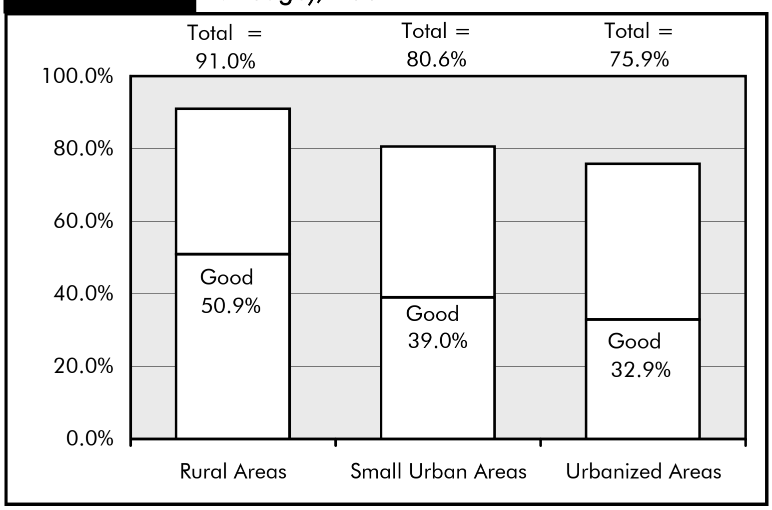

*Source: Highway Performance Monitoring System.*

**Exhibit 3-5** *Acceptable Pavement, All Functional Systems except Rural Minor Collectors and Local (Based on Vehicle Miles Traveled), 1995–2002*




*Source: Highway Performance Monitoring System.*

**Exhibit 3-6** *Acceptable Pavement by Area (Based on Mileage), 2002*



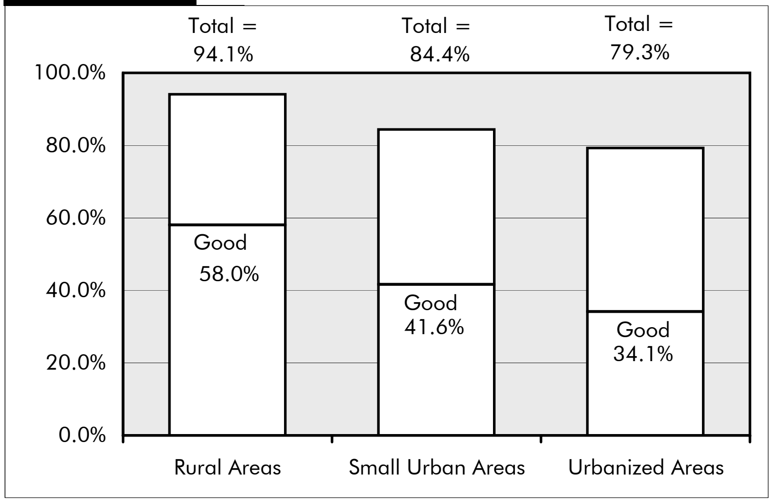

*Source: Highway Performance Monitoring System.*

# Rural and Urban Pavement Conditions

When discussing pavement conditions, it is important to note the different travel characteristics between rural and urban areas. As noted in Chapter 2, rural areas contain 77.3 percent of road miles, but only 39.4 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 2002 mileage data, pavement conditions in rural areas are slightly better than those in small urban and urbanized areas. *Exhibit 3-6* shows that 91.0 percent of total road miles in rural areas are rated acceptable, while 80.6 percent of road miles in small urban areas are rated acceptable, and 75.9 percent of the total road miles in urbanized areas are rated acceptable. The percentages shown as acceptable include mileage that also met the more stringent limit to be classified as good, 50.9 percent of rural miles, 39.0 percent of small urban miles, and 32.9 percent of urbanized miles. The rural and small urban percentages have increased in both categories between 2000 and 2002, while the urbanized percentages have decreased. The rural minor collector and local functional system mileages are not included in these percentages since those data are not collected in the HPMS on a universal basis.

According to the 2002 VMT data, ride quality in rural areas is better than in small urban and urbanized areas. *Exhibit 3-7* shows that 94.1 percent of VMT in rural areas is on pavements that are rated acceptable, while 84.4 percent of VMT in small urban areas is on pavements that are rated acceptable, and 79.3 percent of the VMT in urbanized areas is on pavements that are rated acceptable. These percentages also include VMT on pavements that met the more stringent limit to be classified as good, 58.0 percent for rural areas, 41.6 percent for small urban areas, and 34.1 percent for urbanized areas. Note that rural minor collector and local functional system routes also are not included in these percentages, for the same reason as given above.

**Exhibit 3-7** *Acceptable Pavement by Area (Based on Vehicle Miles Traveled), 2002*



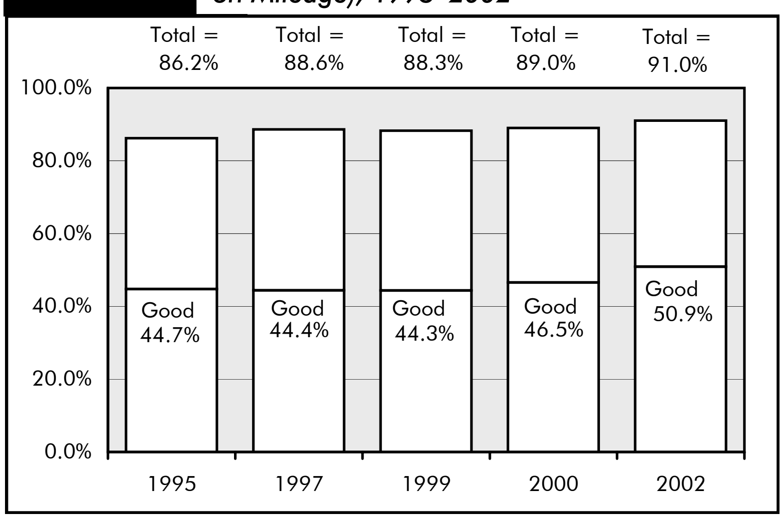

*Source: Highway Performance Monitoring System.*

**Q.** How can the percentage of mileage with acceptable pavement shown in Exhibit 3-4 logically be higher than the percentage of VMT on acceptable pavements shown in Exhibit 3-5 for all areas combined, while the opposite is true for rural, small urban and urbanized areas individually?

**A.** As shown in Exhibits 3-6 and 3-7, the percentage of acceptable pavement based on mileage is lower than the percentage of acceptable pavements based on VMT for rural areas, small urban areas, and urbanized areas. However, these exhibits also show that ride quality in rural areas is significantly better than in urbanized areas on either a mileage or VMT basis. Since a majority of mileage is in rural areas, while a majority of VMT is in urban areas, this means that the condition of rural roads has a much greater impact on a mileage-based measure (such as that shown in Exhibit 3-4) than it does on a VMT-weighted measure (such as that shown in Exhibit 3-5).

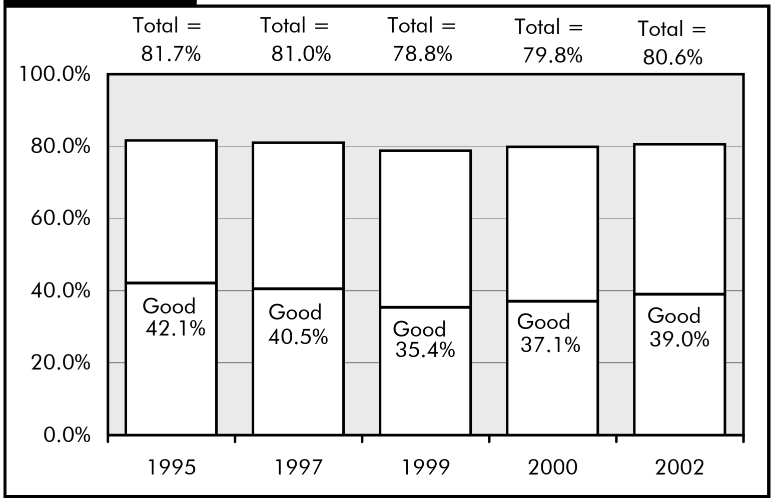
Pavement conditions based on mileage in rural areas have generally been improving over time. Since 1995, the percentage of road miles in acceptable condition has increased from 86.2 percent to 91.0 percent in rural areas [*Exhibit 3-8*]. However, both small urban and urbanized areas have experienced decreases in acceptable pavement miles, from 81.7 percent to 80.6 percent [*Exhibit 3-9*] and from 81.7 percent to 75.9 percent [*Exhibit 3-10*], respectively, between 1995 and 2002. Comparable trends can be observed in the percentage of miles rated as good.

**Exhibit 3-8** *Acceptable Rural Area Pavement (Based on Mileage), 1995–2002*



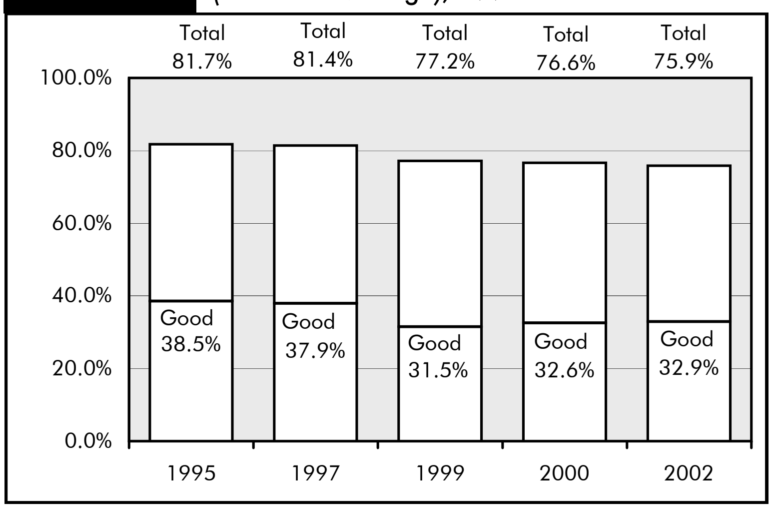

*Source: Highway Performance Monitoring System.*

**Exhibit 3-9** *Acceptable Small Urban Area Pavement (Based on Mileage), 1995–2002*




*Source: Highway Performance Monitoring System.*

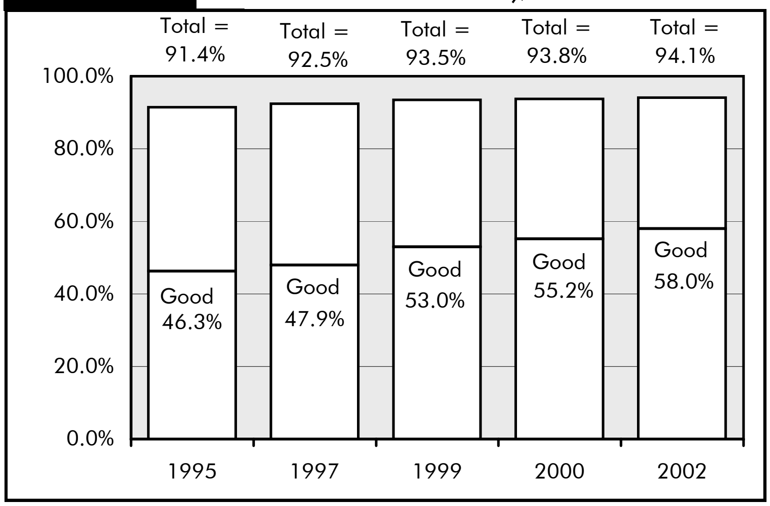
**Exhibit 3-10** *Acceptable Urbanized Area Pavement (Based on Mileage), 1995–2002*




*Source: Highway Performance Monitoring System.*

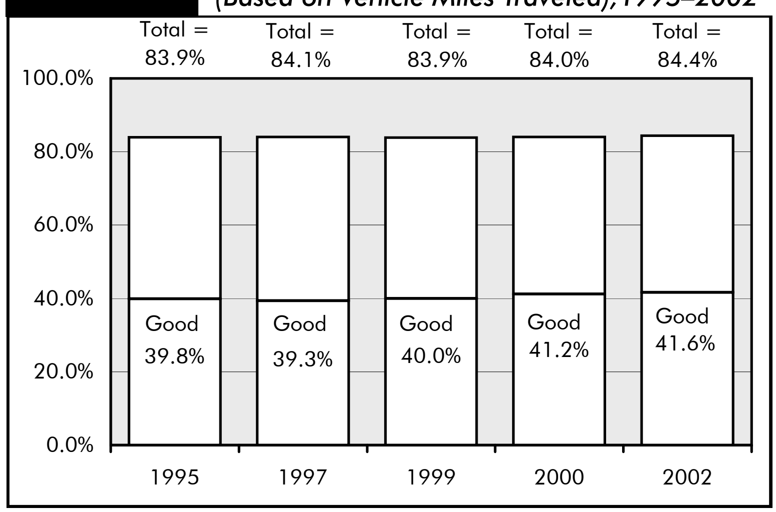
Ride quality based on VMT has followed a similar trend in rural and urbanized areas, and remained somewhat constant in small urban areas. Since 1995, the percentage of VMT on pavements rated in acceptable condition has increased from 91.4 percent to 94.1 percent in rural areas [*Exhibit 3-11*]. The percentage of VMT on pavements rated in acceptable condition in small urban areas has fluctuated from a low of 83.9 percent in 1995 and 1999 to a high of 84.4 percent in 2002 [*Exhibit 3-12*]. The percentage of VMT on pavements rated in acceptable condition has decreased from 83.5 percent to 79.3 percent in urbanized areas [*Exhibit 3-13*]. The percentage of VMT on pavements rated as good in rural areas has increased from 46.3 percent in 1995 to 58.0 percent in 2002. For small urban areas, the percentage increases very slightly over time. For urbanized areas, the percentage fluctuates, with a high of 35.2 percent in 1995 and a low of 34.1 percent in 1999 and 2002.

**Exhibit 3-11** *Acceptable Rural Area Pavement (Based on Vehicle Miles Traveled), 1995–2002*



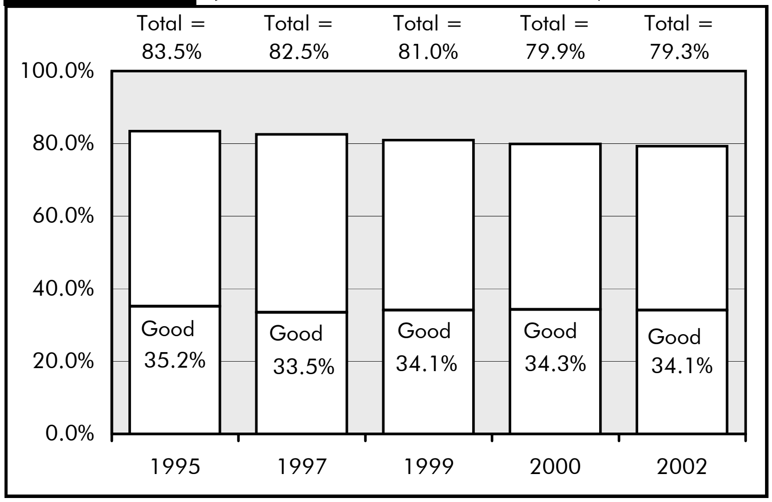

*Source: Highway Performance Monitoring System.*

**Exhibit 3-12** *Acceptable Small Urban Area Pavement (Based on Vehicle Miles Traveled),1995–2002*




*Source: Highway Performance Monitoring System.*

**Exhibit 3-13** *Acceptable Urbanized Area Pavement (Based on Vehicle Miles Traveled), 1995–2002*




*Source: Highway Performance Monitoring System.*

# Pavement Condition by Functional Classification

As stated in Chapter 2, approximately 52.9 percent of the total mileage in the United States is functionally classified as local. Nevertheless, 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 Interstate route affects more users than improving ride quality on a mile of road on a lower functional classification. Interstate mileage in rural areas is 97.8 percent acceptable. In small urban areas, Interstate mileage is 95.3 percent acceptable. In urbanized areas, Interstate mileage is 91.7 percent acceptable. The equivalent percentages based on VMT are 97.3, 94.6, and 89.3 percent, respectively. Ride quality on pavements rated as good follows the same order. For every functional classification, the same pattern as shown for Interstates is followed for each combination of population area and pavement rating, whether comparing based on mileage or VMT, with the exception that, based on mileage, collector routes in large urban areas are generally rated better than those in small urban areas.

A historical view helps clarify where pavement improvements are occurring and at what rate. *Exhibit 3-14* shows the pavement condition by category, functional classification, and location from 1995 to 2002 based on mileage. The exhibit illustrates that pavement conditions have changed in a variety of ways. For example, since 1995, the percentage of Interstate miles in rural areas classified as acceptable has increased from 94.5 percent to 97.8 percent.

The percentage of Interstate miles in urbanized areas rated as acceptable has increased from 90.0 percent to 91.7 percent. However, during the same time period, the percentage of other principal arterials in urbanized areas listed as acceptable has decreased from 75.9 percent to 67.5 percent.

**Exhibit 3-14** *Ride Quality by Functional System (Based on Mileage), 1995–2002*

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

*Source: Highway Performance Monitoring System.*

One consistent trend is the faster rate of pavement condition improvement in rural areas versus small urban and urbanized areas. Since 1995, the percent of total rural road miles classified as acceptable has increased in each of the four functional classes of rural roads. However, for the five functional classes of roads for small urban areas, three functional classifications—Interstate, other freeway and expressway, and other principal arterials—have seen an increase in acceptable road miles, while two functional classes—minor arterials and collectors—have experienced declines in acceptable road miles. For the five functional classes of roads for the urbanized areas, two functional classifications—Interstate and other freeway and expressway—have seen an increase in acceptable road miles, and three functional classes—other principal arterials, minor arterials, and collectors—have experienced declines in acceptable road miles.

*Exhibit 3-15* shows the equivalent pavement condition by category, functional classification, and location from 1995 to 2002 based on VMT. The exhibit illustrates that pavement conditions based on VMT have generally mirrored those based on mileage. For example, since 1995, the percentage of Interstate VMT in rural areas on pavements classified as acceptable has increased from 94.5 percent to 97.3 percent.

**Exhibit 3-15** *Ride Quality by Functional System (Based on Vehicle Miles Traveled), 1995–2002*

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

*Source: Highway Performance Monitoring System.*

Again, a consistent trend is the faster rate of pavement condition improvement in rural areas versus small urban and urbanized areas. Since 1995, the percent of total rural road VMT on pavements classified as acceptable has increased in each of the four functional classes of rural roads. However, for the five functional classes of roads for small urban areas, only two functional classifications—other freeway and expressway, and other principal arterials—have seen an increase in VMT on pavements rated as acceptable, while the other three functional classes—Interstate, minor arterials, and collectors—have experienced declines. For the five functional classes of roads for the urbanized areas, only one functional classification—Interstate— has seen an increase in VMT on pavements rated as acceptable, while the other four functional classes—other freeway and expressway, other principal arterials, minor arterials, and collectors—have experienced declines.

Since the statistics based on VMT track reasonably well with those based on mileage and since the FHWA has chosen to use the former as its measure of effectiveness for performance planning, future editions of this report are likely to scale back on the use of mileage-based statistics in favor of VMT-based statistics.

# Roadway Alignment

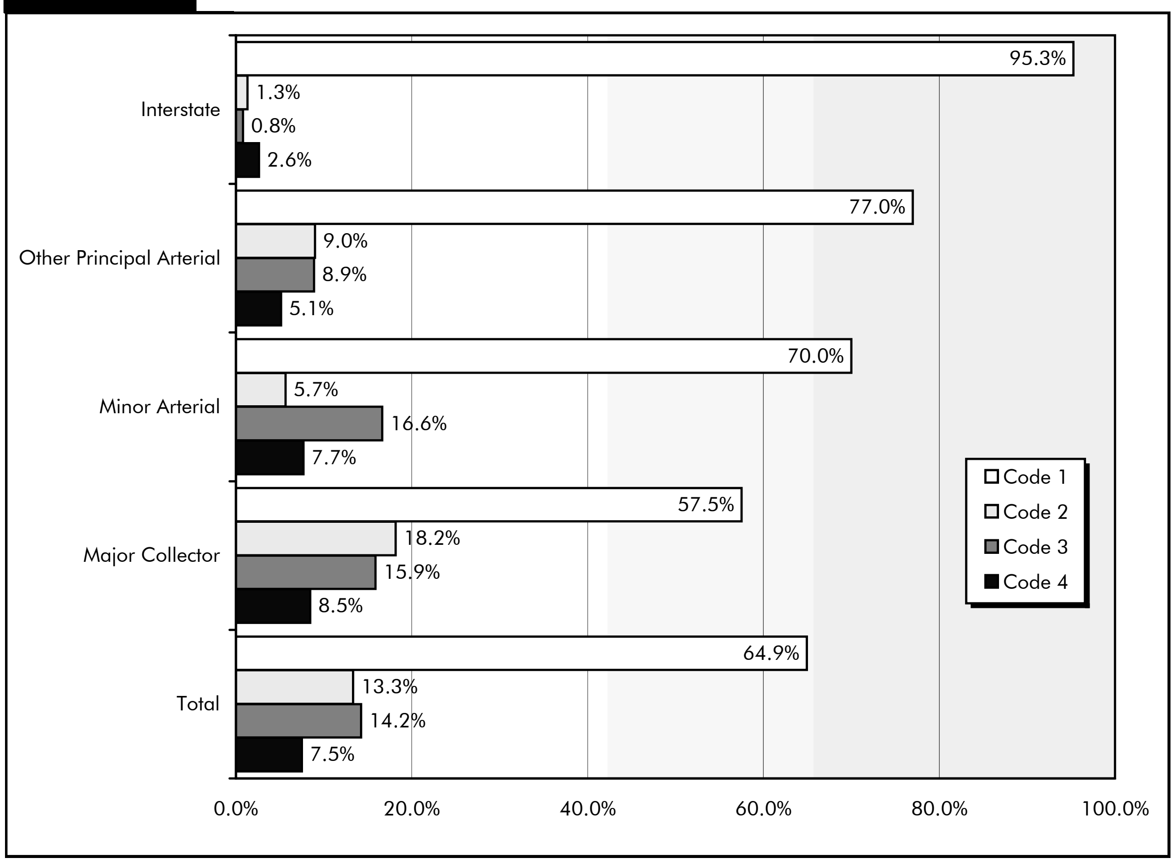
Alignment adequacy affects the level of service and safety of the highway system. There are two types of alignment: horizontal (curves) and vertical (grades). Inadequate alignment may result in speed reductions and impaired sight distance. In particular, excessive grades and/or curves may significantly affect the speeds at which trucks can safely operate. Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst). *Exhibit 3-16* explains the alignment rating system.

**Exhibit 3-16** *Alignment Rating*

| Rating | Description |
|---|---|
| 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. |

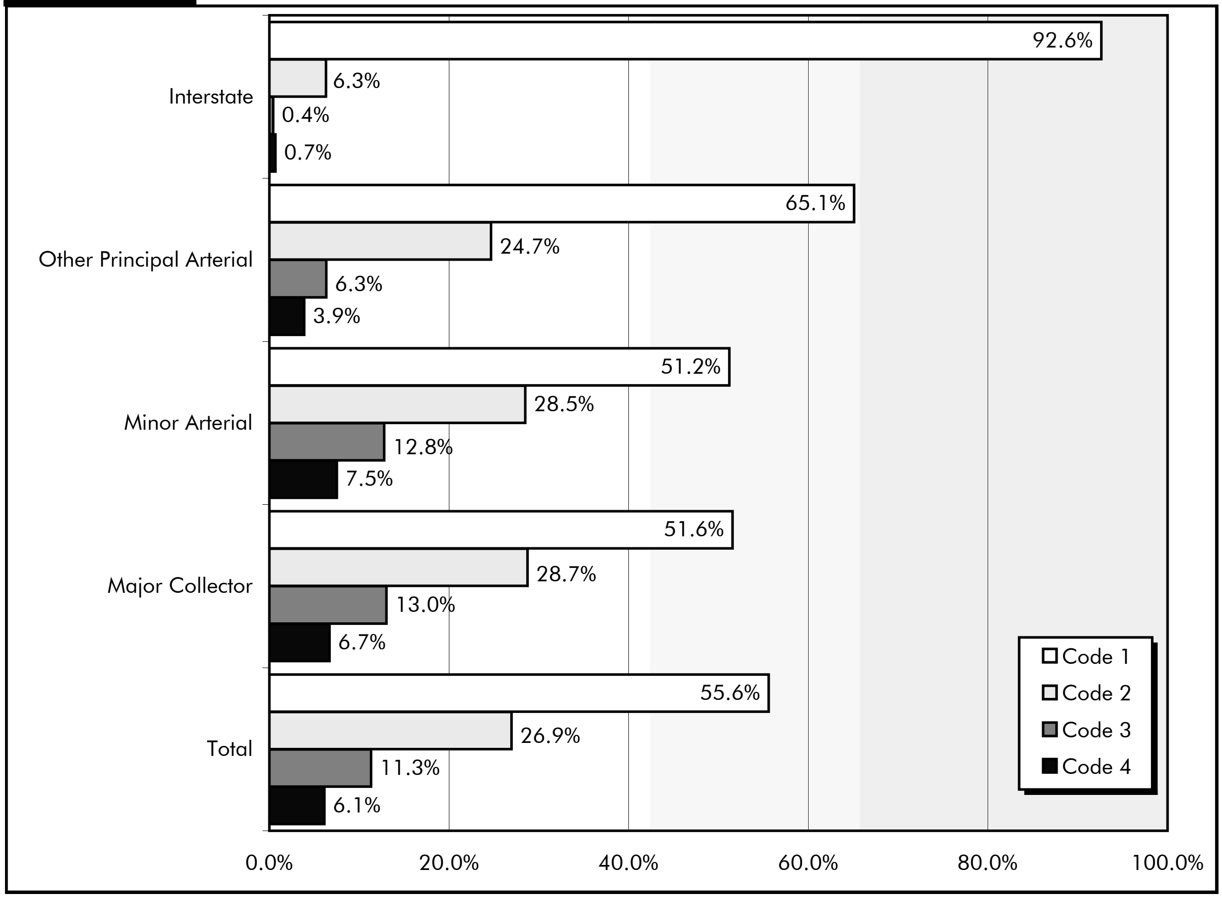
Adequate alignment is more important on roads with higher travel speeds and/or higher volumes (e.g., Interstates). Alignment is normally not an issue in urban areas; therefore, this section presents only rural data. *Exhibits 3-17* and *3-18* illustrate that 95.3 percent of rural Interstate miles are classified as Code 1 for horizontal alignment and 92.6 percent are classified as Code 1 for vertical alignment. The share of rural roads classified as Code 4 for horizontal alignment is 7.5 percent. For vertical alignment, 6.1 percent are rated Code 4. Roadway alignment continues to improve gradually as sections with poor alignment are reconstructed.

**Exhibit 3-17** *Rural Horizontal Alignment Adequacy, 2002*




*Source: Highway Performance Monitoring System.*

**Exhibit 3-18** *Rural Vertical Alignment Adequacy, 2002*




*Source: Highway Performance Monitoring System.*

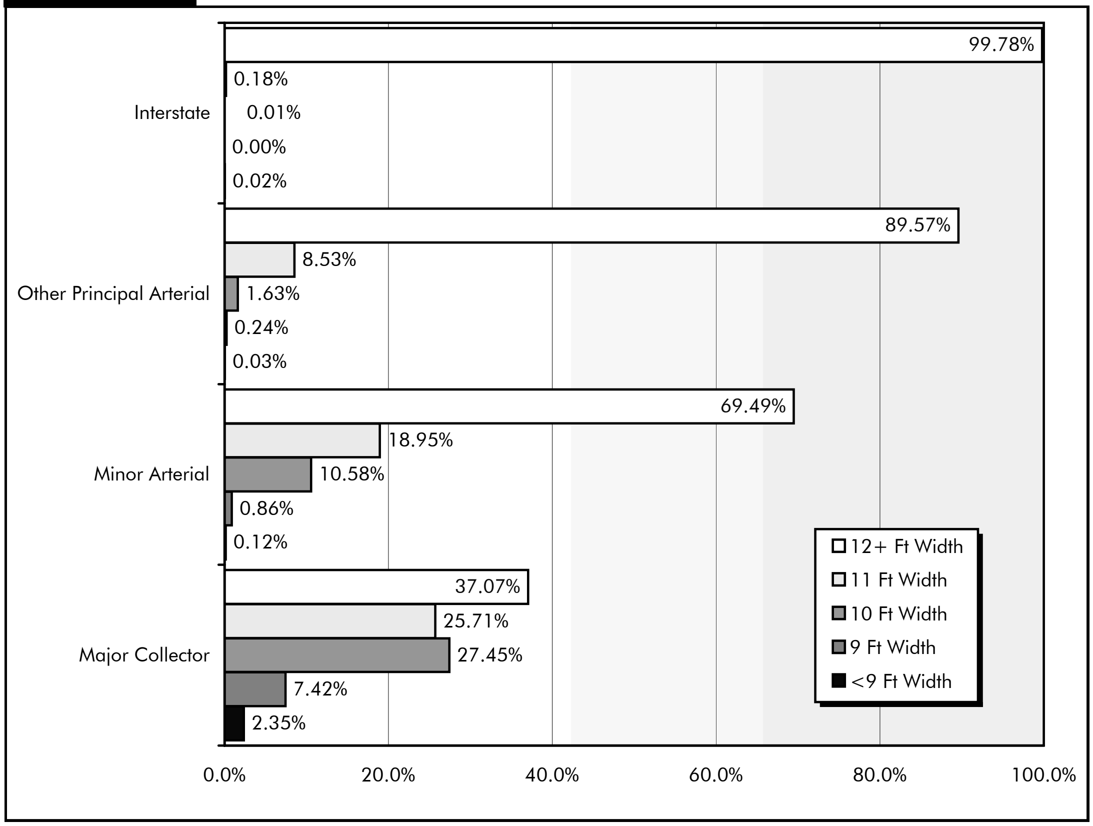
# Lane Width

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.

Currently, high-type facilities (e.g., Interstates) are expected to have 12-foot lanes. *Exhibits 3-19* and *3-20* illustrate that almost the entire Interstate System meets the 12-foot standard (less than one-quarter of 1 percent of the rural Interstate and only 1.5 percent of the urban Interstate do not). The percentage of miles with 12-foot-plus lane widths is lower on lower-type facilities that carry less traffic. Lanes that are less than 9 feet wide are mainly concentrated on the collector roads.

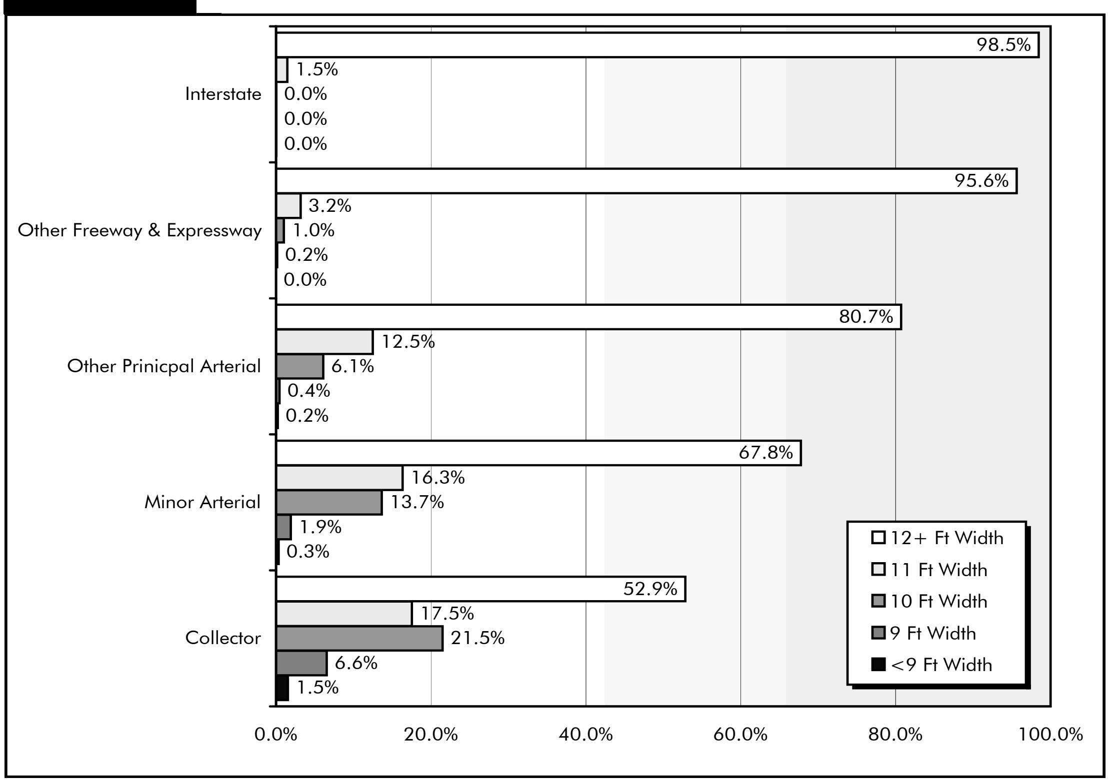
Lanes have been widened over time through new construction, reconstruction, and widening projects. Total rural mileage with lane width greater than or equal to 12 feet increased from 51.6 percent in 1993 to 53.8 percent in 2002. The urban mileage with 12-foot-plus lanes has fluctuated; but, in 2002, it was up to 67.9 percent from a low of 66.6 percent in 1995. Part of the reason for the urban fluctuation may be the reclassification of roads from rural to urban from time to time as a result of population growth [*Exhibit 3-21*].

**Exhibit 3-19** *Rural Lane Width by Functional System, 2002*



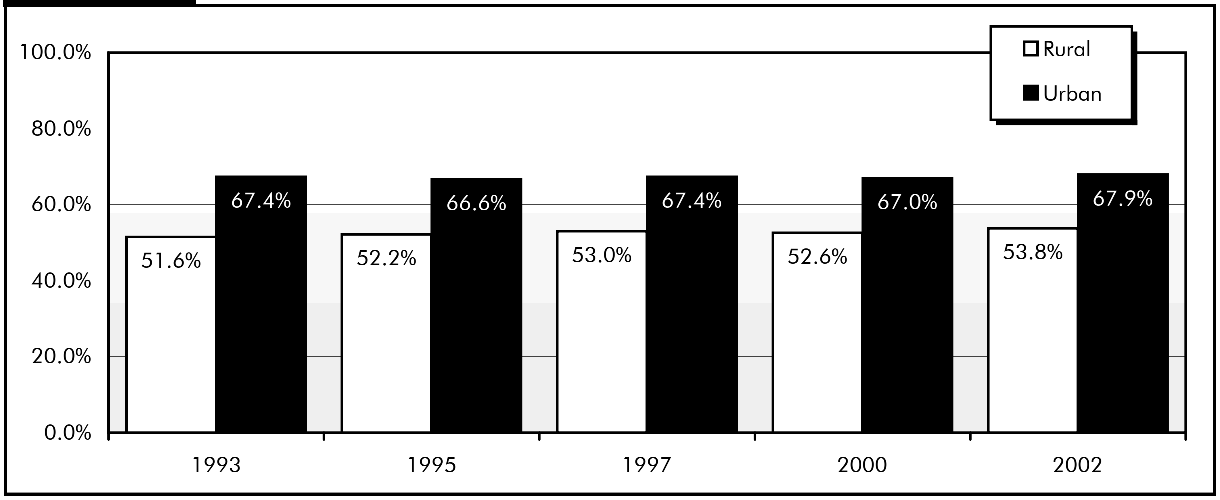

*Source: Highway Performance Monitoring System.*

**Exhibit 3-20** *Small Urban and Urbanized Lane Width by Functional System, 2002*




*Source: Highway Performance Monitoring System.*

**Exhibit 3-21** *Percentage of Roadways with 12+ Foot Lane Width, 1993–2002*




*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 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, etc. 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.** How often are the bridges inspected?

**A.** Most bridges in the US Highway Bridge inventory are inspected once every two years. These inspections are performed by qualified inspectors. Where structures have advanced deterioration or other conditions warranting closer monitoring, inspections can be performed more frequently. Certain types of structures in very good condition may receive an exemption from the two-year inspection cycle. Inspections can be performed on these structures once every 4 years. Qualification for this extended inspection cycle is reevaluated depending on the conditions of the bridge. Eighty three percent (490,000 bridges) are inspected once every 2 years, twelve percent (71,000 bridges) are inspected annually, and five percent (28,000 bridges) are inspected on a 4-year cycle.

## Classification 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. Within the superstructure are the girders, stringers, and other structural elements. The substructure is the foundation of the bridge and transfers the loads of the structure to the ground. The superstructure is supported by the substructure elements, such as the abutments and piers.

Condition ratings are assigned for these primary components during periodic safety inspections. Condition ratings are also assigned for the channel and channel protective systems and for culvert designs. These structures do not have distinct deck, superstructure, or substructure elements. The ratings do not translate directly into an overall rating of a bridge's condition, but are good indicators of the quality of specific components. Condition ratings are either assigned directly by the bridge inspector or translated from more detailed element-level models employed in bridge management systems, such as Pontis, using the FHWA-provided translator.

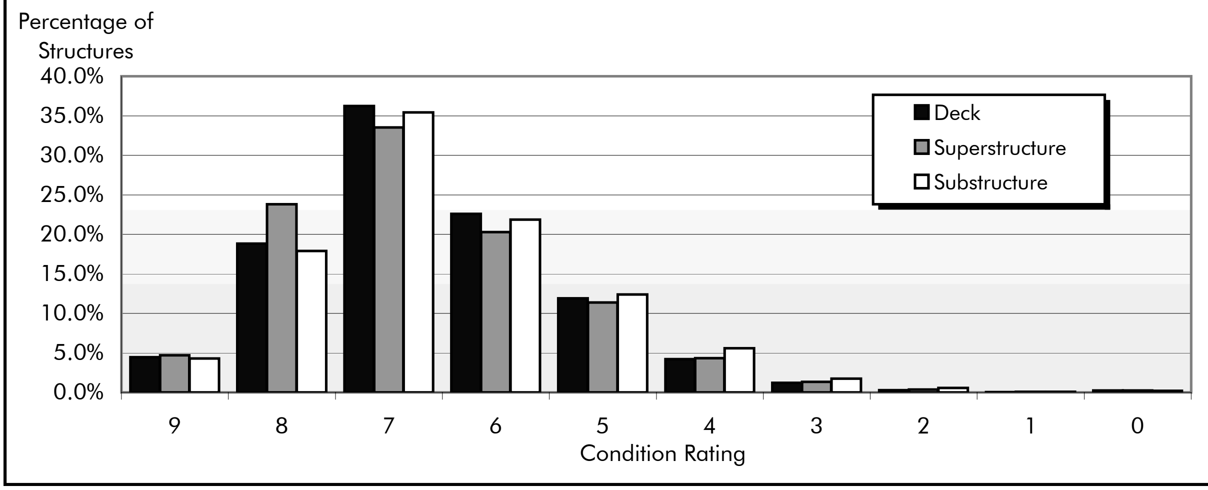
Condition ratings are used to describe the existing, in-place status of a component and not its as-built state. Rather, the existing condition is compared with an as-new condition. Bridge inspectors assign condition ratings by evaluating the severity of the deterioration or disrepair and the extent it 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 3-22* describes the bridge condition ratings in more detail.

***Exhibit 3-22*** *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 3-23* for the deck, superstructure, and substructure. Condition ratings of 4 and below indicate poor or worse conditions and result in structural deficiencies. Approximately 7 percent of all bridge decks are deficient based on condition rating, and 7 percent of all superstructures and 9% of all substructures are deficient. These classifications are not mutually exclusive, and an individual structure may have one or more than one deficient component.

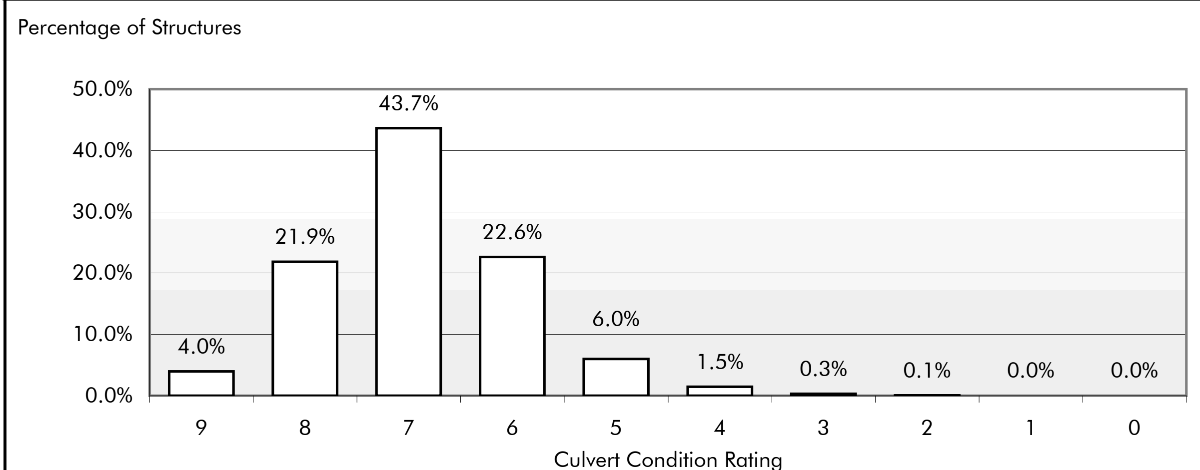
**Exhibit 3-23** *Bridge Condition Ratings, 2002*




*Source: National Bridge Inventory.*

There are 118,394 culverts in the bridge inventory. These structures do not have a deck, superstructure, or substructure, but rather are self-contained units 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 3-24*. Of all 118,394 culverts in the inventory, approximately 2 percent are classified as structurally deficient based on condition ratings less than or equal to 4 (poor conditions).

**Exhibit 3-24** *Culvert Condition Ratings, 2002*




*Source: National Bridge Inventory.*

## *Structural Appraisal Ratings*

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 3-25* describes appraisal rating codes in more detail.

**Exhibit 3-25** *Bridge Appraisal Rating Categories*

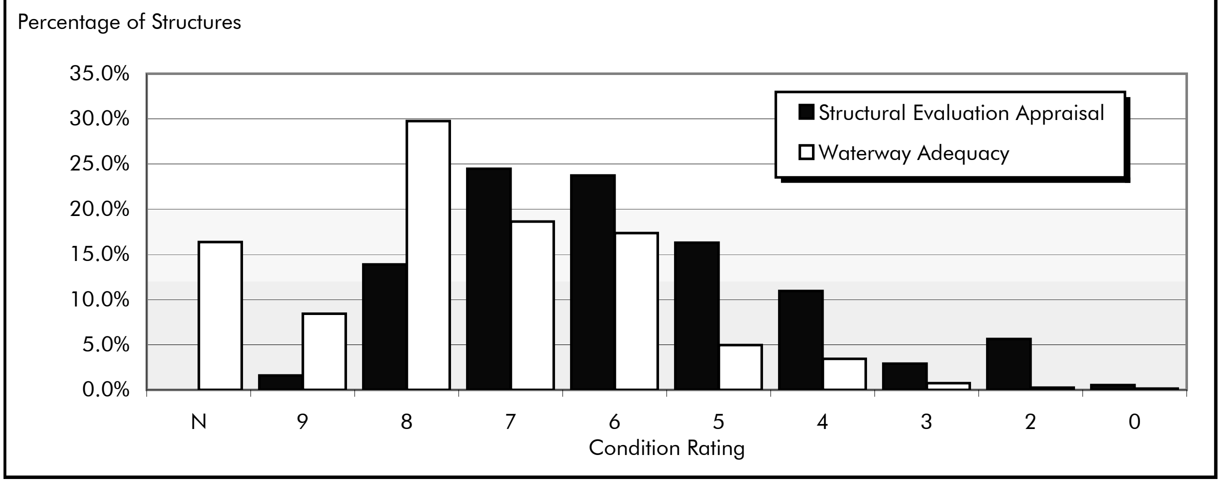
| Rating | Description |
|---|---|
| N | Not applicable. |
| 9 | Superior to present desirable criteria. |
| 8 | Equal to present desirable criteria. |
| 7 | Better than present minimum criteria. |
| 6 | Equal to present minimum criteria. |
| 5 | Somewhat better than minimum adequacy to tolerate being 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. |

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.

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 3-26.* Roughly 6 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 3-26** *Structural Evaluation/Waterway Adequacy Ratings, 2002*




*Source: National Bridge Inventory.*

## *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. For each of these appraisals, ratings are assigned based on the descriptions provided in Exhibit 3-25.

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

**Q.** **How does a bridge become functionally obsolete?**

**A.** 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.

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 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 3-25. 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 structural deficiencies as these ratings typically are not correctable without replacement.

The distribution of structural evaluation appraisal and waterway adequacy ratings is shown in Exhibit 3-26. Approximately 3 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 3-27.*

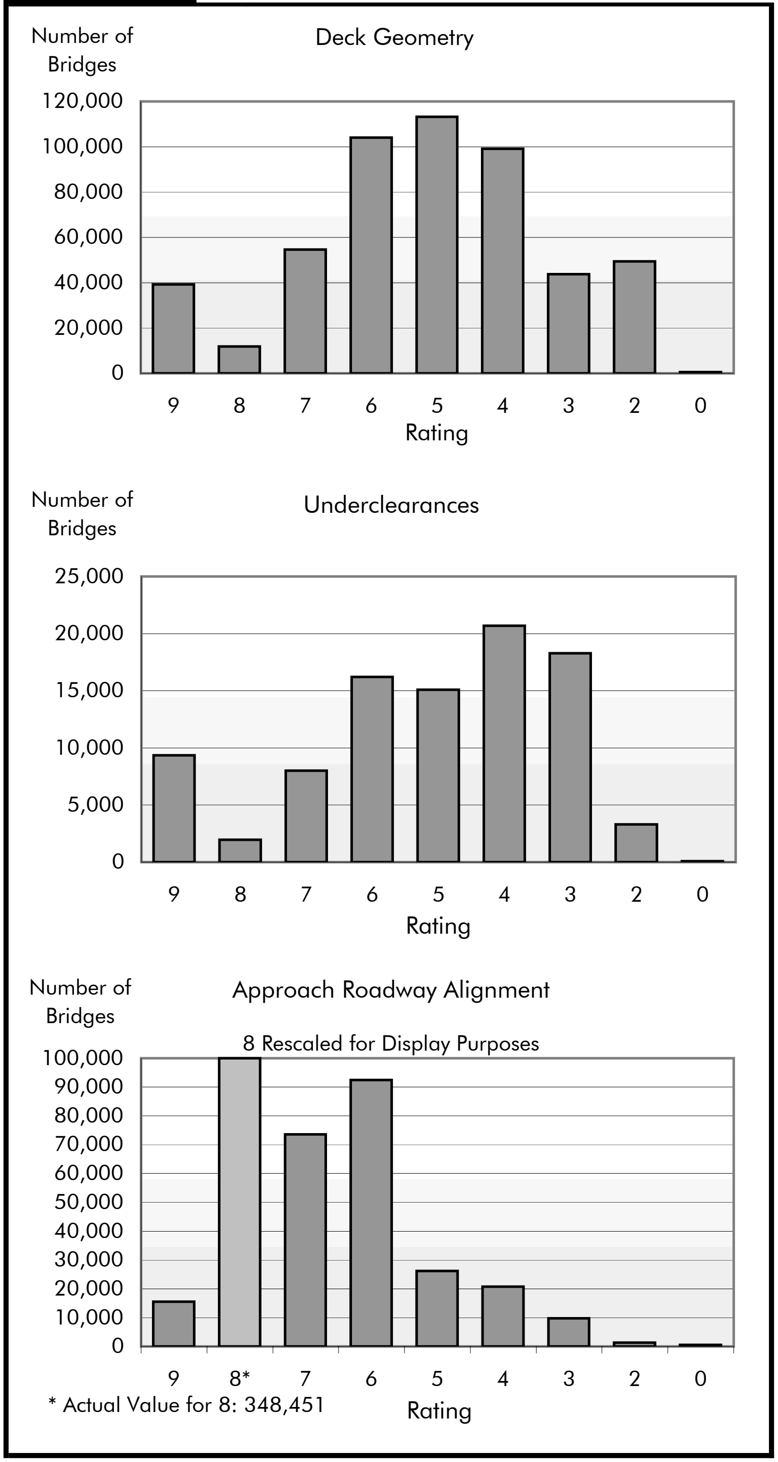
### Number of Deficient Bridges

The most commonly cited indicator of bridge condition is the number of deficient bridges. Of the 591,707 bridges in the inventory, 162,869 are classified as deficient (27.5 percent), either for structural or functional causes. Of these, 81,304 are classified as structurally deficient and 81,565 are classified as functionally obsolete. Thus, roughly half of the deficiencies are structural and half are functional.

*Exhibit 3-28* shows the trend of deficiency percentages from 1994 through 2002. Bridge deficiencies have been reduced primarily through reduction in the numbers of structurally deficient bridges. The percentage of functionally obsolete bridges has remained static over this time period.

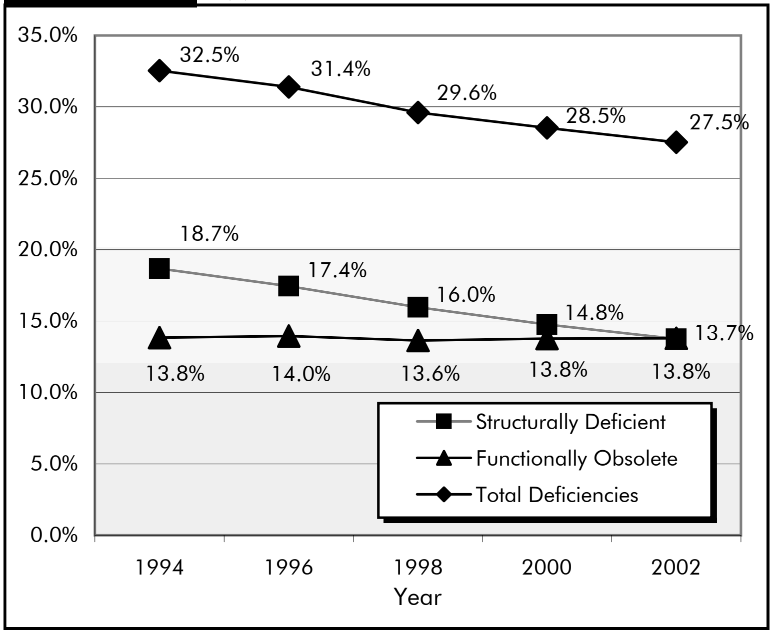
As indicated earlier, structural deficiencies and functional obsolescence are considered mutually exclusive, with structural deficiencies taking precedence where ratings classify a given bridge as both structurally deficient and functionally obsolete. Roughly half of the 81,304 structurally deficient 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.

**Exhibit 3-27** *Functional Obsolescence: Deck Geometry, Underclearance, and Approach Alignment Ratings, 2002*




*Source: National Bridge Inventory.*

**Exhibit 3-28** *Bridge Deficiency Percentages, 1994–2002*




*Source: National Bridge Inventory.*

## *Deficient Bridges by Owner*

Bridge deficiencies by ownership are examined in *Exhibit 3-29.* For Federally owned bridges, the number of bridges classified as functionally obsolete outweighs the number classified as structurally deficient by 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 47 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. These percentages have not changed significantly from those reported in the 2002 edition of the C&P report, based on year 2000 data.

**Exhibit 3-29** *Bridge Deficiencies by Owner, 2002*

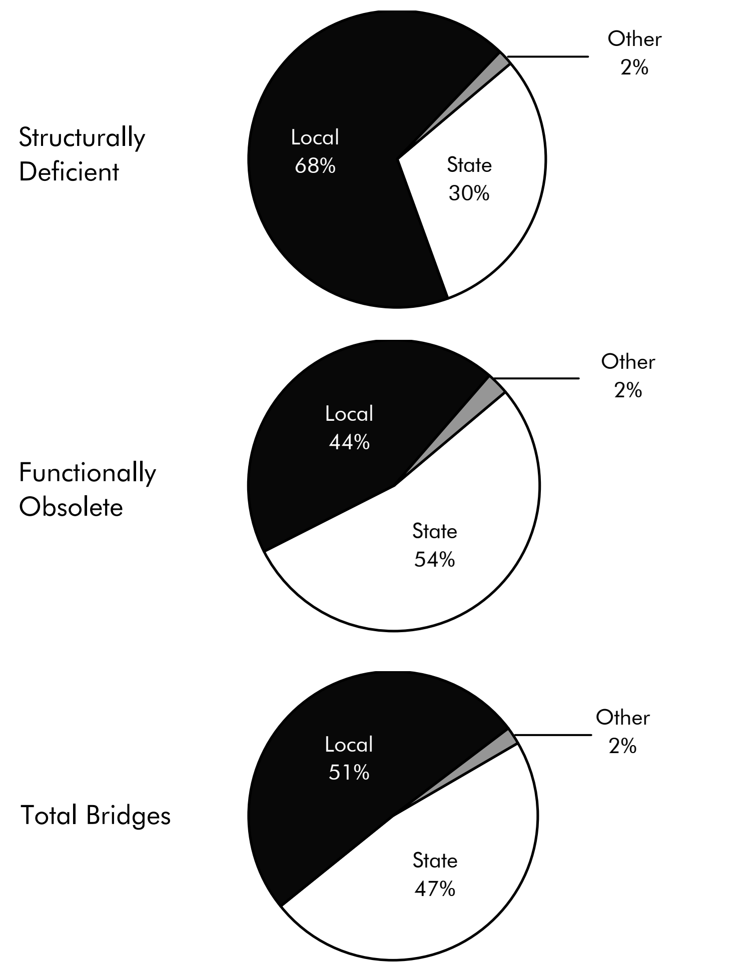
| | Owner | | | | |
|---|---|---|---|---|---|
| | Federal | State | Local | Private/Other | Total |
| **Numbers** | | | | | |
| Total Bridges | 9,371 | 280,266 | 299,354 | 2,716 | 591,707 |
| Total Deficient | 2,216 | 68,472 | 90,981 | 1,200 | 162,869 |
| Structurally Deficient | 748 | 24,736 | 55,147 | 673 | 81,304 |
| Functionally Obsolete | 1,468 | 43,736 | 35,834 | 527 | 81,565 |
| **Percentages** | | | | | |
| % of Total Inventory for Owner | 2% | 47% | 51% | 0% | 100.0% |
| % Deficient | 24% | 24% | 30% | 44% | 27.5% |
| % Structurally Deficient | 8% | 9% | 18% | 25% | 13.7% |
| % Functionally Obsolete | 16% | 16% | 12% | 19% | 13.8% |

*Source: National Bridge Inventory.*

Examination of ownership percentages for structurally deficient and functionally obsolete bridges reveals 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 in *Exhibit 3-30.* 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.

As indicated earlier, the most commonly used criteria for measuring bridge deficiencies is the actual number of deficient structures. However, there are alternative measures available, such as accounting for traffic by weighting structures according to ADT or accounting for size of structures by weighting according to the bridge deck area. Deficiencies for all structures, regardless of owner, are compared using these alternative performance measures in *Exhibit 3-31.* Deficiency percentages using these alternative performance measures are compared for Federal, State, local, and other owners in *Exhibit 3-32.*

**Exhibit 3-30** ***Bridge Deficiencies by Owner and Type, 2002***

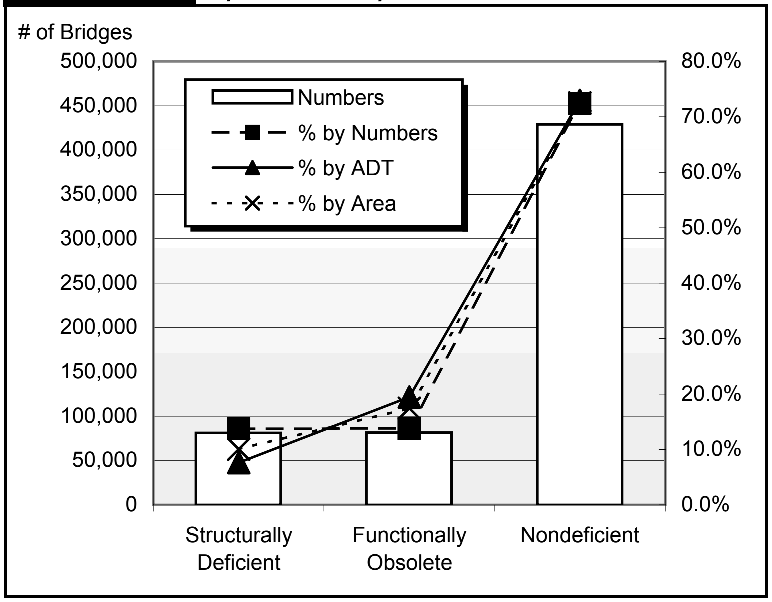



*Source: National Bridge Inventory.*

**Q.** What bridge deficiency criteria is used in the annual FHWA performance plan?

**A.** The *FHWA Fiscal Year 2005 Performance Plan* includes targets for the deck area on deficient bridges for NHS and non-NHS bridges. These measures are discussed in Chapter 17.

**Exhibit 3-31** *Bridge Deficiencies by Numbers, by ADT, and by Deck Area*




*Source: National Bridge Inventory.*

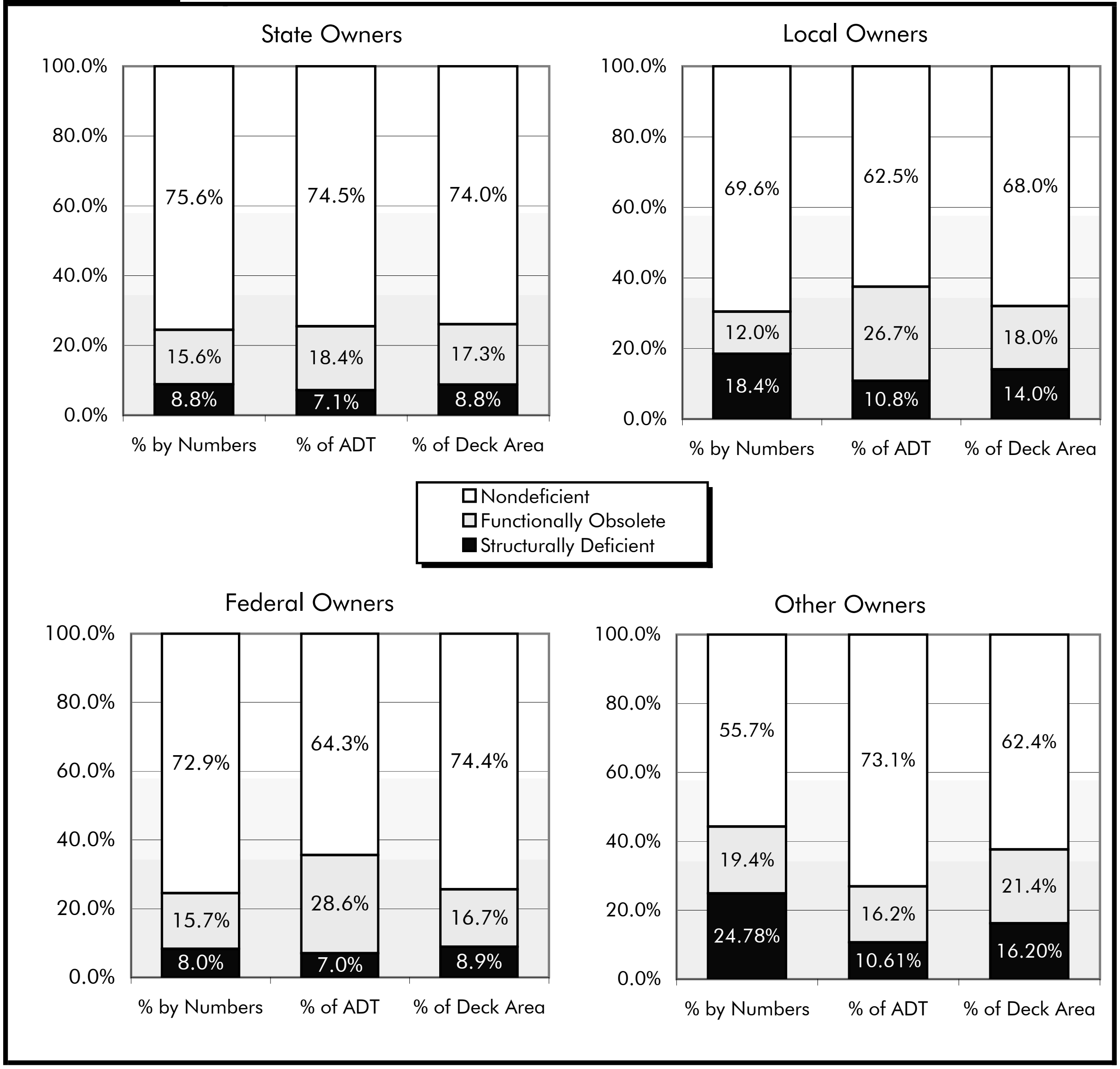
## *Deficient Bridges by Functional Classification*

Functional classifications are maintained for each bridge recorded in the NBI. The functional classification codes designate whether the bridge carries Interstates or other principal arterials, minor arterials, collectors, or local roadways. The number of structurally deficient and functionally obsolete bridges are shown by functional classification in *Exhibit 3-33.*

The functional classification codes designate whether a structure is located in a rural or urban environment. As noted in Chapter 2 and as shown in Exhibit 3-33, the majority of bridges in terms of numbers are located in rural environments. With rural bridges, the number of structural deficiencies (15 percent) outweighs the number of bridges classified as functionally obsolete (11 percent). Urban roadways carry significantly higher volumes of traffic, as noted in Chapter 2. With urban bridges, the number of structurally deficient bridges (9 percent) is significantly lower than the number of functionally obsolete bridges (22 percent). Overall, a higher percentage of urban structures is classified as deficient (31 percent total); however, the majority of these deficiencies result from functional obsolescence. While the percentage of rural bridges classified as deficient is lower, the 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 3-34,* overall deficiencies and structural deficiencies have both decreased. Functional obsolescence percentages, however, have not decreased but have remained static in both rural and urban environments. Exhibit 3-34 does not include structure records with unknown functional classification codes for any of the years depicted. Total numbers are thus slightly lower than the population figures presented in previous exhibits.

**Exhibit 3-32** *Bridge Deficiencies by Owner, by Numbers, ADT, and Deck Area*




*Source: National Bridge Inventory.*

## Exhibit 3-33 Bridge Deficiencies by Functional System, 2002

| Functional Class | Total Number of Structures | Structurally Deficient | Functionally Obsolete | Total Deficiencies |
|---|---|---|---|---|
| Rural Interstate | 27,316 | 1,104 | 3,210 | 4,314 |
| Rural Other Principal Arterial | 35,227 | 1,886 | 3,364 | 5,250 |
| Rural Minor Arterial | 39,587 | 3,407 | 4,451 | 7,858 |
| Rural Major Collector | 94,781 | 11,426 | 10,217 | 21,643 |
| Rural Minor Collector | 49,320 | 6,783 | 5,579 | 12,362 |
| Rural Local | 209,722 | 44,156 | 25,029 | 69,185 |
| **Total Rural** | **455,953** | **68,762** | **51,850** | **120,612** |
| Urban Interstate | 27,929 | 1,715 | 5,617 | 7,332 |
| Urban Other Freeways of Expressway | 16,844 | 1,025 | 3,431 | 4,456 |
| Urban Other Principal Arterial | 24,307 | 2,273 | 5,428 | 7,701 |
| Urban Minor Arterial | 24,516 | 2,605 | 6,402 | 9,007 |
| Urban Collector | 15,171 | 1,739 | 3,783 | 5,522 |
| Urban Local | 26,609 | 3,147 | 5,014 | 8,161 |
| **Total Urban** | **135,376** | **12,504** | **29,675** | **42,179** |
| Total Identified by Functional Class | 591,329 | 81,266 | 81,525 | 162,791 |
| Rural and Urban Interstate | 55,245 | 2,819 | 8,827 | 11,646 |
| Rural and Urban Other Principal Arterial | 64,103 | 6,012 | 10,853 | 16,865 |
| Rural and Urban Minor Arterials | 76,378 | 5,184 | 12,223 | 17,407 |
| Rural and Urban Collectors | 159,272 | 19,948 | 19,579 | 39,527 |
| Rural and Urban Local | 236,331 | 47,303 | 30,043 | 77,346 |
| Unknown | 378 | 38 | 40 | 78 |
| **Total, Including Unknown** | **591,707** | **81,304** | **81,565** | **162,869** |

*Source: National Bridge Inventory.*

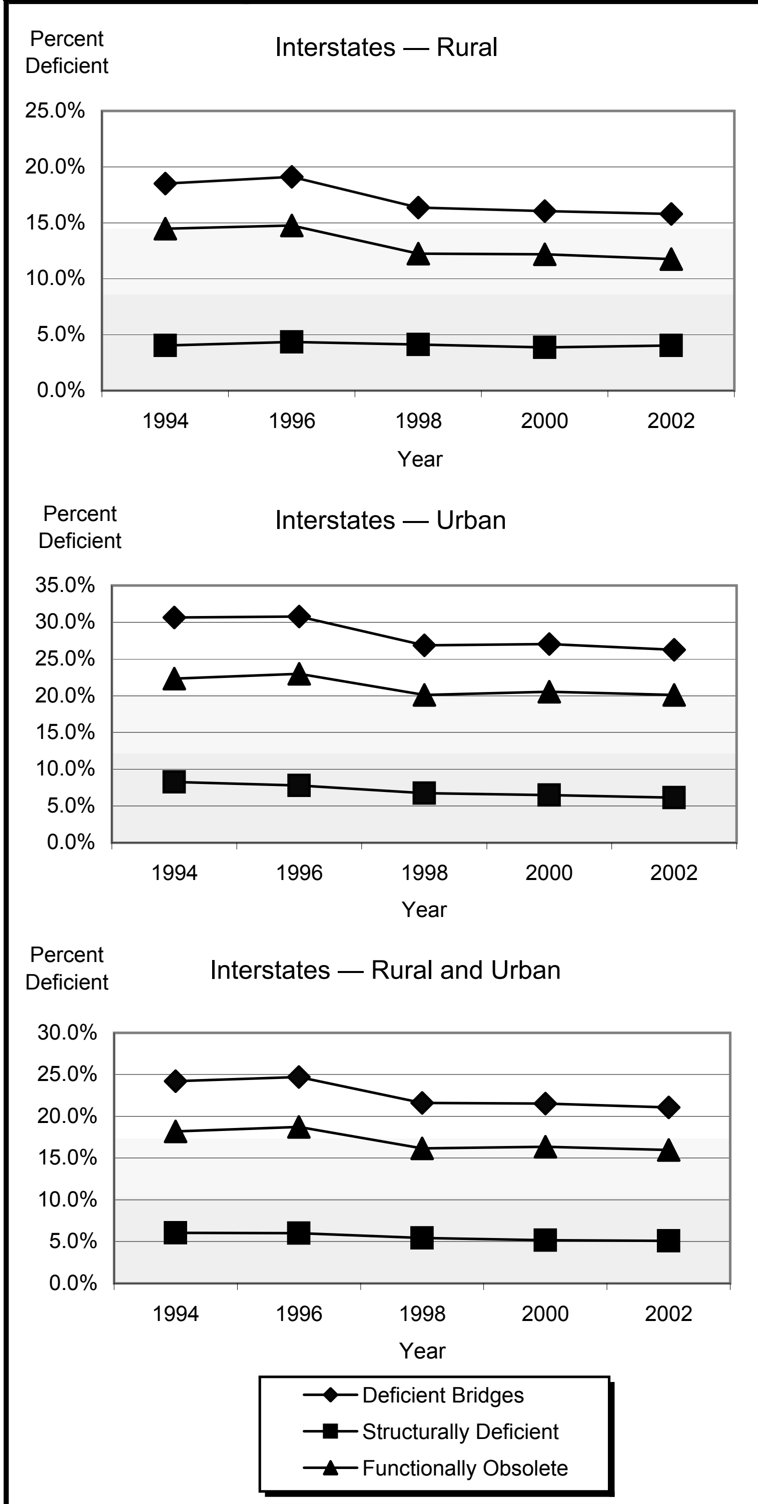
## Exhibit 3-34 Rural and Urban Bridge Deficiencies, 1994–2002

| Year | 1994 | | 1996 | | 1998 | | 2000 | | 2002 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Rural Bridges** | **455,319** | | **456,958** | | **454,664** | | **455,365** | | **455,953** | |
| Deficiencies | 144,799 | 31.8% | 139,545 | 30.5% | 130,911 | 28.8% | 125,523 | 27.6% | 120,612 | 26.5% |
| Structurally Deficient | 91,991 | 20.2% | 86,424 | 18.9% | 78,999 | 17.4% | 73,599 | 16.2% | 68,762 | 15.1% |
| Functionally Obsolete | 52,808 | 11.6% | 53,121 | 11.6% | 51,912 | 11.4% | 51,924 | 11.4% | 51,850 | 11.4% |
| **Urban Bridges** | **121,141** | | **124,949** | | **128,312** | | **131,780** | | **135,376** | |
| Deficiencies | 42,716 | 35.3% | 43,181 | 34.6% | 41,661 | 32.5% | 42,031 | 31.9% | 42,179 | 31.2% |
| Structurally Deficient | 15,692 | 13.0% | 15,094 | 12.1% | 14,073 | 11.0% | 13,079 | 9.9% | 12,504 | 9.2% |
| Functionally Obsolete | 27,024 | 22.3% | 28,087 | 22.5% | 27,588 | 21.5% | 28,952 | 22.0% | 29,675 | 21.9% |
| **All Bridges** | **576,460** | | **581,907** | | **582,976** | | **587,145** | | **591,329** | |
| Deficiencies | 187,515 | 32.5% | 182,726 | 31.4% | 172,572 | 29.6% | 167,554 | 28.5% | 162,791 | 27.5% |
| Structurally Deficient | 107,683 | 18.7% | 101,518 | 17.4% | 93,072 | 16.0% | 86,678 | 14.8% | 81,266 | 13.7% |
| Functionally Obsolete | 79,832 | 13.8% | 81,208 | 14.0% | 79,500 | 13.6% | 80,876 | 13.8% | 81,525 | 13.8% |

*Source: National Bridge Inventory.*

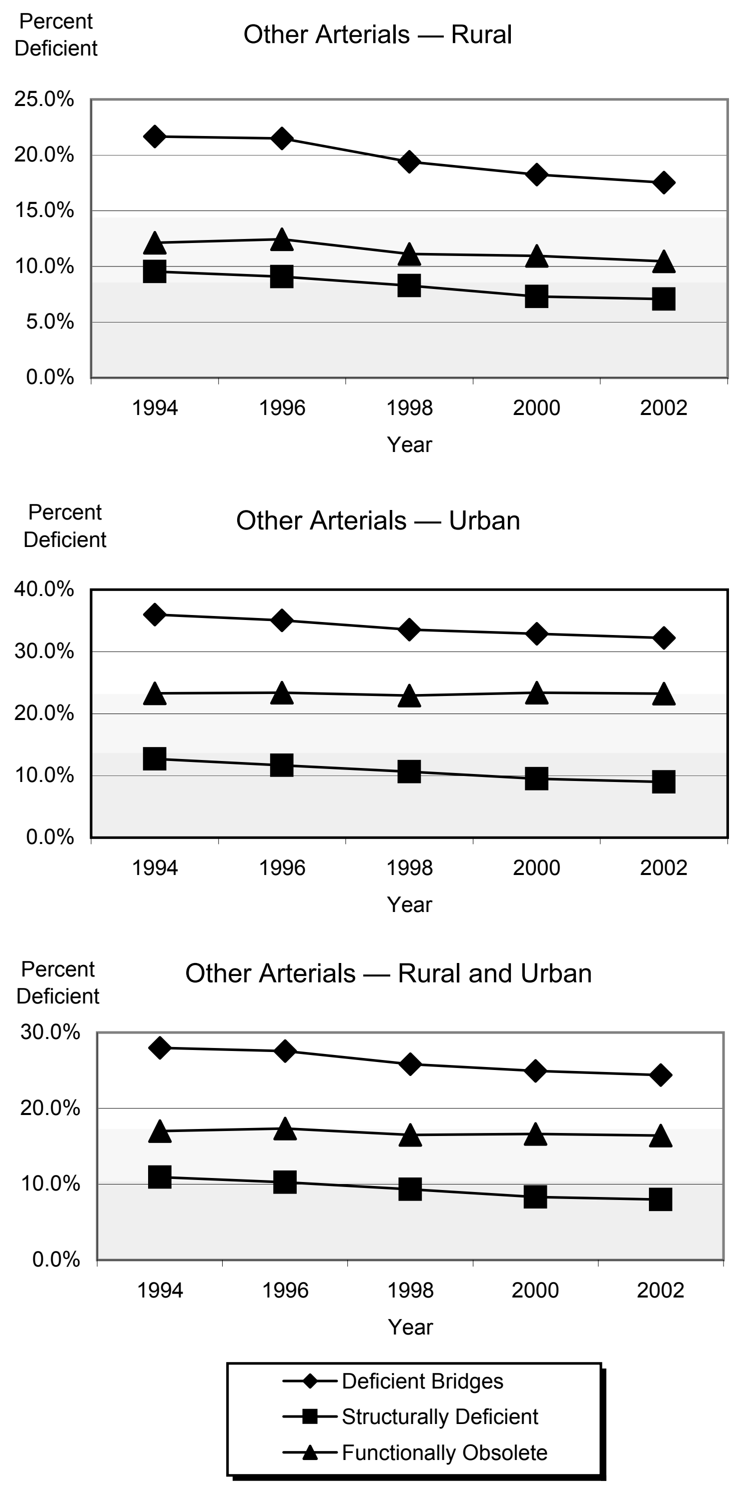
The trends for individual functional classifications can be examined. *Exhibits 3-35* through *3-38* show the trends for Interstate, other arterial, collector, and local bridges, respectively. Decreases in the number of structural deficiencies are exhibited for every functional classification, irrespective of the rural and urban designations. For Interstate bridges, decreases are also exhibited in the percentages of functionally obsolete bridges. For other functional classifications, there has been little change in the functionally obsolete percentages.

**Exhibit 3-35** *Interstate Bridge Deficiencies, 1994–2002*



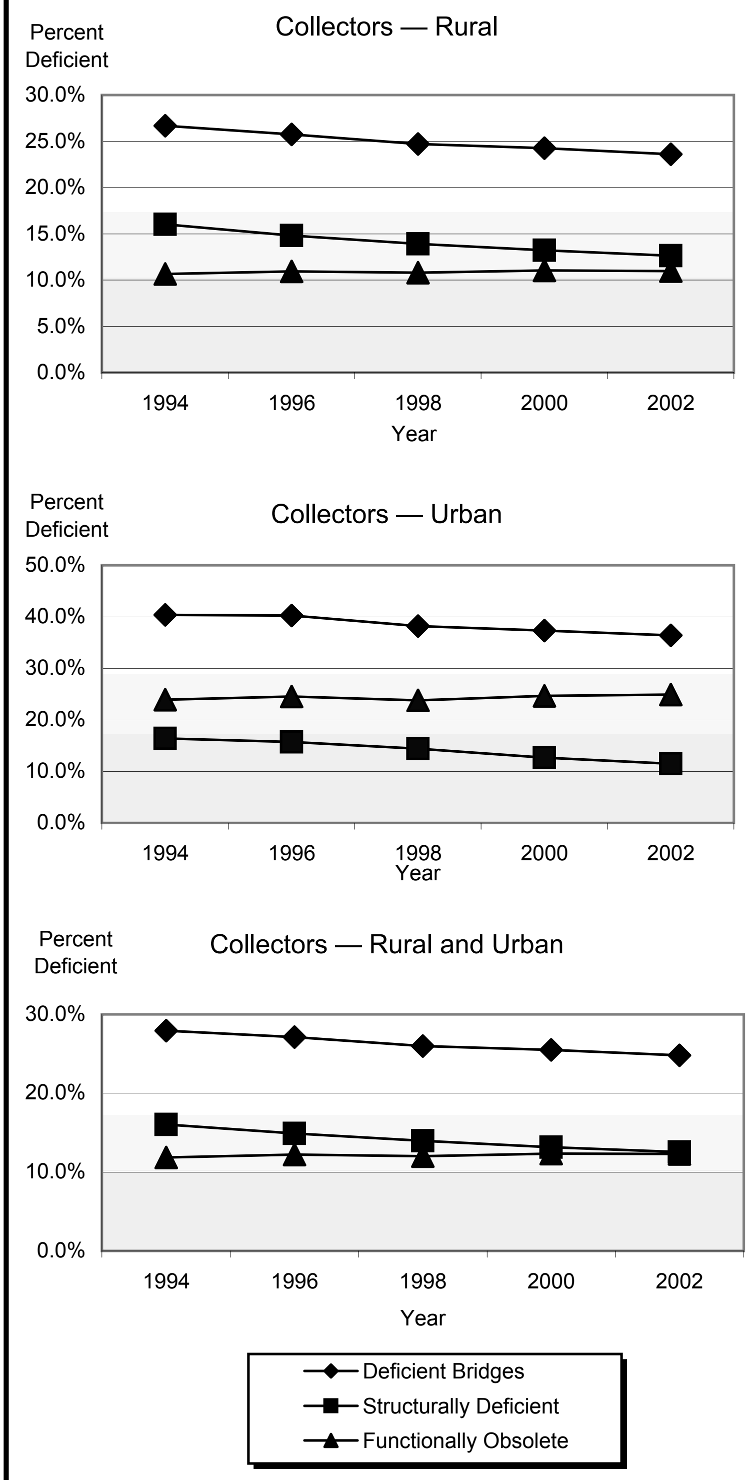

*Source: National Bridge Inventory.*

**Exhibit 3-36** *Other Arterial Bridge Deficiencies, 1994–2002*



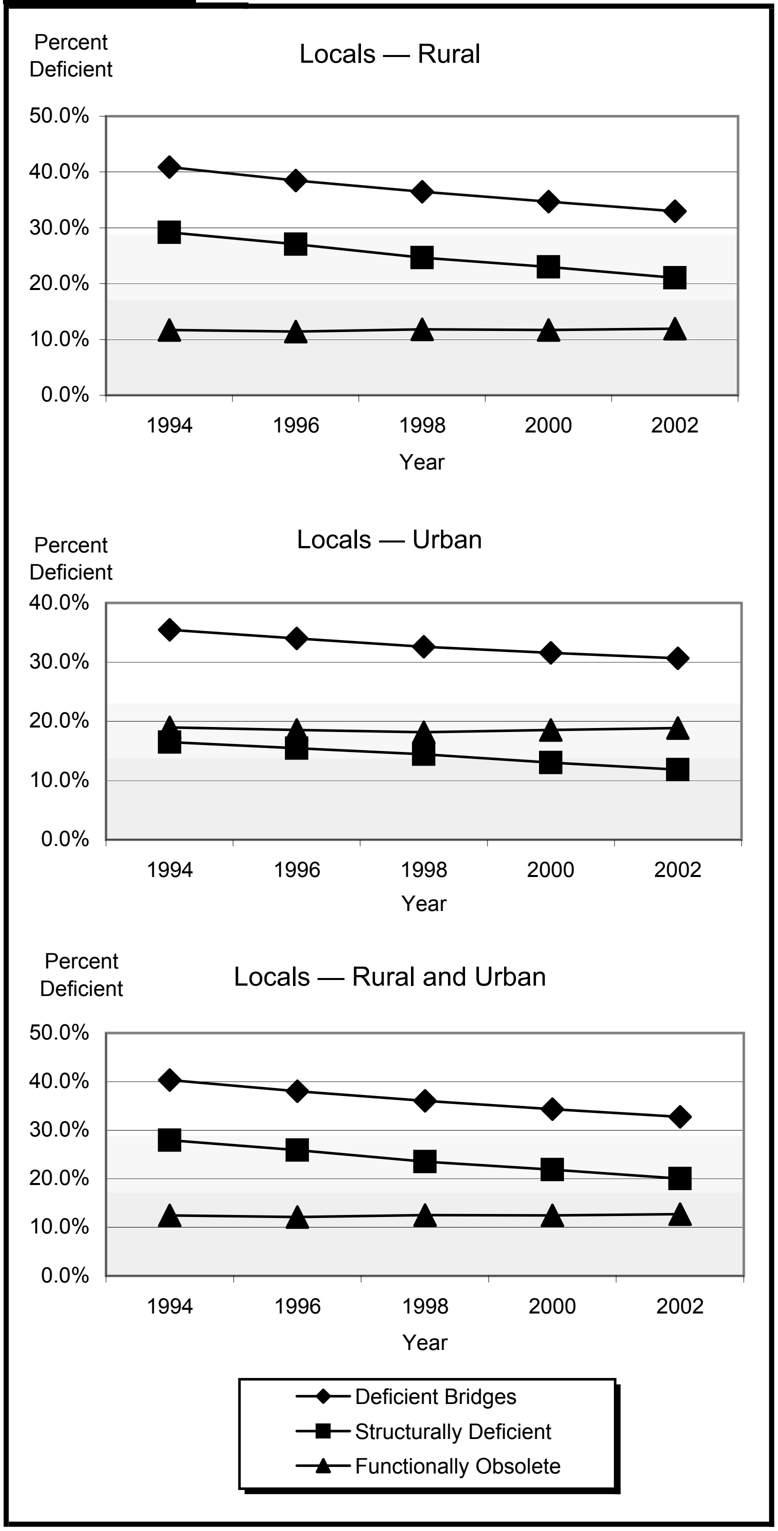

*Source: National Bridge Inventory.*

**Exhibit 3-37** *Collector Bridge Deficiencies, 1994–2002*




*Source: National Bridge Inventory.*

**Exhibit 3-38** *Local Bridge Deficiencies, 1994–2002*




*Source: National Bridge Inventory.*

# Transit System Conditions

The condition of the U.S. transit infrastructure depends 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 3-39*].

**Exhibit 3-39** *Definitions of Transit Asset Condition*

| 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 and, in the case of vehicles, as a function of their estimated usage and maintenance history. The deterioration schedules used by TERM were initially estimated using 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. A detailed description of these deterioration schedules is provided in a January 1996 FTA report, "The Estimation of Transit Asset Condition Ratings." The deterioration curves developed from the Chicago data continue to be used in TERM, with the exception of those for vehicles, maintenance facilities, and stations. The deterioration schedules for these assets have been re-estimated based on information collected from nationwide on-site engineering sample surveys.

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. Between 1999 and 2003, FTA conducted a large number of on-site inspections and collected information on the condition, age, and maintenance history of 1,179 transit vehicles. A total of 284 rail vehicles have been inspected: 88 commuter rail vehicles at 9 agencies, 94 heavy rail vehicles at 6 agencies, and 102 light rail vehicles at 11 agencies. A total of 895 bus vehicles have been inspected at 43 agencies. Fifty-eight articulated buses, 626 standard 40-foot buses, 84 low-floor 40-foot buses, 77 small buses (i.e., shorter than 40 feet), and 50 paratransit and vanpool vans were inspected [*Exhibit 3-40*].

**Exhibit 3-40** *National Condition Assessments of Transit Vehicles*

| | | Vehicles | Number of Agencies |
|---|---|---|---|
| **Buses** | | **895** | **43** |
| | 1999 | 572 | 31 |
| | 2001-2002 | 323 | 12 |
| **Commuter Rail** | | **88** | **9** |
| | 2003 | 88 | 9 |
| **Heavy Rail** | | **94** | **6** |
| | 2000 | 92 | 5 |
| | 2001 | 2 | 1 |
| **Light Rail** | | 102 | **11** |
| | 2000 | 28 | 5 |
| | 2001 | 74 | 6 |
| **Total Number of Vehicles Inspected** | | **1,179** | |

*Source: National Condition Bus and Rail Assessments.*

Each vehicle inspected 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.

The FTA also has made a major effort to re-estimate the deterioration schedules for maintenance facilities. Between 1999 and 2003, 165 on-site maintenance facility surveys have been conducted at 45 rail and bus agencies. Facility conditions were determined by the conditions of a range of facility components and subcomponents. The components that were examined included the roof structure, heating and ventilation systems, mechanical and plumbing systems, electrical equipment, specialty shops, and work bays and their subcomponents. The condition of each type of specialty shop (e.g., machine shop, metal working shop) was evaluated separately. The condition of each component is estimated as an average of the condition of its subcomponents. For example, the condition of a roof structure is based on an average of the conditions of its roofing frames, its gutters, and its drainage system. Bus and rail facilities, on average, follow different deterioration schedules. While rail facilities are estimated to fall to a condition of 3.0 in just under 25 years, bus facilities take 40 years to reach this condition. Most of the decline in both rail and bus maintenance facility conditions takes place in the first 23 years. 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 the remaining years of their lives [*Exhibit 3-48* on page 3-44].

Since the 2002 edition of the C&P report, stations have used the same deterioration schedule as maintenance facilities. Prior to this report, stations used deterioration curves based on the relationship between station age and structure condition from data collected in Chicago. The decision to replace the station deterioration schedule based on Chicago data with the deterioration schedule for maintenance facilities was based on the premise that both stations and maintenance facilities are primarily structures, and the data collected for maintenance facilities were more recent and more accurate than the Chicago data. Engineering assessments of stations have recently been completed. Condition estimates based on newly estimated station deterioration curves will be provided in the 2006 edition of this report.

The TERM includes a detailed inventory of the physical assets of transit agencies in urbanized areas that report to the National Transit Database (NTD). Assets are segmented by mode, asset type, and asset age. This asset inventory was initially based on FTA studies in the early 1990s, which collected the number, purchase price, and date of purchase of bus, light rail, and heavy rail assets. This information was updated and supplemented with data collected from Chicago (also used to estimate deterioration schedules) and subsequently, through special data collection efforts, directly from agencies. The TERM has internal checks, which are used to generate values for assets that are not reported by agencies or in cases where the quality of asset information reported to FTA is poor. Missing or incorrect assets are identified using relationships between agency-mode-dimensions and expected dimensions. For example, an agency with 20 miles of rail investment would be expected to have half the investment in train control equipment as an agency with 40 miles of investment. The TERM uses industry standard relationships like this to check that the asset inventory in TERM makes sense and makes adjustments to the industry data as required. Industry standard relationships are also used to estimate data where no data exist.

Transit asset condition estimates are updated with information collected from on-site assessments in each edition of the C&P report to reflect any revisions made to deterioration rates. This edition of the report uses newly estimated deterioration curves for bus vehicles and for commuter rail vehicles. Since the last edition of the report in 2002, 323 bus vehicles inspections were undertaken at 12 agencies. This bus sample included a mix of full-size, 40- to 60-foot buses; medium and small buses; and vans. In 2003, 88 commuter rail vehicle inspections were undertaken at 9 agencies.

Transit vehicle asset conditions also reflect the most recently available information on vehicle age, use, and level of maintenance from the NTD. The information used in this report is for 2002. Age information is available on a vehicle-by-vehicle basis from the NTD, but information on use and maintenance expenditures are not reported for each vehicle separately. However, average vehicle use, i.e., vehicle revenue miles per vehicle, is available by agency, by mode. Average maintenance expenditures per vehicle are also available on an agency and modal basis. For this reason, for the purpose of calculating conditions, average agency use and maintenance expenditures for a particular mode are assumed to be the same for all vehicles operated by an agency in that mode. Because maintenance levels may fluctuate from year to year, TERM uses a 5-year average.

**Q.** **What is the Asset Conditions Reporting Module (ACM)?**

**A.** The ACM is an effort, undertaken in 2002 through the NTD, to expand the collection of data on the Nation's transit asset infrastructure and its physical condition. Participation by agencies was voluntary. Several large operators opted not to participate, and not all agencies that participated submitted a complete set of information. The ACM data cover all asset types, excluding revenue vehicles. The ACM provided the following information, which is used to estimate transit asset conditions: (1) asset type, (2) asset age and quantity, (3) asset replacement cost, (4) the year in which the asset replacement cost is denominated, and (5) the percentage of the asset (e.g., facility) used by the reporting agency to provide transit services. In some cases, information reported to the ACM on the condition of an asset and its useful life was used to estimate the current age of the asset, which is used as input into TERM.

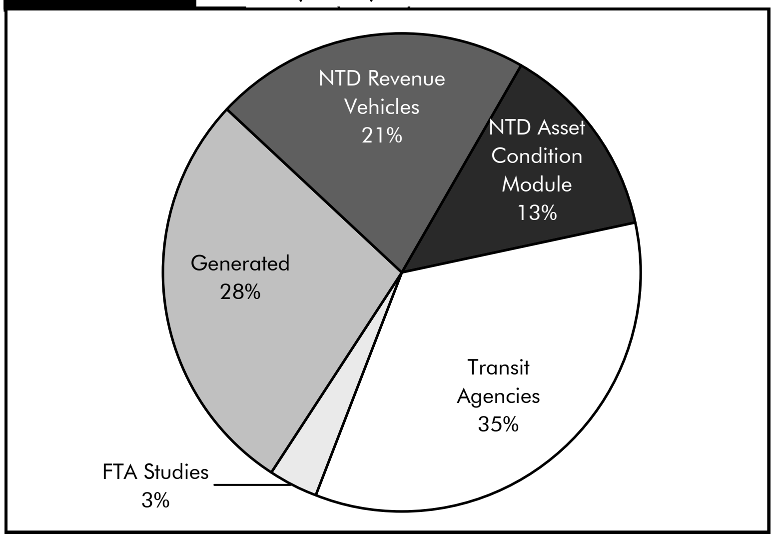
Condition estimates in each new edition of the C&P report are based on updated asset inventory information and reflect updates in TERM's asset inventory. Since the 2002 C&P report, conditions for approximately 70 percent of the Nation's transit assets have been updated. Vehicle data from the NTD was used to update 22 percent of the TERM data and data collected by the NTD Asset Conditions Reporting Module (ACM) was used to update approximately 15 percent. An additional 30 percent of TERM data was updated with inventory data provided by the New York Metropolitan Transportation Authority (MTA). Capital unit costs were updated for heavy and light rail based on FTA capital cost studies undertaken since the last edition of this report.

The ACM data included asset inventories for a few key major rail operators—including the Southeastern Pennsylvania Transit Authority and

Massachusetts Bay Transportation Authority—whose assets had previously been estimated within TERM. The ACM also provided real data for several recent light rail investments for which assets had previously been estimated, and more complete coverage on small- to medium-size bus operators than what was previously available. In general, the ACM asset records were more complete and often implicitly reported a higher total replacement value for an asset than what existed in TERM.

Since the MTA alone accounts for roughly one fourth of the Nation's transit assets in urbanized areas, the data received from the MTA were used to update more than 50 percent of all data obtained directly from transit operators.

**Exhibit 3-41** *2002 Transit Economic Requirements Model (TERM) Data Sources*




Thirty-five percent of the TERM's existing asset inventory is currently based on asset information directly provided by transit agencies. Twenty-one percent is based on revenue vehicle data from the 2002 NTD, and 13 percent is based on asset data from the 2002 ACM. Three percent is based on information collected by asset studies undertaken by FTA in the early to mid- 1990s. Twenty-eight percent of the asset inventory in TERM is generated endogenously; 35 percent of the data was generated endogenously before the inventory was updated with asset information collected by the ACM and from the MTA. Asset quantities are converted to values with asset replacement cost information collected by FTA. [*Exhibit 3-41*].

# Bus Conditions

As a result of the bus assessments completed since the last edition of this report, bus deterioration schedules have been revised to reflect the fact that bus conditions decline slightly more rapidly during the first three years of life than previously estimated, and slightly less rapidly after the age of 15. The study found that vans, paratransit vehicles, and small buses tend to decay more rapidly than full-size buses and their condition estimates, although included in the total average, is based on a decay curve that is different from the one used to estimate the conditions of mid-size, full-size, and articulated motor buses. Variations among the average age of agencies' fleets and maintenance practices created large differences in average fleet conditions. Vehicles that are rehabilitated have condition levels approximately 0.5 higher than vehicles that are not.

Bus vehicle age and condition information is reported according to bus vehicle type for 1993 to 2002 in *Exhibit 3-42.* These condition estimates are based on slightly revised deterioration schedules for buses based on engineering surveys undertaken since the last report. The allocation of buses among bus categories also has been revised since the last edition of this report. 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

**Exhibit 3-42** *Urban Transit Bus Fleet Count[1], Age, and Condition, 1993–2002*

| Year | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 | Revised Basis 2002 |
|---|---|---|---|---|---|---|---|
| **Articulated Buses** | | | | | | | |
| Total Fleet | 1,807 | 1,716 | 1,523 | 1,967 | 2,078 | 2,307 | 2,765 |
| Percent Overage Vehicles | 16% | 33% | 61% | 46% | 29% | 15% | 17% |
| Average Age | 9.5 | 10.7 | 11.8 | 8.7 | 6.9 | 6.7 | 7.1 |
| Average Condition | 2.88 | 2.66 | 2.49 | 3.10 | 3.33 | 3.17 | 3.11 |
| **Full-Size Buses** | | | | | | | |
| Total Fleet | 46,824 | 46,335 | 47,149 | 49,195 | 49,721 | 50,294 | 46,685 |
| Percent Overage Vehicles | 20% | 23% | 25% | 26% | 25% | 22% | 19% |
| Average Age | 8.5 | 8.6 | 8.2 | 8.7 | 8.5 | 7.7 | 7.5 |
| Average Condition | 2.82 | 2.83 | 2.86 | 2.90 | 2.93 | 2.99 | 3.02 |
| **Mid-Size Buses** | | | | | | | |
| Total Fleet | 3,598 | 3,879 | 5,328 | 6,807 | 7,643 | 8,914 | 7,304 |
| Percent Overage Vehicles | 24% | 23% | 18% | 14% | 15% | 21% | 34% |
| Average Age | 6.4 | 6.8 | 5.6 | 5.7 | 5.7 | 5.6 | 8.1 |
| Average Condition | 3.14 | 3.08 | 3.30 | 3.30 | 3.30 | 3.30 | 2.93 |
| **Small Buses** | | | | | | | |
| Total Fleet | 4,064 | 5,447 | 7,081 | 8,461 | 9,039 | 10,096 | 14,857 |
| Percent Overage Vehicles | 13% | 13% | 13% | 13% | 12% | 14% | 18% |
| Average Age | 4.0 | 4.0 | 3.7 | 4.0 | 4.2 | 4.1 | 4.5 |
| Average Condition | 3.48 | 3.55 | 3.56 | 3.51 | 3.47 | 3.53 | 3.39 |
| **Vans[2]** | | | | | | | |
| Total Fleet | 8,353 | 11,969 | 13,796 | 14,539 | 16,234 | 17,300 | 17,300 |
| Percent Overage Vehicles | 22% | 21% | 22% | 5% | 6% | 11% | 11% |
| Average Age | 3.1 | 3.2 | 2.3 | 3.2 | 3.2 | 3.2 | 3.2 |
| Average Condition | 3.59 | 3.71 | 3.75 | 3.71 | 3.71 | 3.62 | 3.62 |
| **Total Fleet** | 64,646 | 69,346 | 74,877 | 80,969 | 84,715 | 88,911 | 88,911 |
| Percent Overage Vehicles | 20% | 22% | 24% | 20% | 19% | 19% | 19% |
| Weighted Average Age | 7.4 | 7.3 | 6.6 | 7.0 | 6.8 | 6.2 | 6.2 |
| Average Condition | 2.87 | 2.88 | 2.94 | 3.01 | 3.05 | 3.21 | 3.19 |

[1] Includes vehicles that are not in active service. Bus vehicle fleets sizes reported here are slightly larger than those reported for active bus vehicles in Chapter 2.

[2]Vehicles used in for both demand response and vanpool services.

Sources: Transit Economic Requirements Mode and National Transit Database.

are reported in Exhibit 3-42 for 2002. 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) have been reclassified as small. The number of articulated buses increased by 20 percent as a result of the reclassification, the number of full-size buses decreased by 7 percent, the number of mid-size buses decreased by 18 percent, and the number of small buses increased by 47 percent. Vans were not affected by the reclassification.

Conditions have gradually improved for all bus vehicle types since 1993. In 2002, the estimated average condition of the urban bus fleet was 3.21 (old classification) and 3.19 (new classification) compared with 3.05 in 2000 and 2.87 in 1993. [Note that all condition estimates prior to 2002 are based on the old classification system since information on length was not collected.] This improvement in conditions reflects a decrease in the average age of the bus vehicle fleet from 7.4 years in 1993, to 6.8 years in 2000, to 6.2 years in 2002. Since 1993, 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.

*Articulated buses* experienced the largest fluctuations in conditions between 1993 and 2002, ranging from 2.49 in 1997 to 3.33 in 2000. In 2002, the average condition of articulated buses was 3.11 (new classification) and 3.17 (old classification). 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 were purchased between 1983 and 1984. 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 17 percent (new classification) in 2002. Mid-size buses have 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 2002 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. Vehicles reclassified from the full and mid-size bus categories to the small bus category lowered the average conditions of small buses from 3.47 in 2000 to 3.39 in 2002. Full-size buses, which were on average consistently just below "adequate" condition between 1993 and 2000, reached an "adequate" average condition of 3.02 in 2002 under the new classification system.

# Urban Bus Maintenance Facilities

## Age

The estimated age distribution of urban maintenance facilities for bus, vanpool, and demand response systems in 2002 is shown in *Exhibit 3-43.* This distribution is based on age information collected by the 1999 and 2002 National Bus Condition Assessments and applied to the total national bus facilities in 2002 as reported in the NTD. The percentage of bus maintenance facilities less than 10 years old increased from 8 percent in 2000 to 12 percent in 2002, and the percentage more than 30 years old declined from 31 to 24 percent. The percentage of facilities aged 11 to 30 years remained about the same, increasing from 61 to 64 percent, but within this distribution the proportion of facilities aged 20 years to 30 years increased. Individual facility ages may not relate well to condition, since substantive renovations are made to facilities at varying intervals over time.

**Exhibit 3-43** *Age of Maintenance Facilities for Urban Bus Vehicles*[1]

| | 2002 | |
|---|---|---|
| **Age (years)** | **Number** | **Percent** |
| 0-10 | 151 | 12% |
| 11-20 | 406 | 33% |
| 21-30 | 372 | 31% |
| 31+ | 289 | 24% |
| **Total** | **1,219** | **100%** |

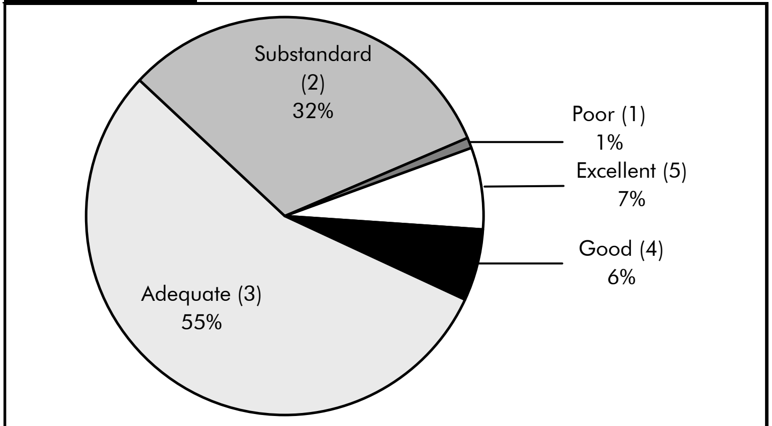
[1] Includes maintenance facilities for both directly operated and purchased transportation services. Exhibit 2-18 in Chapter 2 reports the number of maintenance facilities for directly operated services only.

*Source: National Bus Condition Assessments, 1999 and 2001-2002, and 2002 NTD.*

### *Condition*

The average condition of maintenance facilities for buses, including vans and demand response vehicles, improved from 3.23 in 2000 to 3.34 in 2002. In 2002, 55 percent of all urban bus maintenance facilities were in adequate condition, 6 percent in good condition, and 7 percent in excellent condition, for a combined total of 68 percent in compared with 71 percent in adequate-or-better condition in 2000. Thirty-three percent of these facilities, however, are estimated to be in unacceptable condition—32 percent in substandard condition and 1 percent in poor condition. In 2000, 24 percent were in substandard condition and 5 percent in poor condition. [The average condition within each condition category increased, leading to an increase in average condition in spite of the slight decrease in the percentage of facilities in adequate or better condition.] [*Exhibit 3-44*]

**Exhibit 3-44** *Distribution of Condition of Urban Bus Maintenance Facilities, 2002*




| | 2002 | |
|---|---|---|
| **Condition** | **Number** | **Percent** |
| Excellent (5) | 83 | 7% |
| Good (4) | 68 | 6% |
| Adequate (3) | 672 | 55% |
| Substandard (2) | 387 | 32% |
| Poor (1) | 10 | 1% |
| **Total** | **1,219** | **100%** |

*Source: Transit Economic Requirements Model.*

# Rail Vehicle Conditions

The average rail vehicle condition increased to 3.47 in 2002, from 3.38 in 2000, reflecting a decline in the average age from 21.8 years in 2000 to 20.4 years in 2002. By comparison, in 1993 the average rail vehicle condition was 3.54 and average age 17.7 years [*Exhibit 3-45*]. 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 total U.S. rail fleet. All rail vehicles combined have been, on average, in slightly better condition than all bus and bus-type vehicles. The condition of all rail vehicles combined averaged 3.45 for the years 1993 to 2002.

Changes in ages and conditions of all rail vehicles appear to fall within the range of normal depreciation, rehabilitation, and replacement cycles. In 2002, the average condition of each of the individual vehicle types was slightly lower or the same as in 1993, and the average age slightly higher except in the case of commuter rail self-propelled passenger coaches, which is significantly higher. In contrast with other rail vehicle types, the average age of commuter rail self-propelled vehicles has increased substantially, although the decline in their average condition has been more moderate, indicating that these vehicles have received a substantial amount of rehabilitation since 1993. (The percentage of overage commuter rail self-propelled passenger coaches increased from 6 percent in 1993 to 68 percent in 2002, their average age climbed from 18.2 to 27.1 years, and their condition declined from 3.69 to 3.50).

The average condition of commuter rail vehicles has been re-estimated based on engineering surveys of rail vehicle physical conditions undertaken in 2002. These new estimates are lower than those previously reported. This downward revision is similar to the one that occurred for heavy and light rail vehicles as a result of surveys made between 1999 and 2001 and reported in the 2002 edition of this report. It has led to a reduction in the commuter rail conditions, reported in earlier editions of this report, by about 15 percent. Analysis of the rail vehicle condition information collected by the engineering survey revealed that commuter rail vehicles decay more rapidly in early years than previously estimated. It was also revealed that the deterioration schedule of commuter rail vehicles differs from the deterioration schedule of heavy and light rail vehicles. Heavy and light rail vehicles deteriorate most rapidly in the first year of life, and then shift to a more gradual rate of constant decline for the remainder of their lives. By comparison, commuter rail vehicles deteriorate most rapidly in the first five years of their lives, at which point their conditions plateau until they reach approximately 22 years. After this, their condition starts to decline again albeit very gradually [*Exhibit 3-46*]. The conditions, shown in *Exhibit 3-46,* reflect these revisions and are not directly comparable to conditions reported in earlier editions of this report.

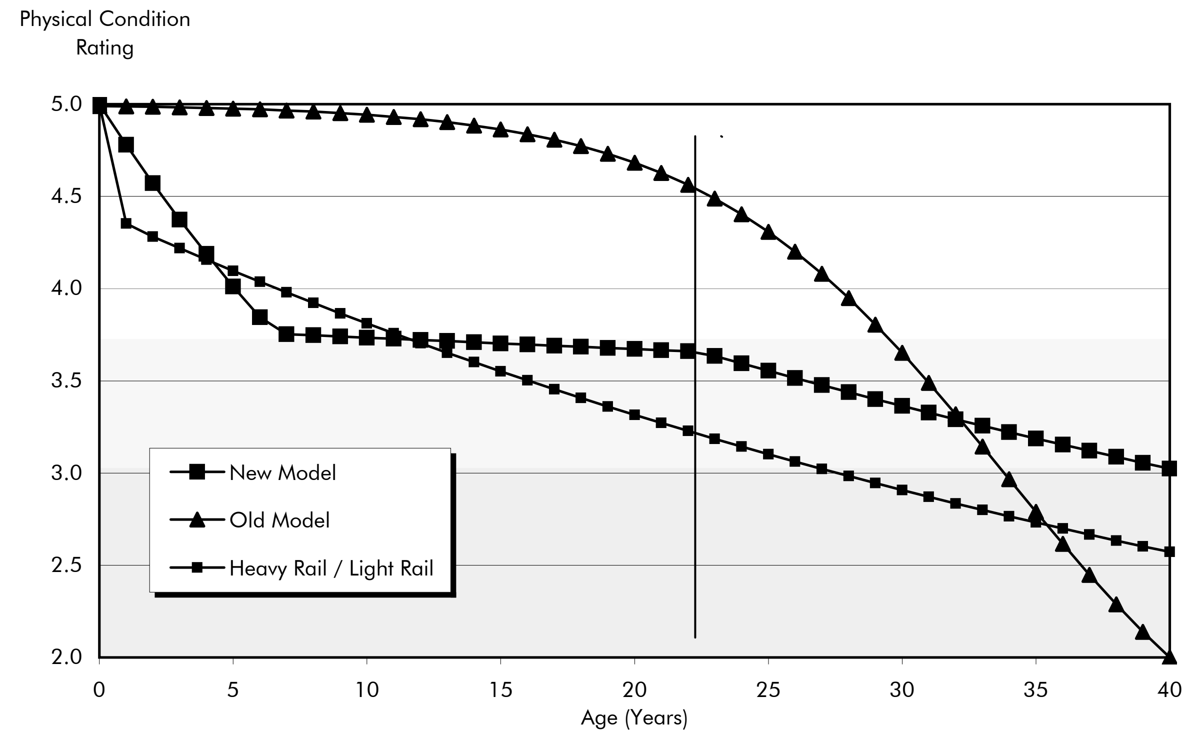
**Exhibit 3-45** *Urban Transit Rail Fleet Count, Age, and Condition[1], 1993–2002*

| Year | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| **Commuter Rail Locomotives** | | | | | | |
| Total Fleet | 556 | 570 | 586 | 644 | 591 | 709 |
| Percent Overage Vehicles | 17% | 21% | 22% | 17% | 19% | 23% |
| Average Age | 15.6 | 15.6 | 16.5 | 16.1 | 15.8 | 16.9 |
| Average Condition | 3.77 | 3.77 | 3.70 | 3.82 | 3.77 | 3.72 |
| **Commuter Rail Passenger Coaches** | | | | | | |
| Total Fleet | 2,402 | 2,402 | 2,470 | 2,886 | 2,793 | 2,985 |
| Percent Overage Vehicles | 29% | 36% | 33% | 32% | 29% | 34% |
| Average Age | 18.6 | 20.1 | 19.8 | 18.5 | 17.7 | 19.0 |
| Average Condition | 3.68 | 3.63 | 3.68 | 3.74 | 3.76 | 3.68 |
| **Commuter Rail Self-Propelled Passengers Coaches** | | | | | | |
| Total Fleet | 2,526 | 2,645 | 2,681 | 2,455 | 2,472 | 2,389 |
| Percent Overage Vehicles | 6% | 24% | 25% | 60% | 61% | 68% |
| Average Age | 18.2 | 19.7 | 22.0 | 24.3 | 25.2 | 27.1 |
| Average Condition | 3.69 | 3.68 | 3.62 | 3.57 | 3.55 | 3.50 |
| **Heavy Rail** | | | | | | |
| Total Fleet | 10,074 | 10,157 | 10,173 | 10,366 | 10,375 | 11,093 |
| Percent Overage Vehicles | 27% | 37% | 36% | 40% | 40% | 36% |
| Average Age | 17.8 | 19.3 | 21.0 | 22.5 | 23.0 | 20.0 |
| Average Condition | 3.47 | 3.39 | 3.31 | 3.26 | 3.25 | 3.41 |
| **Light Rail** | | | | | | |
| Total Fleet | 943 | 955 | 1,132 | 1,400 | 1,524 | 1,637 |
| Percent Overage Vehicles | 10% | 12% | 10% | 15% | 13% | 14% |
| Average Age | 14.9 | 14.8 | 14.6 | 18.9 | 18.4 | 16.1 |
| Average Condition | 3.64 | 3.55 | 3.63 | 3.62 | 3.63 | 3.61 |
| **Total Rail** | | | | | | |
| **Total Fleet** | 16,501 | 16,729 | 17,042 | 17,751 | 17,755 | 18,813 |
| Percent Overage Vehicles | 23% | 33% | 32% | 39% | 38% | 37% |
| Weighted Average Age | 17.7 | 19.1 | 20.4 | 21.6 | 21.8 | 20.4 |
| Weighted Average Condition | 3.54 | 3.48 | 3.42 | 3.40 | 3.38 | 3.47 |

[1] Rail conditions for commuter rail vehicles have been revised downward based on revised deterioration schedules. Average conditions for the rail fleet are therefore also lower than reported in earlier reports.

*Sources: Transit Economic Requirements Model and National Transit Database.*

**Exhibit 3-46** *Commuter Rail Vehicle Condition Versus Age*




# Urban Rail Maintenance Facilities

## *Age*

Data collected since the last edition of this report through the ACM reveal that a much larger percentage of rail maintenance facilities are less than 10 years old and a much smaller percentage are more than 30 years old than was previously estimated. In 2002, 30 percent of all rail facilities were estimated to be 10 years old or less (compared with 15 percent in 2000), and 33 percent were estimated to be more than 30 years old (compared with 48 percent in 2000) [*Exhibit 3-47*].

**Exhibit 3-47** *Rail Maintenance Facility Ages*

| Age of Facility | Number | Percent |
|---|---|---|
| 0-10 | 47 | 30% |
| 11-20 | 38 | 24% |
| 21-30 | 19 | 12% |
| 31+ | 52 | 33% |
| **Total** | **156** | **100%** |

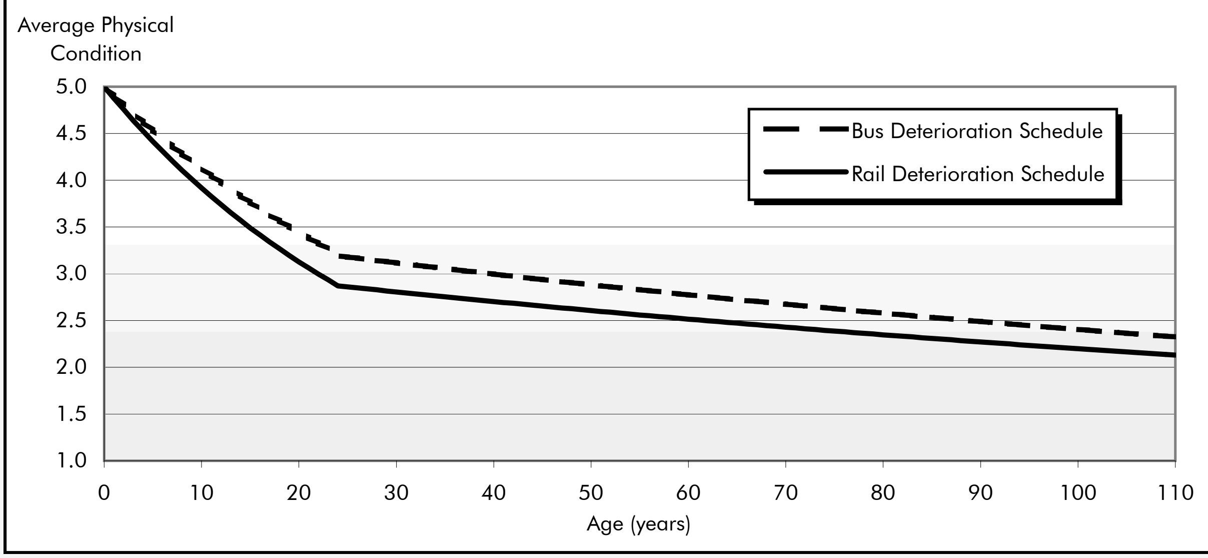
*Source: National Rail Assessment.*

Note: Includes Alaska Rail and Inclined Plane.

## Q. Do rail and bus maintenance facilities follow the same deterioration schedules?

**A.** Bus and rail maintenance facilities have similar, but not identical, deterioration schedules. Bus maintenance facilities are, on average, in slightly better condition than rail maintenance facilities of the same age [*Exhibit 3-48*].

**Exhibit 3-48** *Bus and Rail Maintenance Facilities Average Conditions and Age*

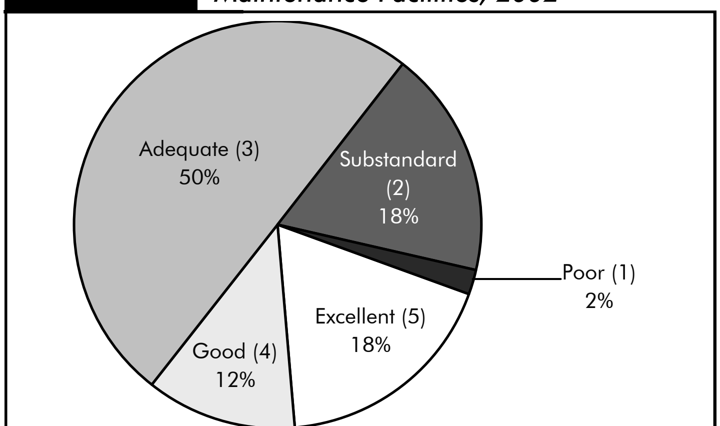



*Source: National Bus and Rail Condition Assessments.*

## *Condition*

In 2002, the average condition of urban rail maintenance facilities was estimated to be 3.56, compared with 3.20 in 2000. The estimated condition improved largely due to expanded information on facilities ages collected by the ACM. As *Exhibit 3-49* shows, in 2000, 30 percent of all rail maintenance facilities were estimated to be in good or excellent condition and 80 percent in adequate or better condition. Twenty percent, however, are believed to be in poor or substandard condition and have immediate capital investment needs.

**Exhibit 3-49** *Distribution of Condition of Urban Rail Maintenance Facilities, 2002*




| Condition | 2002 Number | 2002 Percent |
|---|---|---|
| Excellent (5) | 27 | 18% |
| Good (4) | 18 | 12% |
| Adequate (3) | 76 | 50% |
| Substandard (2) | 27 | 18% |
| Poor (1) | 3 | 2% |
| **Total** | **152** | **100%** |

*Source: Transit Economic Requirements Model.*

Note: Excludes Alaska Rail and Inclined Plane.

# Other Rail Urban Infrastructure

The condition of rail urban infrastructure other than maintenance facilities and stations is estimated on the basis of decay curves principally relating condition to age, although the conditions a few nonvehicle assets are also estimated on the basis of usage and maintenance history. 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. Additional, but considerably more limited, asset condition data were provided by Metra and Pace, two transit operators in the Chicago area at that time. The data collected were used to estimate decay curves for more than 40 types of transit assets and averaged into a smaller number of aggregate decay curves, according to each asset's contribution to the total replacement cost for the group of assets into which it was averaged. As a part of the validation process, industry experts reviewed the results and assessed whether they accurately captured the dynamics of transit asset decay. The results were published in *The Estimation of Transit Asset Condition Ratings, Heavy Rail Systems,* January 1996.

Infrastructure data 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 edition of the report also provides estimates of average condition by asset type [*Exhibit 3-50*].

**Exhibit 3-50** *Physical Condition of U.S. Transit Rail Infrastructure—Selected Years, 1997–2002*

| | CONDITION ESTIMATES | | Distribution of Assets by Condition | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 POOR | | | 2 SUBSTANDARD | | | 3 ADEQUATE | | | 4 GOOD | | | 5 EXCELLENT | | |
| | 2000 | 2002 | 1997 | 2000 | 2002 | 1997 | 2000 | 2002 | 1997 | 2000 | 2002 | 1997 | 2000 | 2002 | 1997 | 2000 | 2002 |
| **Maintenance** | | | | | | | | | | | | | | | | | |
| Facilities | 3.20 | 3.56 | 6% | 12% | 2% | 17% | 24% | 18% | 17% | 43% | 50% | 53% | 21% | 12% | 7% | 0% | 18% |
| Yards | 4.00 | 3.64 | 0% | 0% | 0% | 0% | 0% | 20% | 37% | 50% | 48% | 63% | 50% | 31% | 0% | 0% | 1% |
| **Power Systems** | | | | | | | | | | | | | | | | | |
| Substations | 4.17 | 4.33 | 12% | 6% | 4% | 6% | 6% | 2% | 10% | 10% | 12% | 57% | 58% | 51% | 15% | 20% | 31% |
| Overhead Wire | 4.00 | 3.93 | 5% | 6% | 8% | 11% | 6% | 11% | 18% | 11% | 16% | 34% | 61% | 46% | 32% | 16% | 19% |
| Third Rail | 4.05 | 4.10 | 14% | 8% | 7% | 11% | 8% | 7% | 15% | 11% | 13% | 43% | 48% | 50% | 17% | 24% | 23% |
| **Track** | 4.06 | 4.17 | 7% | 7% | 6% | 10% | 10% | 9% | 10% | 12% | 12% | 49% | 45% | 34% | 24% | 26% | 40% |
| **Structures** | | | | | | | | | | | | | | | | | |
| Elevated Structure | 4.02 | 4.27 | 1% | 2% | 2% | 29% | 22% | 7% | 12% | 16% | 3% | 59% | 59% | 83% | 0% | 2% | 5% |
| Underground Tunnels | 3.75 | 4.09 | 9% | 12% | 8% | 19% | 11% | 9% | 18% | 19% | 13% | 47% | 46% | 37% | 7% | 12% | 34% |
| **Stations** | 3.44 | 2.99 | 15% | 0% | 30% | 13% | 16% | 26% | 15% | 50% | 18% | 46% | 33% | 22% | 11% | 1% | 3% |

*Sources: Transit Economic Requirements Model (TERM).*

Information collected by ACM and directly from MTA has replaced 46 percent of the nonvehicle data collected from these earlier studies, which was used in the last edition of this report. The nonvehicle asset condition levels for 2002 provided in Exhibit 3-50 reflect these updates to the asset inventory information and new information provided to the NTD. The decay curves used to estimate conditions are the same as used in previous editions of this report. Conditions for 1992, reported in the 2000 edition of this report, have been dropped from Exhibit 3-50. These condition estimates were based on earlier surveys and are not fully comparable with estimates for subsequent years.

As discussed earlier, rail maintenance facilities are in better condition than previously estimated. By comparison, the condition of maintenance *yards* (vehicle storage yards) has declined. In 2002, 32 percent of all yards were in good or excellent condition, compared with 50 percent in 2000. The percentage in substandard condition increased from 0 percent in 2000 to 20 percent in 2002. No yards were reported as being in poor condition in either 2000 or 2002.

*Power systems* are on average in good condition. Changes in the conditions of power systems are mixed, depending on the particular asset type. The estimated condition of substations increased from 4.17 in 2000 to 4.33 in 2002. The percentage of substations in excellent condition increased from 20 percent in 2000 to 31 percent in 2002. The condition of overhead wire declined slightly from 4.00 in 2000 to 3.93 in 2002. In 2002, 65 percent of overhead wire was reported to be in good or excellent condition compared with 77 percent in 2000. The estimated conditions of third rail increased very slightly from 4.05 to 4.10. There were only very minor changes in the distribution of third rail according to condition.

*Track conditions* are estimated to have improved slightly from an average condition of 4.06 in 2000 to an average condition of 4.17 in 2002, principally on the basis of updated information. The percentage of track in excellent condition increased from 26 percent in 2000 to 40 percent in 2002, and the percentage in good condition declined from 45 to 34 percent. The percentage of track in substandard or poor condition was relatively unchanged, falling from 17 to 15 percent.

The estimated conditions of *structures* also improved. The average condition of *elevated structures* increased from 4.02 in 2000 to 4.27 in 2002. The percentage of elevated structures in good or excellent condition increased from 59 percent in 2000 to 83 percent in 2002, and the percent in excellent condition increased from two to five percent over the same period. The average condition of *underground tunnels* increased from 3.75 to 4.09. The percentage of underground tunnels in excellent condition increased from 12 percent in 2000 to 34 percent in 2002, largely due to a shift out of the good to the excellent condition category. The percentage of underground tunnels in substandard and poor condition decreased from 23 percent in 2000 to 17 percent in 2002.

The condition of *rail stations* is estimated to have declined from 3.53 to 2.87. Although the percentage of all stations in excellent condition increased from 1 percent in 2000 to 3 percent in 2002, the percentage in good condition fell from 33 to 22 percent and the percentage in substandard or poor condition increased from 42 percent in 2000 to 56 percent in 2002. FTA will be undertaking physical inspections of a sample of stations in 2004. The results of these inspections will be included in the 2006 edition of this report.

**Q.** How does the condition of nonrail stations compare with the condition of rail stations?

**A.** Nonrail stations are in better condition than rail stations. The condition of nonrail stations is estimated to have declined from 4.65 in 2000 to 4.37 in 2002. The condition of *stations* for all modes combined declined from 3.44 in 2000 to 2.99 in 2002.

# The Value of U.S. Transit Assets

The value of the transit infrastructure in the United States is estimated to be $347.7 billion in 2002 dollars based on the information contained in TERM and on data collected through the NTD and the other data collection efforts discussed in this chapter. It excludes the value of assets that belong to rural and special service operators that do not report to the NTD. The reader should bear in mind that this is a very preliminary estimate, which will be subject to revision as more information is collected. Rail assets are estimated to be $264.6 billion, nonrail assets are estimated to be $66.7 billion, and systems are estimated to be $16.4 billion [*Exhibit 3-51*]. The systems category comprises assets that serve more than one mode within a single agency. Systems investments 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 vans and autos).

**Exhibit 3-51** *Estimated Valuation of the Nation's Transit Assets, 2002*

(Billions of current dollars)

| | Nonrail | Rail | Systems | Total |
|---|---|---|---|---|
| Maintenance Facilities | $38.0 | $6.4 | $4.4 | $48.9 |
| Guideway Elements | $2.5 | $130.9 | $0.6 | $134.0 |
| Stations | $1.4 | $42.9 | $9.0 | $53.3 |
| Power Systems | $0.6 | $33.6 | $1.5 | $35.6 |
| Vehicles | $24.3 | $50.7 | $0.9 | $75.9 |
| Grand Total | $66.7 | $264.6 | $16.4 | $347.7 |

*Source: Transit Economic Requirements Model.*

# Rural Transit Vehicles and Facilities

Data on the conditions of rural vehicles and 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 over age. 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 3-52*]. 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 over age.

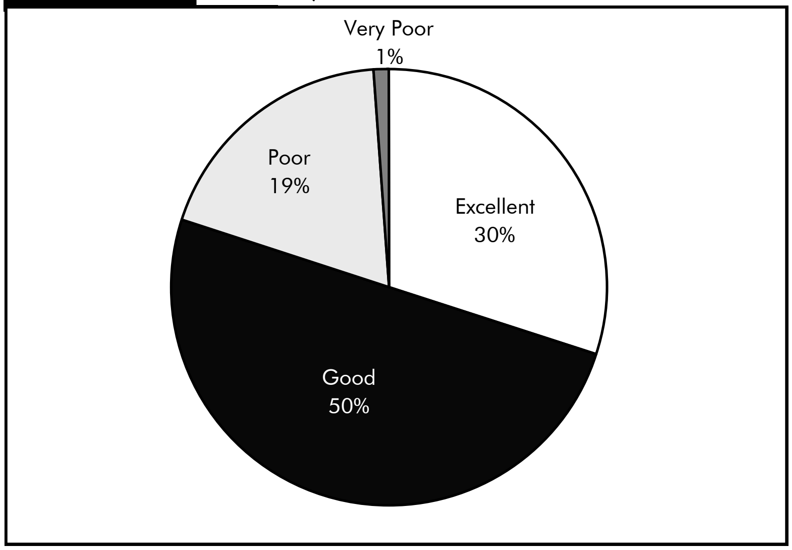
**Exhibit 3-52** *Number of Overage Vehicles and Average Vehicle Age in Rural Transit*

| 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.*

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 3-53*].

**Exhibit 3-53** *The Condition of Rural Bus Maintenance Facilities, 1997–1999*




# 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* highlights the key highway and transit statistics discussed in this chapter and compares them with the values from the 2002 C&P Report. The first data column contains the values reported in the 2002 report, which were based on 2000 data. Revised 2000 data are shown in the second column. The third column reports 2002 values.

**Exhibit 4-1** *Comparison of Highway and Transit Operational Performance Statistics with Those in the 2002 C&P Report*

| Statistic | 2000 Data: 2002 C&P Report | 2000 Data: Revised as of 12/23/04 | 2002 Data |
|---|---|---|---|
| Percent of Additional Travel Time | 51% | 35% | 37% |
| Annual Hours of Traveler Delay per Year | 31.2 | 21.8 | 23.8 |
| Percent of Travel Under Congested Conditions | 33.1% | 29.4% | 30.5% |
| Daily Vehicle-Miles of Travel (DVMT) per Lane-Mile | | | |
| Interstates in Urbanized Areas | 15,310 | 15,333 | 15,689 |
| Other Freeways and Expressways in Urbanized Areas | 12,210 | 12,285 | 12,730 |
| Other Principal Arterials in Urbanized Areas | 6,103 | 6,284 | 6,408 |
| Passenger-Mile Weighted Average Operating Speed (miles per hour) | | | |
| Total | 19.6 | | 20.1 |
| Rail | 24.9 | | 25.8 |
| Nonrail | 13.7 | | 13.8 |
| Annual Passenger Miles per Capacity-Equivalent Vehicle (thousands) | | | |
| Bus | 393 | 393 | 390 |
| Heavy Rail | 784 | 697 | 675 |
| Commuter Rail | 914 | 863 | 831 |
| Light Rail | 688 | 546 | 528 |
| Demand Response | 169 | 188 | 178 |

To examine highway operational performance, this chapter looks at the Percent of Travel Under Congested Conditions, the Percent of Additional Travel Time, and Annual Hours of Traveler Delay. An increase in all three of these measures from 2 years ago indicates a decline in mobility in the urbanized portions of the Nation.

Percent of Travel Under Congested Conditions is defined as the percentage of traffic on the freeways and principal arterial streets in urbanized areas moving at less than free-flow speeds. This measure has increased from 29.4 percent in 2000 to 30.5 percent in 2002. Based on this measure, the average congested period or length of "Rush Hour" has increased 6 minutes from 2000 to 2002. For the purposes of this chapter, "rush hour" is defined as the combined periods of time for the A.M. and P.M. travel times when traffic is moving at less than free-flow speeds. The average "rush hour" in 2002 was approximately 6.6 hours; however, some communities have experienced average lengths of congested periods of up to 8 hours.

Percent of Additional Travel Time is an indicator of the additional time required to make a trip during the congested peak travel period rather than at other times of the day. In 2002, a trip that would take 20 minutes during nonpeak, noncongested conditions would typically require 27.4 minutes if taken during the peak period of travel or 37 percent longer. In 2000, that same trip would have required 27.0 minutes if taken during the peak travel period, 35 percent longer than under nonpeak, noncongested conditions.

**Q.** **Why are the revised 2000 values for Percent of Additional Travel Time, Annual Hours of Traveler Delay per Year, and Percent of Travel Under Congested Conditions lower than the 2000 values originally presented in the 2002 Conditions & Performance report?**

**A.** These statistics are calculated by the Texas Transportation Institute (TTI) for the FHWA. Since the release of the 2002 Conditions & Performance Report, the TTI has revised its current methodology and recalculated historic figures as well. The new methodology includes the effects of operational improvements in the calculation of mobility estimates. One major change was improved consideration of the impacts of operational improvements on congestion, which resulted in reduced estimates of congestion levels.

Annual Hours of Traveler Delay is an indicator of the total time an individual loses in a single year as a result of traveling under congested conditions. In 2002, the average driver experienced a loss of 23.8 hours due to congestion. This is an increase of 2.0 hours over the amount of annual delay in 2000 or an increase of more than 9 percent in only 2 years.

Travel density continues to increase on all functional classes as daily vehicle miles traveled (DVMT) is growing faster than new lane miles are added. DVMT per lane mile on Interstates in urbanized areas grew from 15,333 to 15,689 (2.3 percent) between 2000 and 2002. DVMT per lane mile on urbanized other freeways and expressways grew from 12,285 to 12,730 (3.6 percent) over the same period.

The highway information presented in this chapter is based on data from the Highway Performance Monitoring System (HPMS), work supplied by the Texas Transportation Institute (TTI), and statistics from the *Federal Highway Administration Fiscal Year 2005 Performance Plan.*

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.

Most transit passengers do not experience unacceptably long waiting times. The 2001 National Household Travel Survey (NHTS) conducted by the Federal Highway Administration (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, to use transit even when the service is not as frequent or reliable as they may prefer.

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 motor bus fleet. As shown in Exhibit 4-1 vehicle utilization rates have been revised using new capacity-equivalent factors as discussed in Chapter 2. This revision does not affect year-to-year changes. Rail vehicle utilization rates have increased from 1993, peaking in 2000 or 2001 and declining slightly across all rail modes in 2002. With the exception of ferryboats, the utilization of non-rail modes, including buses, was lower in 2002 than in 2000 and 1993.

Average transit operating speeds remained relatively constant between 1993 and 2002, increasing slightly between 2000 and 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 2002, the average speed was 19.9 miles per hour, up from 19.6 miles per hour in 2000, and just below the 10-year average of 20.1 miles per hour. The average operating speed as experienced by passengers on rail modes was 25.3 miles per hour in 2002, compared with 24.9 miles per hour in 2000, and a 10-year average of 25.8 miles per hour. The average operating speed of nonrail vehicles, which is affected by traffic, road, and safety conditions, was 13.7 miles per hour in 2002, the same as in 2000 and 2001, and just below the 10-year average of 13.8.

# 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. Safety performance measures are discussed separately in Chapter 5.

While congestion is conceptually easy to understand, it has no universally accepted definition or measurement. The public's perception seems to be that congestion is getting worse, and by some measures it is. However, the perception of what constitutes congestion varies from place to place. Traffic conditions that may be considered congestion 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.

This chapter focuses primarily on measuring operational performance trends from a broad perspective. Chapter 13 discusses issues relating specifically to freight transportation. Chapter 12 includes a discussion of operations strategies that can be effective in addressing some of the operational performance issues identified in this chapter. The "Introduction" to Part II of this report discusses congestion pricing, a potentially effective strategy for reducing peak period congestion. Issues relating to improving the measurement of operational performance are discussed in more depth in the Part V "Afterword" section.

## 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.

**Q.** How do the Percent of Additional Travel Time, Annual Hours of Delay, and Percent of Travel Under Congested Conditions values shown in this report compare to those reported by the Texas Transportation Institute (TTI) in its annual Urban Mobility Study?

**A.** The values shown in this report and in the annual FHWA Performance Plans are calculated by TTI on behalf of the FHWA, using data from the Highway Performance Monitoring System for more than 380 cities/urbanized areas ranging in population from less than 500,000 in population to over 3 million in population are included in this work.

The Urban Mobility Study prepared by the TTI concentrates on 85 urban areas in the Nation 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 85 urbanized areas in the survey do not represent a random sample of all urbanized areas, and instead include most of the largest areas. Consequently, one would 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.

In recent years, the FHWA has adopted three indicators for measuring congestion for use in the annual FHWA Performance Plans: Percent of Additional Travel Time, Annual Hours of Delay, and Percent of Travel Under Congested Conditions. All three measures were included in the *FHWA Fiscal Year 2003 Performance Plan,* while the *FHWA's Fiscal Year 2004 Performance Plan* narrowed the focus to the Percent of Travel Under Congested Conditions measure. All three indicators are presented in this chapter.

## Percent of Additional Travel Time

Percent of Additional Travel Time is an indicator of 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 make a trip during the congested period of travel.

*Exhibit 4-2* shows the growth of the Percent of Additional Travel Time since 1987. In 2002, an average peak period trip required 37 percent longer than the same trip under nonpeak, noncongested conditions. In 1987, an average 20-minute trip during noncongested periods required 24.4 minutes under congested conditions. The same trip in 2002 required 27.4 minutes or an additional 3 minutes.

**Exhibit 4-2** *Percent of Additional Travel Time, 1987–2002*

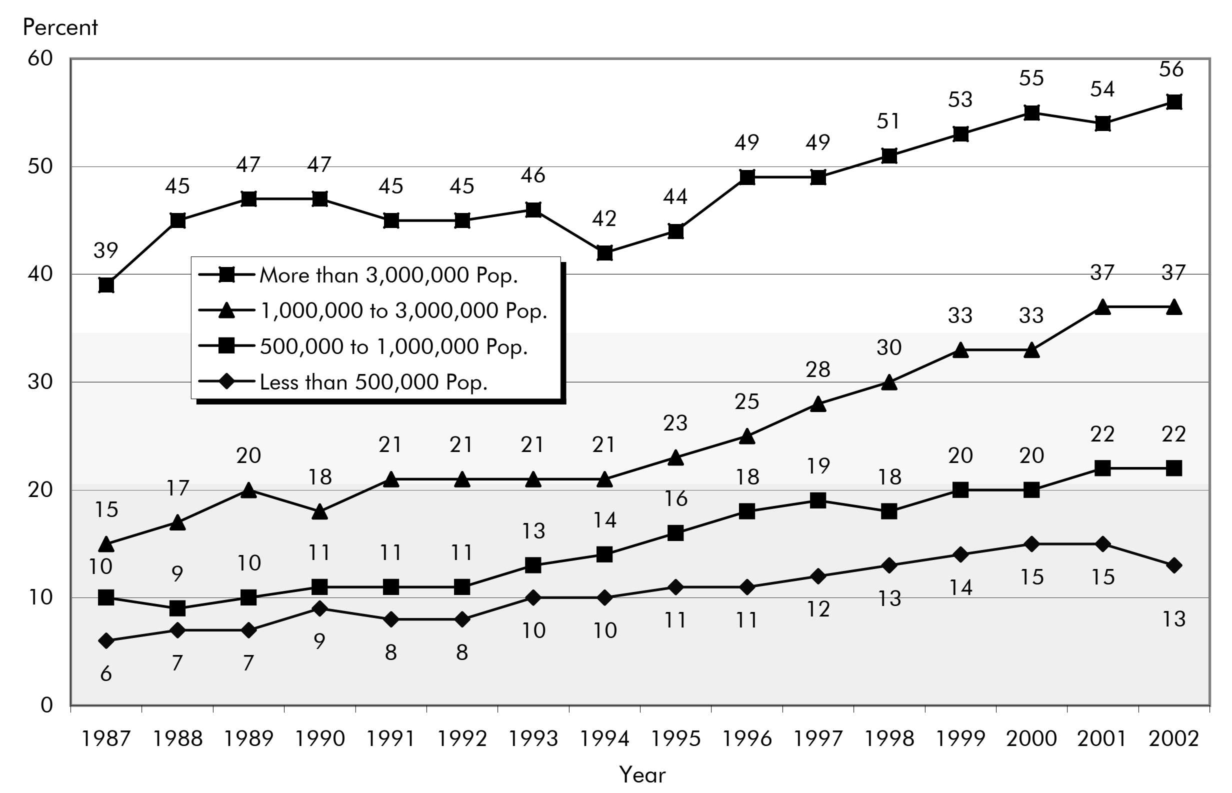
| Year | Percent Additional Travel Time |
|---|---|
| 1987 | 22% |
| 1988 | 26% |
| 1989 | 28% |
| 1990 | 28% |
| 1991 | 27% |
| 1992 | 26% |
| 1993 | 27% |
| 1994 | 26% |
| 1995 | 27% |
| 1996 | 30% |
| 1997 | 30% |
| 1998 | 32% |
| 1999 | 34% |
| 2000 | 35% |
| 2001 | 36% |
| 2002 | 37% |

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

*Exhibit 4-3* demonstrates that the additional travel time required because of congestion tends to be higher in larger urbanized areas than smaller ones. However, the largest increase from 1987 to 2002 occurred in urbanized areas with populations between 1 million and 3 million, as the Percent of Additional Travel Time increased from 15 to 37 percent. This equates to a 4.4-minute increase (from 23.0 to 27.4 minutes) for an average trip that would require 20 minutes during noncongested periods.

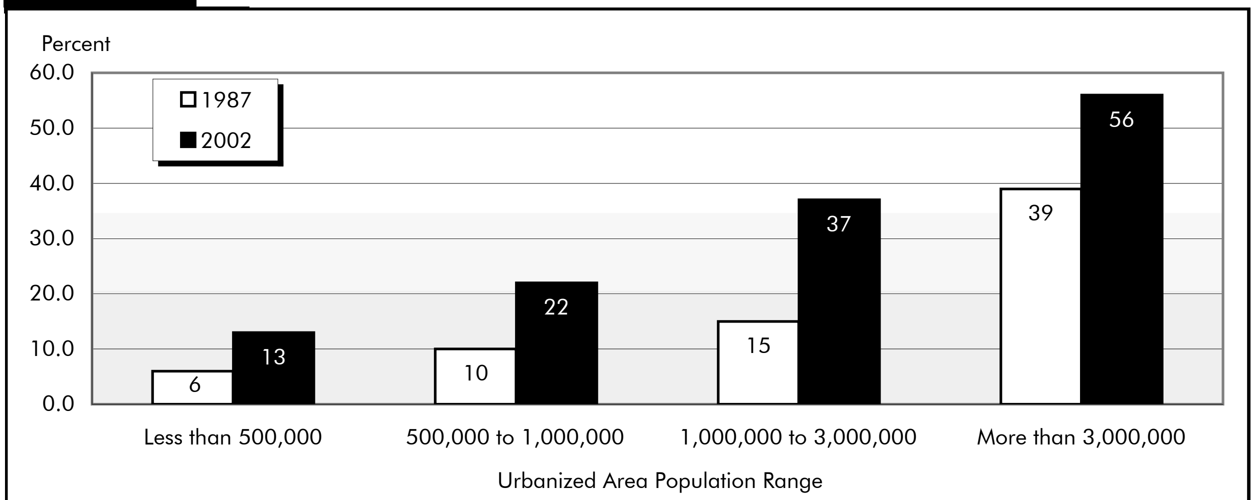
*Exhibit 4-4* directly compares the years 1987 and 2002 to emphasize the impact of increased congestion. The exhibit shows that, in 2002, smaller urbanized areas with populations of less than 500,000 are experiencing nearly the same level of additional travel time because of congestion as urbanized areas with populations of 1 million to 3 million experienced in 1987. This indicates a growing and expanding problem for the Nation's urban highway system.

**Exhibit 4-3** *Percent of Additional Travel Time by Urbanized Area Size, 1987–2002*




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

**Exhibit 4-4** *Percent of Additional Travel Time by Urbanized Area Size, 1987 Versus 2002*

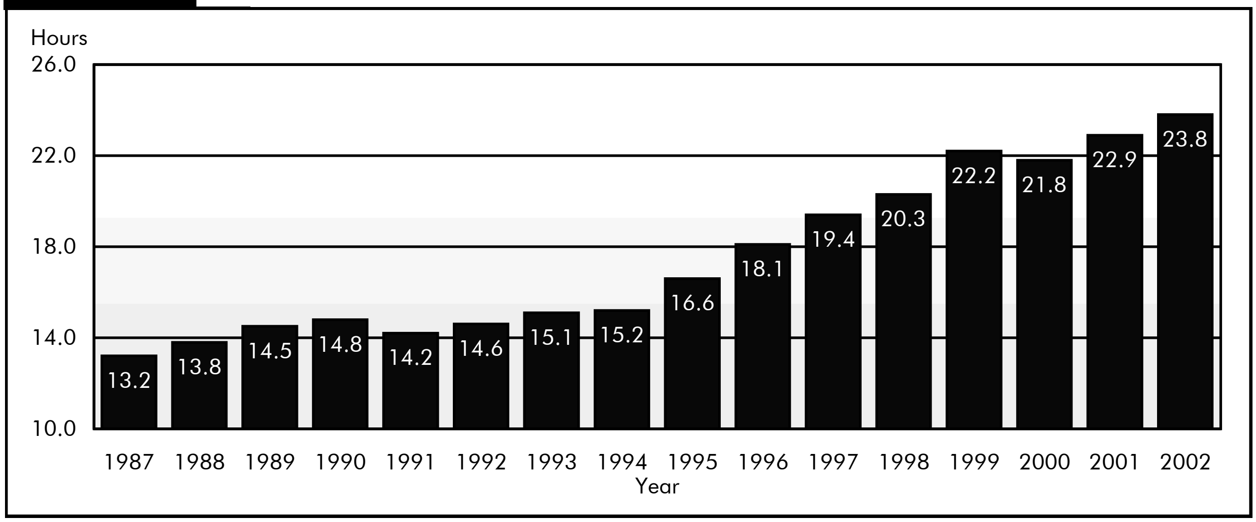



*Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures*

## *Annual Hours of Traveler Delay*

Annual Hours of Traveler Delay represents the average number of hours per year that drivers are delayed in traffic because of recurring congestion and incidents, such as breakdowns and crashes. *Exhibit 4-5* shows that, in 2002, the average driver lost 23.8 hours because of congestion. This is an increase of 2 hours over the amount of annual delay in 2000, or an increase of more than 9 percent in only 2 years. It is an increase of 10.6 hours, or more than 80 percent, since 1987.

**Exhibit 4-5** *Annual Hours of Traveler Delay, 1987–2002*

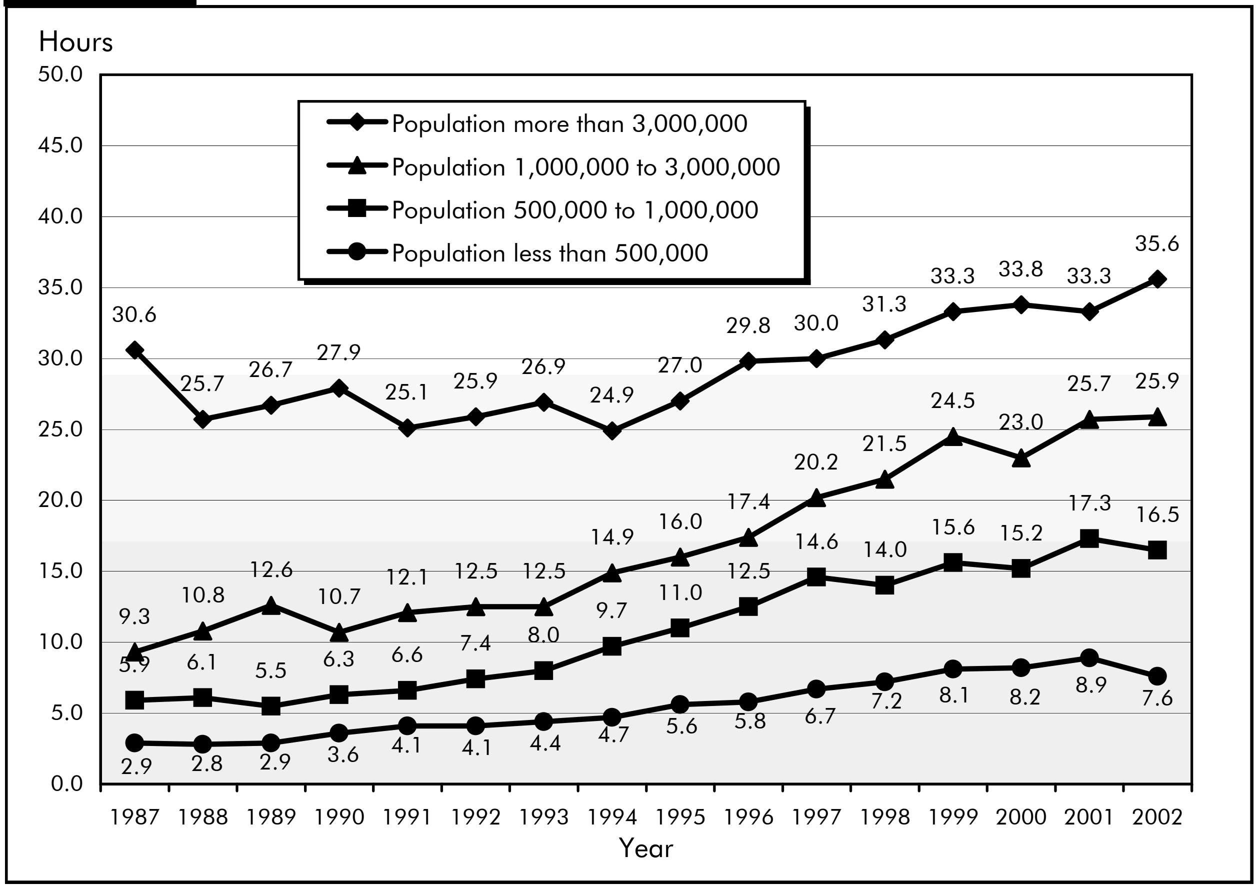



*Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.*

*Exhibit 4-6* shows that cities over 3 million in population have experienced an increase of nearly 2 hours in the Annual Hours of Traveler Delay per traveler since 2000. The average delay per traveler for these cities was 35.6 hours per driver per year in 2002. Cities with populations between 1 million and 3 million experienced the greatest increase in number of hours of annual delay per person, from 23.0 hours in 2000 to 25.9 hours in 2002, for an increase of 2.9 hours of delay per person over the 2-year period. Cities with populations of less than 500,000 actually experienced a decline in traveler delay since 2000—from 8.9 hours to 7.6 hours, a decrease of more than 14 percent.

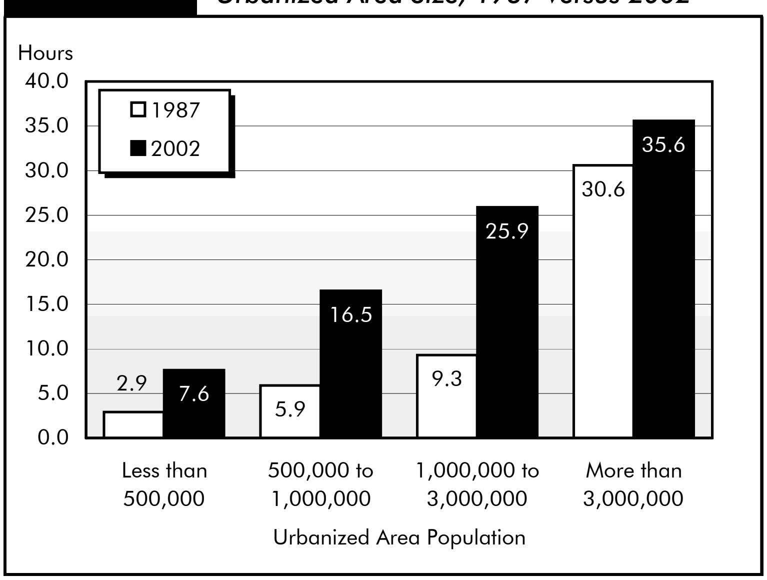
Overall, the level of traveler delay in all urbanized areas is greater than that of 1987. Even though urban areas with populations of less than 500,000 had a decline in traveler delay from 2000 to 2002, drivers in these areas in 2002 were contending with greater delay than drivers in cities double their size in 1987, but without the accompanying population growth. The level of delay faced by drivers in cities of less than 500,000 population in 2002 was approaching that experienced by drivers in cities of 1,000,000 to 3,000,000 in 1987. The significance of the impact of increased Annual Hours of Traveler Delay is shown in *Exhibit 4-7.*

**Exhibit 4-6** *Annual Hours of Traveler Delay by Urbanized Area Size, 1987–2002*




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

**Exhibit 4-7** *Annual Hours of Traveler Delay by Urbanized Area Size, 1987 Versus 2002*




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

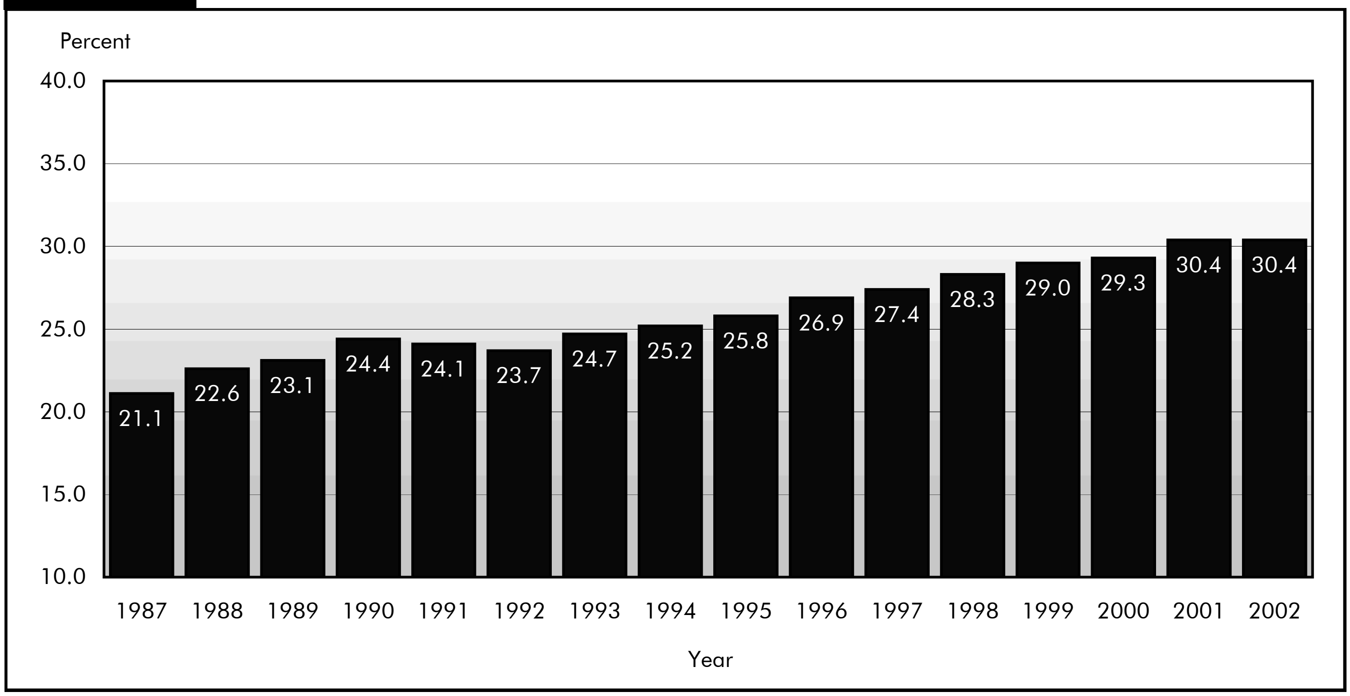
## *Percent of Travel Under Congested Conditions*

The Percent of Travel Under Congested Conditions is defined as the percentage of daily traffic on freeways and principal arterial streets in urbanized areas moving at less than free-flow speeds. *Exhibit 4-8* shows that this percentage has increased from 29.3 percent in 2000 to 30.4 percent in 2002. The average congested travel period has increased from 5.4 hours in 1987 to 6.6 hours in 2002—an increase in length of 72 minutes, or more than 22 percent, over a period of 15 years *(Exhibit 4-9)*.

**Q.** What goal was set for the Percent of Travel Under Congested Conditions in the *FHWA FY 2005 Performance Plan*?

**A.** The plan observes that this percentage has increased by annual rates ranging from 0.3 to 1.1 in recent years. The goal adopted in the FHWA Performance Plan is to slow the annual rate of increase to 0.5 percent. The target is to hold the increase to 33.0 percent in FY 2005, or 0.2 percent below a projected increase of 33.2 percent.

**Exhibit 4-8** *Percent of Travel Under Congested Conditions, 1987–2002*

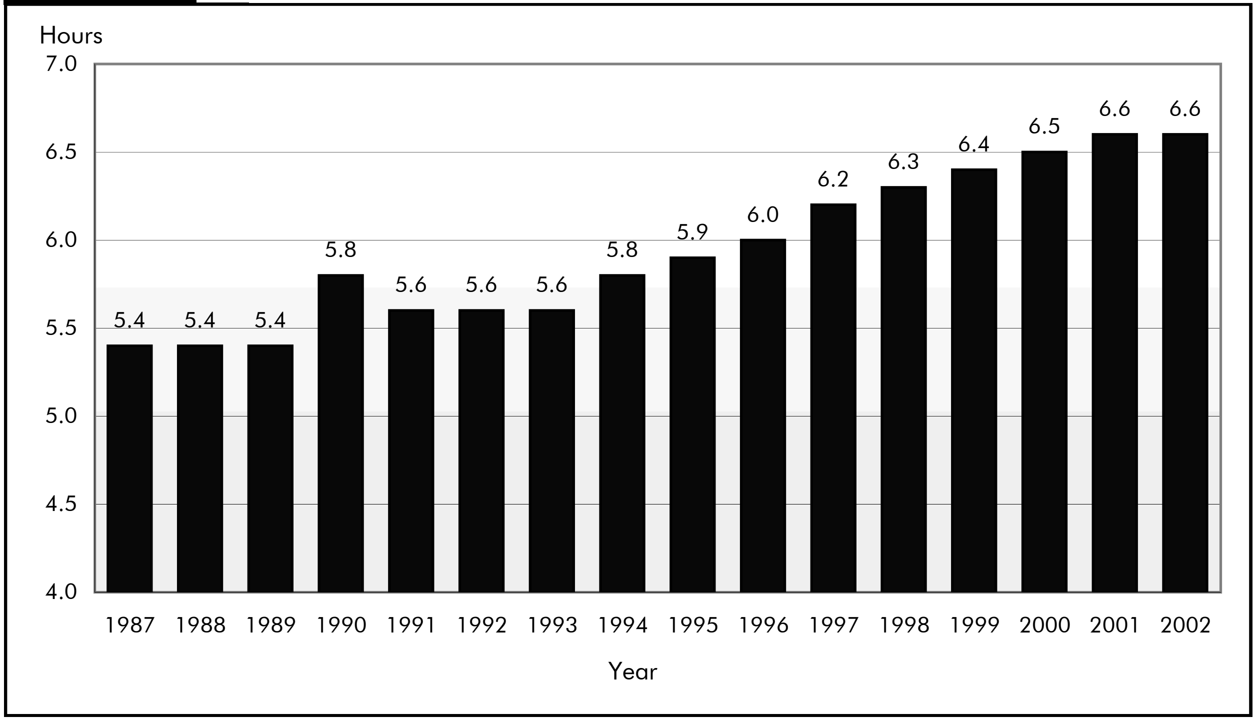



*Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures*

Exhibit 4-9 illustrates a major problem encountered on a daily basis by all users of highway systems in urbanized areas. According to research done by the TTI, periods of recurring congestion are getting longer. What has been called "rush hour" has seen a steady increase in length since 1993. In some urbanized areas, 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 recreational travel is adversely impacted in urbanized areas.

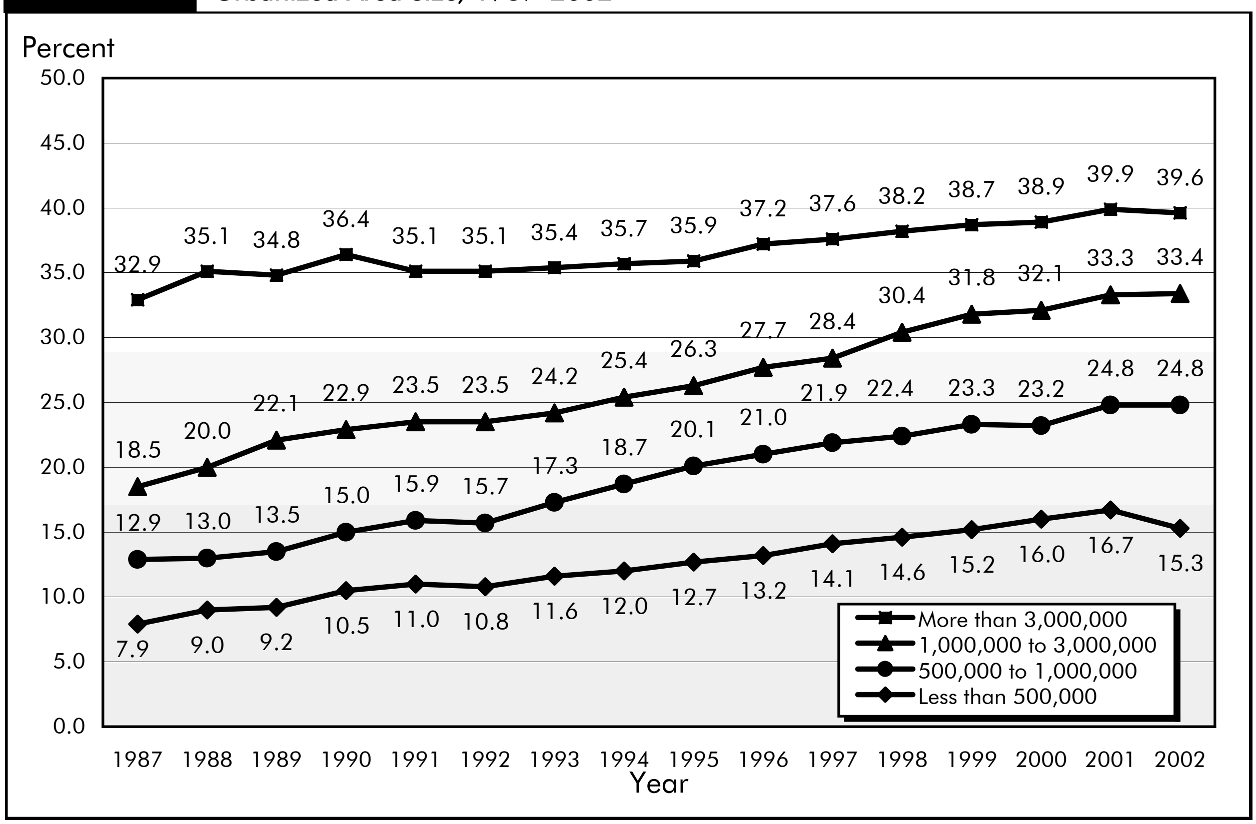
*Exhibit 4-10* shows that in 2002, 39.6 percent of daily travel in urban areas with populations greater than 3 million occurred under congested conditions. For urban areas with populations of less than 500,000, the Percent of Congested Travel was 15.3 percent in 2002.

**Exhibit 4-9** *Average Congested Travel Period*




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

**Exhibit 4-10** *Percent of Travel Under Congested Conditions by Urbanized Area Size, 1987–2002*




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

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 in the most congested metropolitan areas.

## 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. Congestion, then, is a major hurdle for businesses in the Nation's economy.

The TTI's *2004 Urban Mobility Report* estimates that, in the 85 urban areas studied in 2002, drivers experienced in excess of 3.5 billion hours of delay and wasted 5.66 billion gallons of fuel. The total congestion cost for these areas, including wasted fuel and time, was estimated to be approximately $63.2 billion. Over 61 percent of that cost, or approximately $38.7 billion, was experienced in the 10 metropolitan areas with the most congestion. *Exhibit 4-11* shows the 20 urban areas with the highest congestion costs, according to the TTI.

**Q.** Are there major changes to the methods used in the *2004 Urban Mobility Study* compared to the methods used in the 2001 Urban Mobility Study cited in the 2002 Conditions & Performance report?

**A.** Two major changes were made in the *2004 Urban Mobility Study.*

- The value of truck delay cost is lower than in previous reports resulting in lower total congestion costs.
- The number of urban areas studied was increased from 75 to 85 thereby providing a larger base of major population areas for analysis.

**Q. What was reported in the 2001 National Household Travel Survey on the public perception of congestion on the Nation's highway system?**

**A.** The NHTS asked respondents to classify their views of various transportation system issues, including congestion, in one of five categories. The overall response was more positive than expected, given the prominence of the congestion issue in public discourse. Almost half (49.3 percent) of the survey respondents reported that congestion was not a problem or a little problem. Those that gave this response are largely older (65+) or younger (16-19), not working, and living in rural or small towns. Only 28 percent overall said congestion was very much of a problem or a severe problem.

However, for those people living in the largest metro areas (3 million or more in population) only 37.2 percent said congestion was not a problem or a little problem, with just as many (39.5 percent) saying it was very much of a problem or a severe problem.

Additional information from the 2001 NHTS may be found at http://nhts.ornl.gov/2001/index.shtml.

## 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. *Exhibits 4-12, 4-13* and *4-14* show that the volume of travel per lane mile has increased from 1993 to 2002 on every functional highway system for which data are collected.

The largest magnitude increase occurred on the Interstate system in the larger urban areas, where the DVMT per lane-mile increased by 2,446 between 1993 and 2002 *(Exhibit 4-13).*

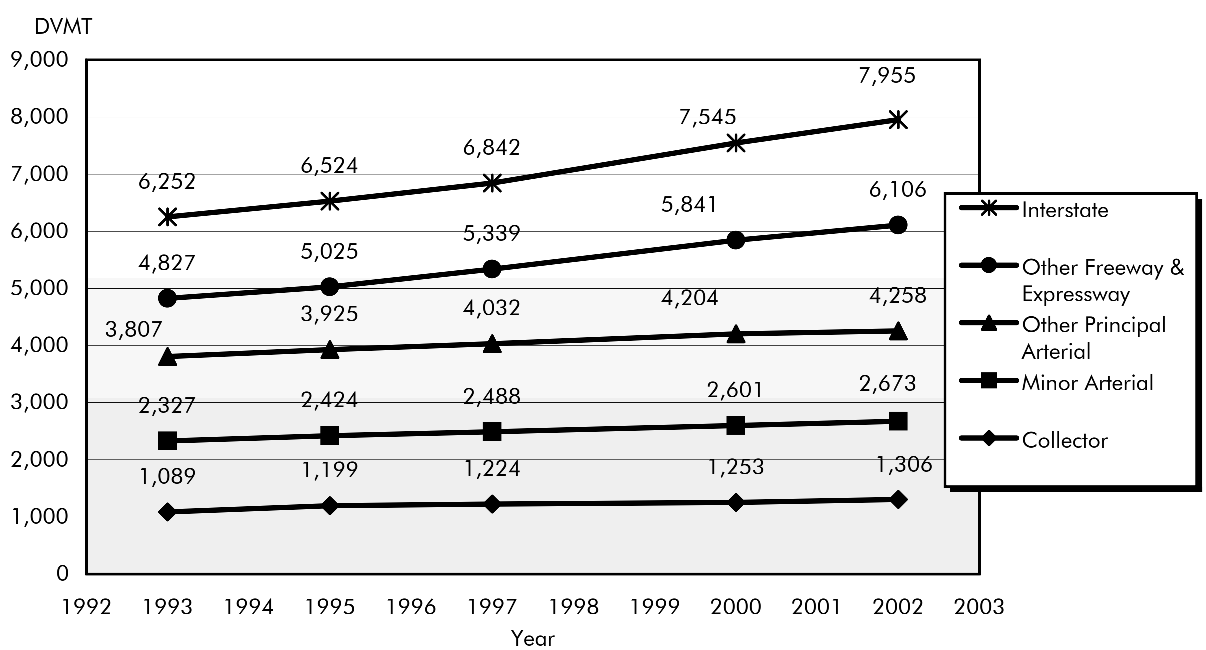
The largest percentage increase occurred on the Interstate system in rural areas, where the DVMT per lane-mile increased by 31.9%, from 4,329 to 5,711 between 1993 and 2002 *(Exhibit 4-14).*

**Exhibit 4-11** *Components of the Congestion Problem—Top 20 Urban Areas*

| Urban Area | Annual Cost of Congestion | | Annual Excess Fuel Consumed | | Annual Travel Delay | |
|---|---|---|---|---|---|---|
| | Millions of Dollars | 2002 Rank | Millions of Gallons | 2002 Rank | Thousands of Hours | 2002 Rank |
| Los Angeles-Long Beach-Santa Ana, CA | 11,231 | 1 | 931 | 1 | 625,063 | 1 |
| New York-Newark, NY-NJ-CT | 7,079 | 2 | 646 | 2 | 394,709 | 2 |
| Chicago, IL-IN | 4,221 | 3 | 365 | 3 | 237,849 | 3 |
| San Francisco-Oakland, CA | 2,779 | 4 | 245 | 4 | 153,195 | 4 |
| Dallas-Fort Worth-Arlington, TX | 2,603 | 5 | 239 | 5 | 147,482 | 5 |
| Miami-Hialeah, FL | 2,558 | 6 | 221 | 6 | 144,824 | 6 |
| Washington, DC-MD-VA | 2,274 | 7 | 203 | 7 | 126,626 | 7 |
| Houston, TX | 2,178 | 8 | 198 | 8 | 123,547 | 8 |
| Detroit, MI | 1,939 | 9 | 176 | 9 | 109,056 | 9 |
| Philadelphia, PA-NJ-DE-MD | 1,871 | 10 | 172 | 10 | 105,528 | 10 |
| Atlanta, GA | 1,717 | 11 | 168 | 11 | 97,220 | 11 |
| Boston, MA-NH-RI | 1,440 | 12 | 130 | 12 | 81,105 | 12 |
| San Diego, CA | 1,314 | 13 | 119 | 13 | 72,126 | 14 |
| Phoenix, AZ | 1,289 | 14 | 116 | 14 | 72,148 | 13 |
| Seattle-Everett, WA | 1,175 | 15 | 110 | 15 | 65,276 | 15 |
| Baltimore, MD | 1,069 | 16 | 101 | 16 | 59,760 | 16 |
| Minneapolis-St. Paul, MN | 971 | 17 | 93 | 17 | 54,606 | 17 |
| Denver-Aurora, CO | 954 | 18 | 83 | 18 | 54,123 | 18 |
| Riverside-San Bernardino, CA | 904 | 19 | 80 | 19 | 49,800 | 19 |
| San Jose, CA | 871 | 20 | 77 | 20 | 48,015 | 20 |
| **Totals:** | **50,437** | | **4,473** | | **2,822,058** | |

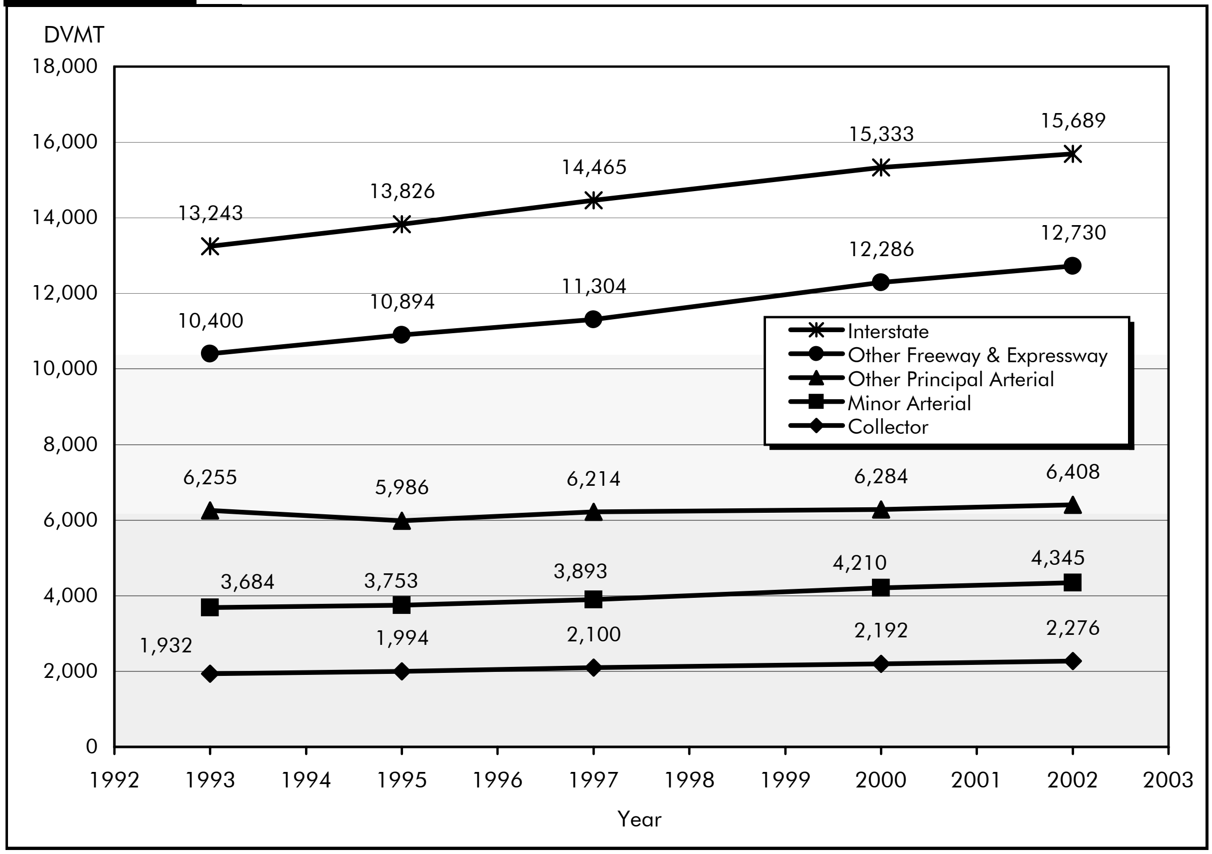
*Source: Texas Transportation Institute, 2004 Urban Mobility Study.*

**Exhibit 4-12** *DVMT per Lane-Mile for Small Urban Systems, 1993–2002*



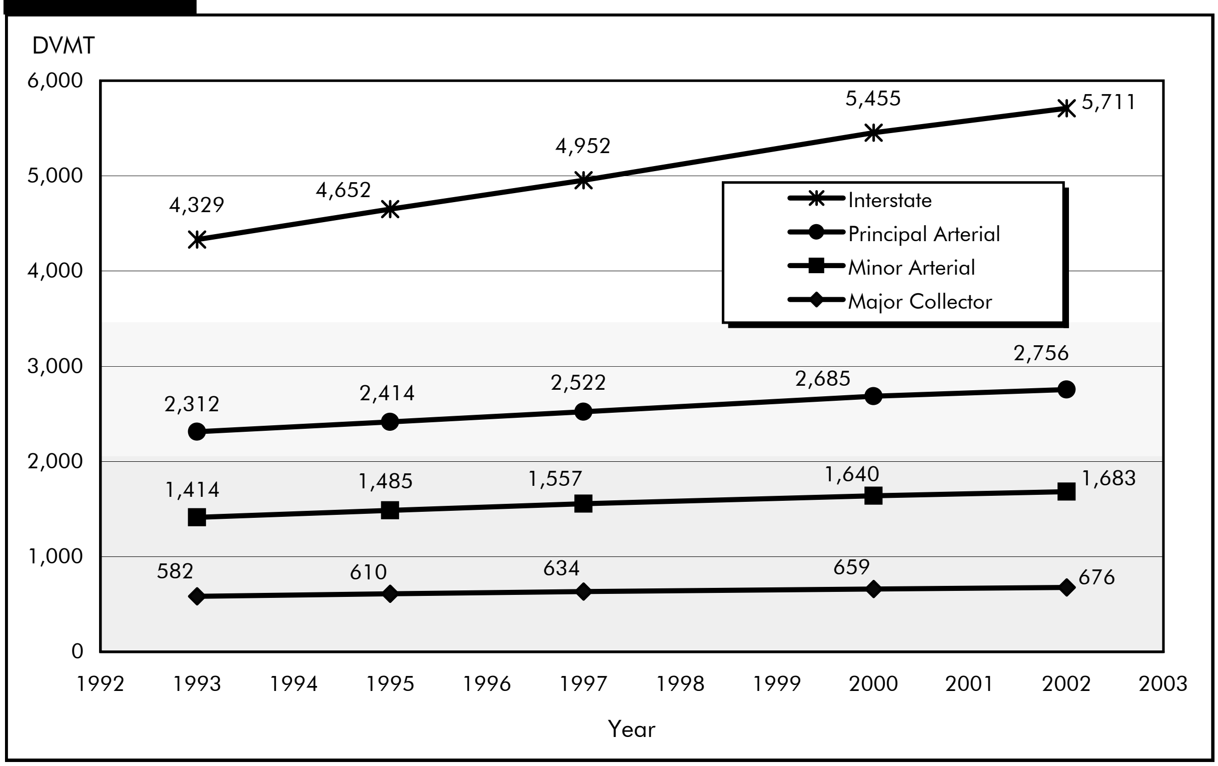

*Source: Highway Performance Monitoring System.*

**Exhibit 4-13** *DVMT per Lane-Mile for Urbanized Systems, 1993–2002*




*Source: Highway Performance Monitoring System.*

**Exhibit 4-14** *DVMT per Lane-Mile for Rural Systems, 1993–2002*




*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 one hour with the theoretical service flow (SF), or the theoretical maximum number of vehicles that could utilize the lane in an hour. The major shortcoming of the V/SF ratio is that it is a single-time indicator of congestion; in other words, it provides a snapshot of what is occurring on a highway section at a particular time, but does not provide a measure of the length of time of a congested period. Also, it does not provide an indication of the effect on congestion caused by emergency situations, adverse weather conditions, construction activities, or any congestion-creating events other than those caused by additional traffic on a facility.

This measure of congestion severity shows mixed results. Based on the V/SF ratio, congestion has increased on 46 percent of the functional classes, decreased on 43 percent, and remained constant on 11 percent since 2000. This indicates that the increases in congestion indicated by broader measures, such as the Percent of Travel Under Congested Conditions cited earlier, could be a function of increases in the duration and extent of congestion, which are aspects of the problem that the V/SF ratio does not address.

*Exhibit 4-15* 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, 64.3 percent had peak-hour travel with a V/SF ratio of 0.80 or higher. Not surprisingly, the values for small urban and rural Interstates were lower.

**Exhibit 4-15** *Percent of Peak-Hour Travel Exceeding V/SF Thresholds*

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

*Source: Highway Performance Monitoring System.*

# Future Research

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 is inexpensive and reliable to collect. 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*

The FHWA is working on a new measure of reliability—the Buffer Index. This index measures the percentage of extra time travelers allow for congestion in order to arrive at a location on-time 95 percent of the time. While 2002 data are currently available for 23 cities, the FHWA is working with the TTI to collect 2003 data for approximately 30 cities. This measure and other measures currently under development will be refined and applied to additional cities as detectors are 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, sub-optimal signal timing, toll facilities, and railroad crossings caused over three and a half billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999. For journeys during peak commuting periods on regularly congested highways, temporary capacity losses added 6 hours for every 1,000 miles of travel to the recurring delay described earlier in this chapter. Americans suffer two and a half 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.

Further research into bottlenecks and the benefits of addressing them could be of significant value in determining the best ways to address growing congestion in the Nation's urbanized areas.

## *Measuring Performance Using ITS Technologies*

The deployment of intelligent transportation systems (ITS) technologies provides opportunities for improved measurement of performance. For example, speeds 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 in significant freight corridors as described in Chapter 13. Methods for compiling ITS data, removing spurious observations, and producing useful statistics are still under development.

# Transit Operational Performance

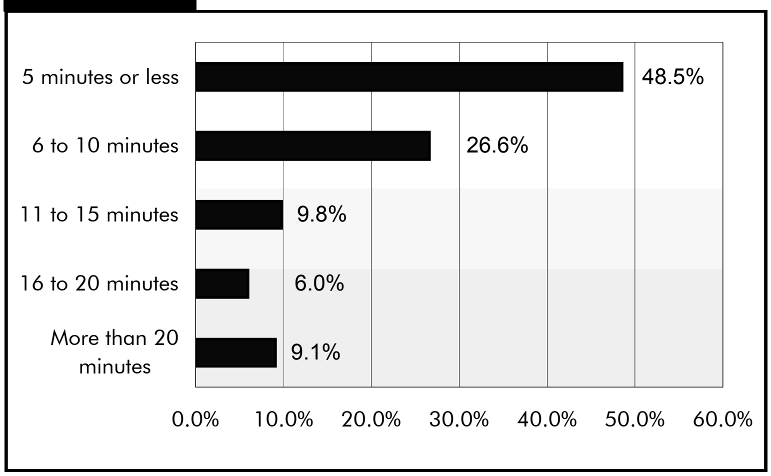
The operational performance of transit affects its attractiveness as a means of transportation. People will be more inclined to use transit that is frequent and reliable, travels more rapidly, has adequate seating capacity, and is not too crowded.

## 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 4-16* shows information on waiting times from the 2001 National Household Travel Survey (NHTS) by the FHWA, the most recent nationwide survey of this information. 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. The relationship between the time spent waiting and frequency of service is not clear. Waiting times of 5 minutes or less are clearly associated with good service that is either frequent or reliably provided according to a schedule. Waiting times of 20 minutes or more indicates that service is likely both infrequent and unreliable. Waiting times of 5 to 10 minutes are most likely consistent with adequate levels of service that are both reasonably frequent and reliable.

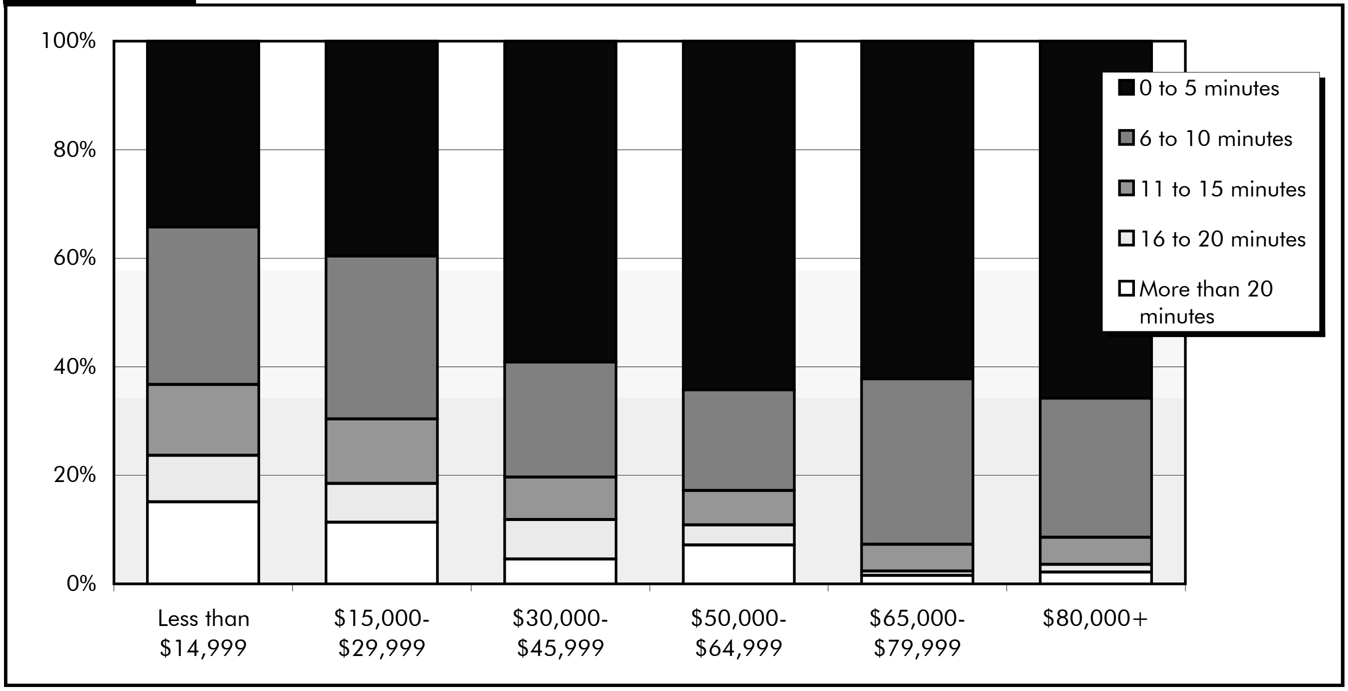
**Exhibit 4-16** *Distribution of Passengers by Waiting Times*




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

Waiting times are correlated with incomes. Passengers from households with annual incomes of $30,000 or more have a greater chance of waiting 5 minutes or less than passengers from households with incomes of less than $30,000. Passengers from households with incomes of $65,000 or more have an increased chance of waiting 6 to 10 minutes rather than more than 10 minutes *(Exhibit 4-17).* Higher-income passengers are more likely to be choice riders and choose to ride transit only if the service 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, to use transit even when the service is not as frequent or reliable as they may prefer.

**Exhibit 4-17** *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), the FHWA nationwide personal travel survey preceding the NHTS, 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.

# Vehicle Utilization—Service Effectiveness

**Q.** What is service effectiveness and how can it be measured?

**A.** Service effectiveness measures to what extent passengers are using a transit service output. In addition to passengers miles traveled per capacity-equivalent vehicle mile, measures of service effectiveness include unlinked passenger trips per vehicle revenue mile, unlinked passenger trips per vehicle revenue hour, annual passenger miles per actual annual vehicle revenue mile, and passenger miles traveled per scheduled vehicle mile.

Vehicle utilization is one indicator of service effectiveness that measures how well a service output attracts passengers. 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 motor bus fleet. The capacity-equivalent factors used to calculate vehicle utilization are the same as those used to calculate capacity-equivalent vehicle miles in Chapter 2. The absolute values of vehicle utilization provided in *Exhibit 4-18* have been revised since the last edition of this report to reflect the revisions made to the capacity-equivalent factors as discussed in Chapter 2. The annual percentage changes in vehicle utilization have remained the same.

**Exhibit 4-18** *Transit Vehicle Utilization, Annual Passenger Miles per Capacity-Equivalent Vehicle by Mode, 1993–2002*

| (Thousands) | Nonrail | | | | | Rail | | |
|---|---|---|---|---|---|---|---|---|
| | Bus | Demand Response | Ferry-boat | Trolley-bus | Vanpool | Commuter Rail [1] | Heavy Rail | Light Rail |
| 1993 | 394 | 192 | 281 | 267 | 767 | 704 | 530 | 361 |
| 1994 | 393 | 163 | 280 | 271 | 649 | 789 | 546 | 429 |
| 1995 | 391 | 172 | 296 | 264 | 628 | 802 | 561 | 457 |
| 1996 | 392 | 170 | 312 | 256 | 702 | 815 | 601 | 482 |
| 1997 | 401 | 189 | 297 | 258 | 607 | 769 | 620 | 506 |
| 1998 | 393 | 189 | 283 | 242 | 607 | 810 | 619 | 538 |
| 1999 | 397 | 195 | 291 | 249 | 604 | 808 | 654 | 520 |
| 2000 | 393 | 188 | 305 | 257 | 577 | 863 | 697 | 546 |
| 2001 | 397 | 179 | 282 | 276 | 752 | 868 | 699 | 556 |
| 2002 | 390 | 178 | 294 | 246 | 539 | 831 | 675 | 528 |
| **Average** | **394** | **182** | **292** | **259** | **643** | **806** | **620** | **492** |

*Source: National Transit Database and APTA 2000 Public Transportation Fact Book.*

[1] Excludes Alaska Rail.

Rail vehicle utilization rates have increased since 1993, peaking in 2000 or 2001 and declining slightly in 2002. There is no overall trend in the utilization rates of nonrail vehicles. During the 1993 to 2002 period, bus utilization was at its highest in 1997, demand response vehicle utilization was at its highest in 1999, ferryboat utilization was at its highest in 2000, trolleybus utilization was at its highest in 2001, and vanpool utilization was at its highest in 1993. However, with the exception of ferryboats, the utilization of all nonrail modes, including buses, was lower in 2002 than in 2000 and 1993.

Commuter rail has consistently had the highest vehicle utilization level. In 2002, commuter rail utilization was 831,000 passenger miles per capacity-equivalent vehicle, which is below the 863,000 passenger miles per capacity-equivalent vehicle in 2000, but above the average capacity utilization of 806,000 passengers experienced between 1993 and 2002. Heavy and light rail vehicles had utilization levels of 675,000 and 528,000 passenger miles per capacity-equivalent vehicle in 2002, in both cases below levels in 2000, but well above the averages for the 1993 to 2002 period. In 2002, utilization of buses was 390,000 passenger miles per capacity-equivalent vehicle, slightly below 393,000 passenger miles per capacity-equivalent vehicle in 2000 and the 10-year average of 394,000 passengers. The utilization levels of demand response vehicles, vanpools, ferryboats, and trolleybuses have fluctuated since 1993 with no discernable trend. Among these modes, vanpools have the highest capacity utilization, 539,000 passenger miles per capacity-equivalent vehicle in 2002. The utilization rates for demand response vehicles, ferryboats, and trolleybuses are considerably lower. In 2002, the utilization levels for these modes were respectively, 178,000, 294,000, and 246,000 passenger miles per capacity-equivalent vehicle.

# Average Operating (Passenger-Carrying) Speeds

Average operating speed measures the average speed that a passenger will travel on transit; it does not measure the pure operating speeds of transit vehicles. These speeds exclude passenger waiting time and the time spent transferring, but are affected by changes in vehicle dwell times to let off and pick up passengers. The average operating speeds as experienced by passengers on all transit vehicles, and on rail vehicles and nonrail service separately, are provided in *Exhibit 4-19.* These average speeds are weighted averages of the average speed traveled by each vehicle in operating service in each modal category (rail, nonrail, and total), using passenger miles traveled on each vehicle as the weights. The average speed of each modal category is calculated by dividing annual vehicle revenue miles by annual vehicle revenue hours of each, as reported to the National Transit Database.

**Exhibit 4-19** *Passenger-Mile Weighted Average Operating Speed by Transit Mode, 1993–2002*

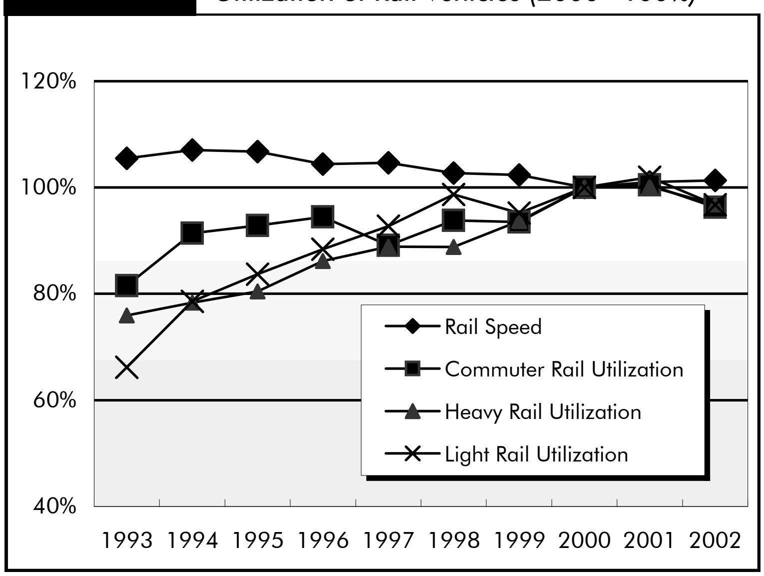
| (Miles per Hour) | Rail | Nonrail | Total |
|---|---|---|---|
| 1993 | 26.3 | 13.7 | 19.9 |
| 1994 | 26.7 | 13.8 | 20.4 |
| 1995 | 26.6 | 13.7 | 20.4 |
| 1996 | 26.0 | 13.8 | 20.4 |
| 1997 | 26.1 | 13.8 | 20.3 |
| 1998 | 25.6 | 14.0 | 20.5 |
| 1999 | 25.5 | 14.0 | 20.1 |
| 2000 | 24.9 | 13.7 | 19.6 |
| 2001 | 25.2 | 13.7 | 19.9 |
| 2002 | 25.3 | 13.7 | 19.9 |
| **Average** | **25.8** | **13.8** | **20.1** |

*Source: National Transit Database.*

Average operating speeds as experienced by passengers on transit remained relatively constant between 1993 and 2002. In 2002, the average speed was 19.9 miles per hour, up from 19.6 miles per hour in 2000, and just below the 10-year average of 20.1 miles per hour. The average operating speed as experienced by passengers on rail modes was 25.3 miles per hour in 2002, compared with 24.9 miles per hour in 2000, and a 10-year average of 25.8 miles per hour. The average operating speed of rail modes was highest between 1993 and 1997, ranging between 26.0 to 26.7 miles per hour. The average operating speed of nonrail vehicles, which is affected by traffic, road, and safety conditions, was 13.7 miles per hour in 2002, the same as in 2000 and 2001, and just below the 10-year average of 13.8. The operating speed of rail vehicles has historically been about 12 miles per hour faster than the average operating speed of nonrail transit vehicles *(Exhibit 4-19).*

Changes in the capacity utilization of rail vehicles appear to have influenced these vehicles' operating speeds through changes in dwell times. As vehicles become more crowded, they take longer to unload and load, increasing the wait at stations and hence passengers' travel time. *Exhibit 4-20* compares an index of rail speed with indexes of the capacity utilization of commuter rail, heavy rail, and light rail vehicles between 1993 and 2002, with 2000 as the base year. As the capacity utilization of these rail vehicles increased between 1993 and 2000, rail speeds decreased. Since 2000, the capacity utilization of these rail modes has fallen slightly and rail speeds have increased slightly.

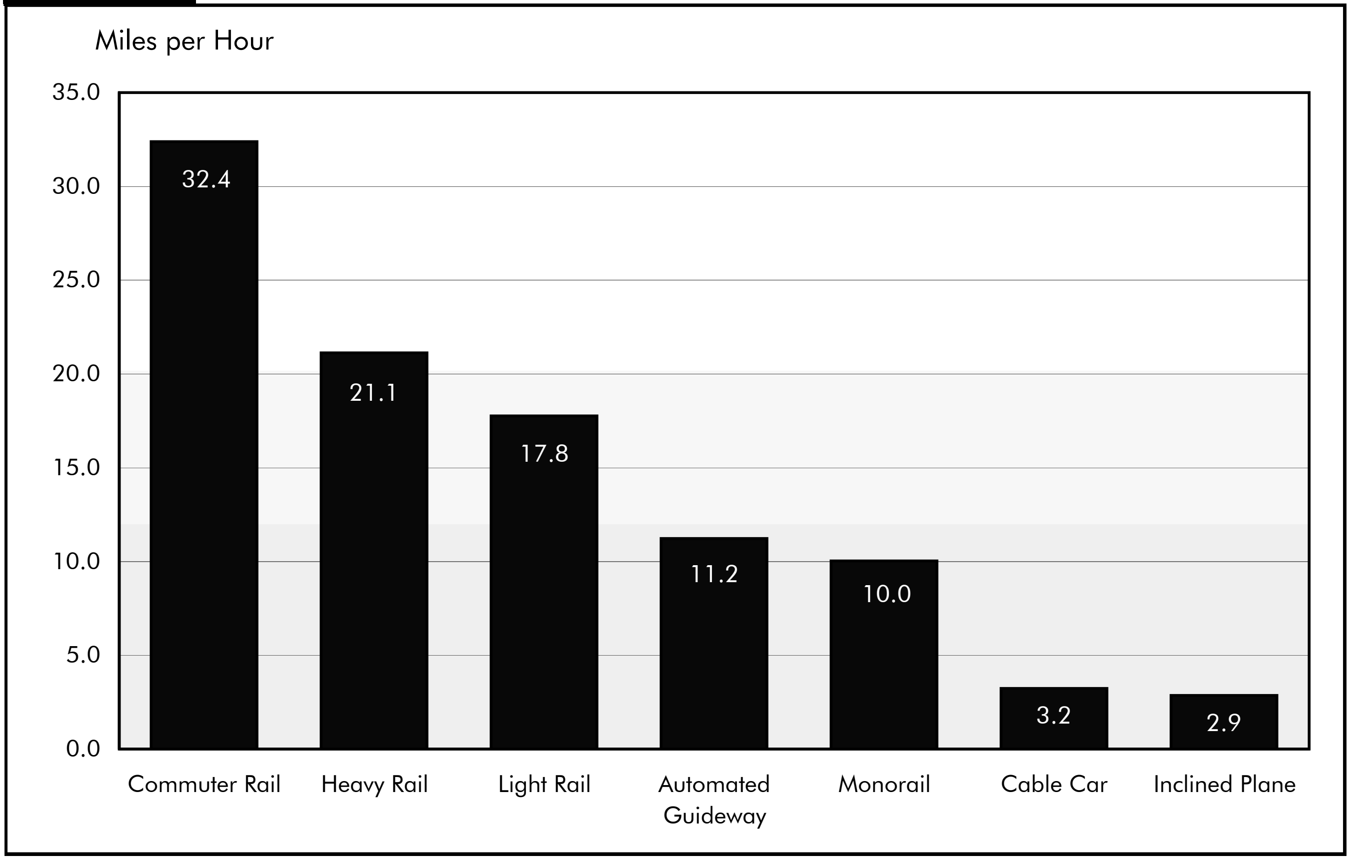
**Exhibit 4-20** *Index of Rail Speed and Capacity Utilization of Rail Vehicles (2000=100%)*




*Source: National Transit Database.*

As *Exhibit 4-21* shows, the average speed as experienced by passengers on rail vehicles differs considerably according to type of vehicle. Commuter rail provides the fastest service. In 2002, commuter rail provided passengers an average speed of 32.4 miles per hour, an increase over an average of 30.1 miles per hour in 2000. Commuter rail services may be faster than heavy and light rail services because they make fewer stops per distance traveled. In 2002, the average operating speed of heavy rail was 21.1 miles per hour and the average operating speed of light rail was 17.8 miles per hour, both the same as in 2000. In 2002, the average operating speed on automated guideways was 11.2 miles per hour, on monorails 10.0 miles per hour, on cable cars 3.2 miles per hour, and on inclined planes (transit vehicles traveling on track a short distance up a steep hill) 2.9 miles per hour.

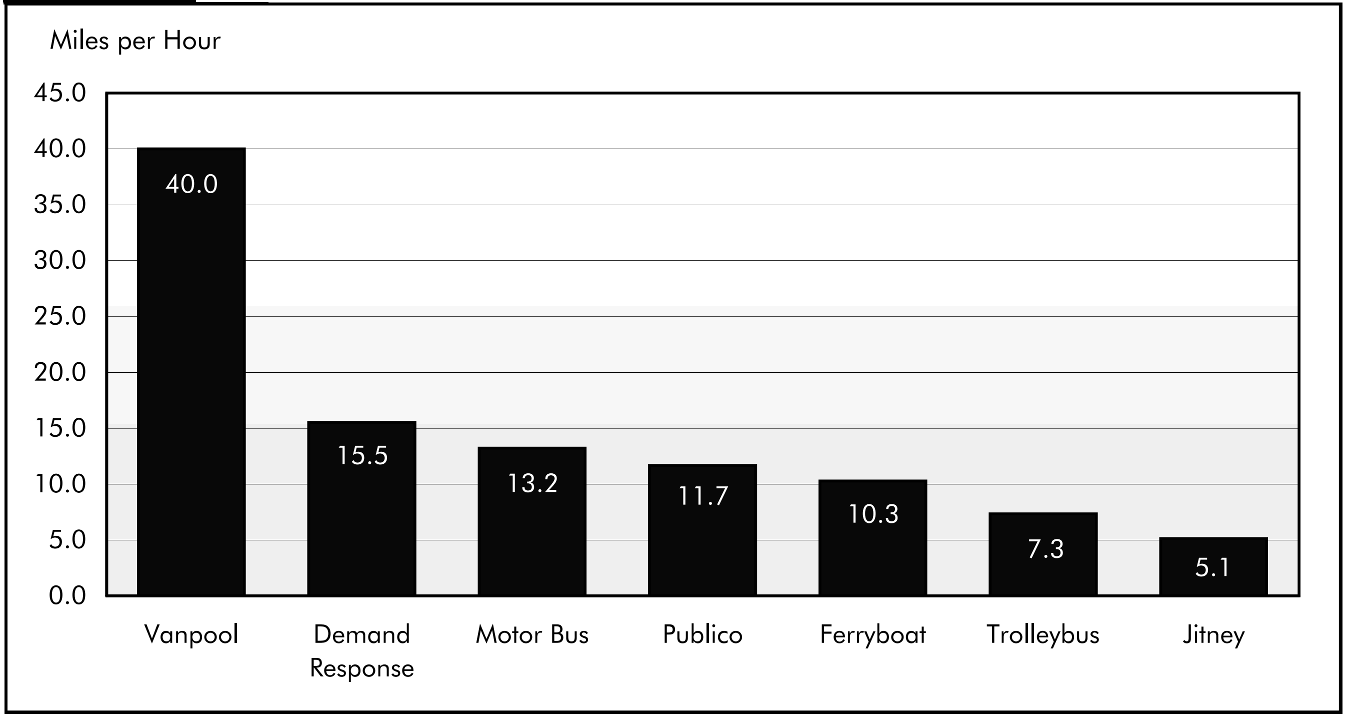
**Exhibit 4-21** *Rail Vehicles' Average Operating Speeds, 2002*




*Source: National Transit Database.*

As shown in *Exhibit 4-22*, the average operating speed as experienced by passengers on nonrail transit vehicles also varies widely. Vanpools, which tend to travel long distances on highways, carry passengers at a faster average operating speed than other nonrail transit vehicles. In 2002, vanpools traveled at an average speed of 40.0 miles per hour. Demand response vehicles carried passengers at an average of 15.5 miles per hour, buses at an average of 13.2 miles per hour, ferryboats at an average of 10.3 miles per hour, and trolleybuses at an average of 7.3 miles per hour. Publico, operated in San Juan, Puerto Rico, carries passengers at a speed of 11.7 miles per hour, and jitney, operated in San Francisco, at a speed of 5.1 miles per hour.

**Exhibit 4-22** *Average Operating Speeds of Nonrail Vehicles, 2002*




*Source: National Transit Database.*

# 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 and its partners to increase highway and transit safety. These programs are examined comprehensively in Chapter 11.

*Exhibit 5-1* compares key data in this chapter with corresponding safety measures in the 2000 edition of the C&P report.

**Exhibit 5-1** *Comparison of Safety Statistics with Those in the 2002 C&P Report*

| Highway Safety | 2000 Data: 2002 C&P Report | 2000 Data: Revised as of 12/23/04 | 2002 Data |
|---|---|---|---|
| Number of Fatalities | 41,821 | 41,945 | 43,005 |
| Fatality Rate per 100,000 People | 15.23 | 14.86 | 14.93 |
| Fatality Rate per 100 Million VMT | 1.5 | 1.53 | 1.51 |
| Number of Injuries | 3,189,000 | | 2,926,000 |
| Injury Rate per 100,000 People | 1,161 | 1,130 | 1,016 |
| Injury Rate per 100 Million VMT | 102 | 116 | 102 |
| **Transit Safety** | | | |
| Number of Fatalities | 275 | | 282 |
| Fatalities per 100 Million PMT | 0.73 | | 0.66 |
| Number of Injuries | 56,535 | Not available | 19,367* |
| Injuries per 100 Million PMT | 151 | Not available | 46* |
| Number of Incidents | 62,009 | Not available | 24,247* |
| Incidents per 100 Million PMT | 165 | Not available | 57* |

* Revised definitions of incidents and injuries since last report.

Highway fatalities increased by 2.5 percent between 2000 (41,945) and 2002 (43,005). 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 2002.

In 2002, the fatality rate per 100,000 people was 14.93, up from the 2000 fatality rate of 14.86. The fatality rate per 100 million vehicle miles traveled (VMT) declined from 1.53 in 2000 to 1.51 in 2002.

The number of injuries declined from 3.19 million in 2000 to 2.93 million in 2002. The injury rate per 100,000 people declined from 1,130 in 2000 to 1,016 in 2002, and the injury rate per 100 million VMT dropped from 116 in 2000 to 102 in 2002.

**Q. Where can I find additional information on fatalities and injuries?**

**A.** NHTSA has posted fatality and injury information on its public website 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.

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.

In 2002, the Federal Transit Administration (FTA) adjusted its definitions of an incident and an injury, which led to a decrease in reported incidents and injuries. These adjusted definitions preclude a direct comparison of 2002 incident and injury statistics with those for earlier years.

Transit vehicles that share the roadway with nontransit vehicles have historically had a higher number of incidents than transit vehicles that travel on exclusive fixed guideways. This relationship continued in 2002, even with the increase of the incident threshold to $7,500 from $1,000. However, as a result of the increase in the dollar value of the incident threshold, the number of reported incidents per 100 million PMT on all modes declined. The change in the definition of injury led to reductions in the number of injuries reported per 100 million PMT on all modes except commuter rail.

**Q. How have FTA's definitions of an incident and an injury been adjusted?**

**A.** 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 injury. Before 2002, any reported incident or injury was reported to National Transit Database. It was felt that this resulted in the collection of claims-based as opposed to safety-based data.

Fatalities decreased from 292 in 2000 to 282 in 2002, and also fell when adjusted for PMT from 0.69 per 100 million PMT in 2000 to 0.66 per 100 million PMT in 2002.

# 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 vehicle miles traveled (VMT). By 2002, the fatality rate had declined to 1.51 per 100 million VMT. This sharp decline in the fatality rate occurred even as the number of licensed drivers grew by more than 92 percent.

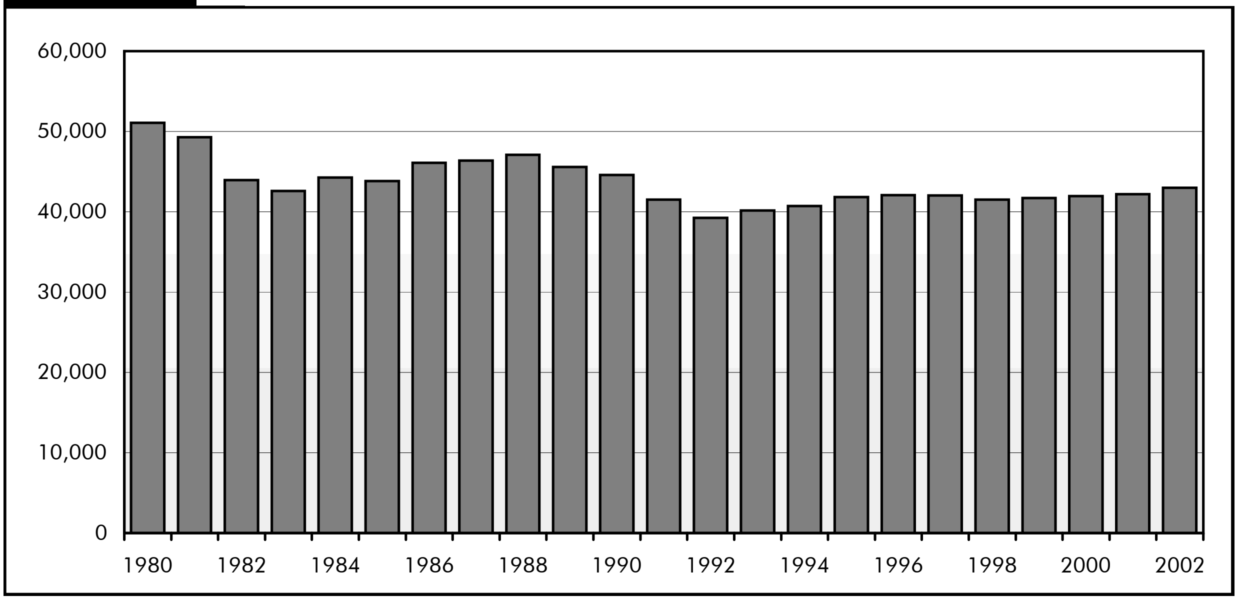
**Exhibit 5-2** *Summary of Fatality and Injury Rates, 1966–2002*

| 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 | 3.2 | | | |
| 1978 | 50,331 | 222,585 | 22.61 | 140,844 | 3.3 | | | |
| 1980 | 51,091 | 227,225 | 22.48 | 145,295 | 3.3 | | | |
| 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 | 282,178 | 14.86 | 190,625 | 1.5 | 3,189,000 | 1,130 | 116 |
| 2002 | 43,005 | 287,974 | 14.93 | 194,296 | 1.5 | 2,926,000 | 1,016 | 102 |

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

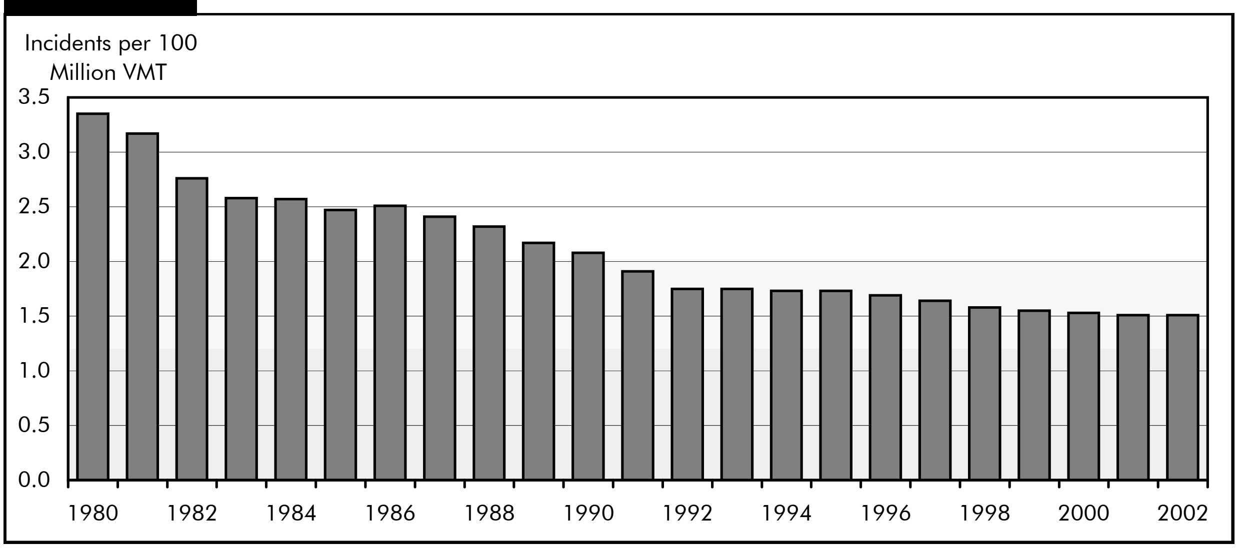
The number of traffic deaths also decreased between 1966 and 2002. In 1966, there were 50,894; by 2002, that number had dropped to 43,005. The number of fatalities, however, has not dropped as consistently as the fatality rate. Fatalities reached their highest point in 1972 (54,589), and then declined sharply following the implementation of a national speed limit. Fatalities reached their lowest point in 1992 (39,250), but steadily increased between 1992 and 2002. *Exhibits 5-3* and *5-4* compare the number of fatalities with fatality rates between 1980 and 2002.

**Exhibit 5-3** *Fatalities, 1980–2002*




*Source: Fatality Analysis Reporting System.*

**Exhibit 5-4** *Fatality Rate, 1980–2002*




*Source: Fatality Analysis Reporting System.*

**Q.** What goal has been set by the Department of Transportation for the national highway fatality rate?

**A.** The *Department of Transportation Strategic Plan 2003–2008* established a goal to reduce the national highway fatality rate to 1.0 per 100 million VMT by 2008. *Exhibit 5-5* illustrates that much remains to be accomplished if the DOT is to reach this goal. Based on a 2002 VMT level of 2,855.8 billion, achieving the goal in 2002 would have required that fatalities not exceed 28,558. The actual fatality count of 43,005 exceeded that amount by 14,447.

**Exhibit 5-5** *Progress Toward Achieving the DOT 1.0 Fatality Rate Goal in 2008*

| | | Fatalities | | | |
|---|---|---|---|---|---|
| Year | VMT (Millions) | At Rate of 1.0 per 100 Million VMT | Actual | Reduction Required to Achieve 1.0 Rate | Actual Fatality Rate |
| 1993 | 2,296,378 | 22,964 | 40,150 | 17,186 | 1.75 |
| 1994 | 2,357,588 | 23,576 | 40,716 | 17,140 | 1.73 |
| 1995 | 2,422,696 | 24,227 | 41,817 | 17,590 | 1.73 |
| 1996 | 2,485,848 | 24,858 | 42,065 | 17,207 | 1.69 |
| 1997 | 2,561,695 | 25,617 | 42,013 | 16,396 | 1.64 |
| 1998 | 2,631,522 | 26,315 | 41,501 | 15,186 | 1.58 |
| 1999 | 2,691,056 | 26,911 | 41,717 | 14,806 | 1.55 |
| 2000 | 2,746,925 | 27,469 | 41,945 | 14,476 | 1.53 |
| 2001 | 2,797,287 | 27,973 | 42,196 | 14,223 | 1.51 |
| 2002 | 2,855,756 | 28,558 | 43,005 | 14,447 | 1.51 |
| 2003* | 2,879,719 | 28,797 | --- | --- | --- |
| 2004* | 2,937,313 | 29,373 | --- | --- | --- |
| 2005* | 2,996,060 | 29,961 | --- | --- | --- |
| 2006* | 3,055,981 | 30,560 | --- | --- | --- |
| 2007* | 3,117,100 | 31,171 | --- | --- | --- |
| 2008* | 3,179,442 | 31,179 | --- | --- | --- |

*2004 to 2008 VMT based on 2% increase each year from 2003 VMT.

The injury rate also declined between 1988 and 2002, the years for which statistics are available. In 1988, the injury rate was 169 per 100 million VMT; by 2002, the number had dropped to 102 per 100 million VMT (the target in the *FHWA FY 2003 Performance Plan* is 107 per 100 million VMT). The number of injuries also decreased between 1988 and 2002, from 3,416,000 to 2,926,000; however, like the number of fatalities, injuries increased between 1992 and 1996.

# Fatalities by Functional Class

*Exhibits 5-6* and *5-7* show the number of fatalities and fatality rates by rural and urban functional system between 1994 and 2002. These exhibits are important in describing the recent increase in fatalities and the distinction between fatalities and the fatality rate.

As shown in Exhibit 5-6, the overall number of fatalities grew between 1994 and 2002, largely because of deaths on rural roads. Between 1994 and 2002, the number of fatalities on rural roads grew from 23,841 to 25,896 and accounted for more than 60 percent of total 2002 fatalities. At the same time, the number of

**Exhibit 5-6** *Fatalities by Functional System, 1994–2002*

| Functional System | 1994 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | | | |
| Interstate | 2,566 | 2,924 | 3,105 | 3,254 | 3,298 |
| Other Principal Arterial | 5,121 | 5,251 | 5,378 | 4,917 | 4,894 |
| Minor Arterial | 4,212 | 4,184 | 4,216 | 4,090 | 4,467 |
| Major Collector | 6,128 | 5,973 | 5,840 | 5,501 | 6,014 |
| Minor Collector | 1,596 | 1,553 | 1,753 | 1,808 | 2,003 |
| Local | 4,152 | 4,396 | 4,459 | 4,414 | 5,059 |
| Unknown Rural | 66 | 280 | 434 | 854 | 161 |
| **Subtotal Rural** | **23,841** | **24,561** | **25,185** | **24,838** | **25,896** |
| **Urban Areas (5,000 and over in population)** | | | | | |
| Interstate | 2,147 | 2,321 | 2,283 | 2,419 | 2,482 |
| Other Freeway and Expressway | 1,919 | 1,538 | 1,282 | 1,364 | 1,506 |
| Other Principal Arterial | 4,960 | 5,528 | 5,285 | 4,948 | 5,124 |
| Minor Arterial | 3,583 | 3,652 | 3,335 | 3,211 | 3,218 |
| Collector | 1,217 | 1,208 | 1,037 | 1,001 | 1,151 |
| Local | 2,921 | 3,052 | 2,921 | 2,912 | 3,497 |
| Unknown Urban | 64 | 69 | 76 | 258 | 35 |
| **Subtotal Urban** | **16,811** | **17,368** | **16,219** | **16,113** | **17,013** |
| Unknown Rural or Urban | 64 | 136 | 97 | 994 | 96 |
| **Total Highway Fatalities** | **40,716** | **42,065** | **41,501** | **41,945** | **43,005** |

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

**Exhibit 5-7** *Fatality Rates by Functional System, 1994–2002 (per 100 Million VMT)*

| Functional System | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| **Rural Areas (under 5,000 in population)** | | | | | | | | | |
| Interstate | 1.19 | 1.19 | 1.26 | 1.27 | 1.23 | 1.25 | 1.21 | 1.15 | 1.18 |
| Other Principal Arterial | 2.47 | 2.30 | 2.37 | 2.36 | 2.26 | 2.17 | 1.98 | 1.98 | 1.90 |
| Minor Arterial | 2.81 | 2.88 | 2.66 | 2.62 | 2.54 | 2.53 | 2.38 | 2.44 | 2.53 |
| Major Collector | 3.37 | 3.34 | 3.13 | 2.93 | 2.87 | 2.82 | 2.62 | 2.78 | 2.82 |
| Minor Collector | 3.29 | 3.20 | 3.10 | 3.29 | 3.23 | 3.06 | 3.14 | 3.02 | 3.26 |
| Local | 3.96 | 4.33 | 4.08 | 3.94 | 3.73 | 3.83 | 3.47 | 3.43 | 3.63 |
| **Subtotal Rural** | **2.62** | **2.61** | **2.53** | **2.48** | **2.40** | **2.37** | **2.21** | **2.24** | **2.28** |
| **Urban Areas (5,000 and over in population)** | | | | | | | | | |
| Interstate | 0.65 | 0.64 | 0.66 | 0.63 | 0.61 | 0.61 | 0.61 | 0.63 | 0.61 |
| Other Freeway and Expressway | 1.30 | 1.19 | 0.98 | 0.81 | 0.77 | 0.79 | 0.77 | 0.78 | 0.79 |
| Other Principal Arterial | 1.36 | 1.36 | 1.46 | 1.41 | 1.36 | 1.29 | 1.24 | 1.28 | 1.25 |
| Minor Arterial | 1.25 | 1.27 | 1.22 | 1.17 | 1.08 | 1.02 | 0.99 | 1.02 | 0.95 |
| Collector | 1.01 | 0.96 | 0.93 | 0.89 | 0.79 | 0.78 | 0.74 | 0.79 | 0.81 |
| Local | 1.46 | 1.54 | 1.46 | 1.43 | 1.29 | 1.26 | 1.24 | 1.43 | 1.46 |
| **Subtotal Urban** | **1.16** | **1.15** | **1.14** | **1.08** | **1.01** | **0.98** | **0.95** | **1.00** | **0.98** |
| **Total Highway Fatality Rate** | **1.72** | **1.71** | **1.67** | **1.62** | **1.55** | **1.53** | **1.45** | **1.49** | **1.50** |

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

fatalities on urban roads increased from 16,811 to 17,013. The fatality rate, however, declined on both rural and urban roads. Although the absolute number of fatalities increased, the fatality rate dropped because the number of VMT significantly increased.

Exhibit 5-7 reveals that fatality rates declined on every urban functional system between 1994 and 2002. Urban Interstate highways were the safest functional system, with a 0.61 fatality rate in 2002. Other freeways and expressways, however, recorded the sharpest decline in fatality rates. The fatality rate for other urban freeways and expressways in 2002 was about 39 percent lower than in 1994.

Fatality rates declined by 13 percent on the rural functional system between 1994 and 2002; however, the fatality rate for rural Interstates has remained more constant. The rural Interstate fatality rate in 2002 was twice that of urban Interstates. Travel speeds tend to be higher on rural Interstates than urban Interstates.

Only a small percentage of crashes are severe enough to kill passengers. *Exhibit 5-8* describes the number of crashes by severity between 1994 and 2002. In 2002, about 69 percent of crashes resulted in property damage only.

**Exhibit 5-8** *Crashes by Severity, 1994–2002*

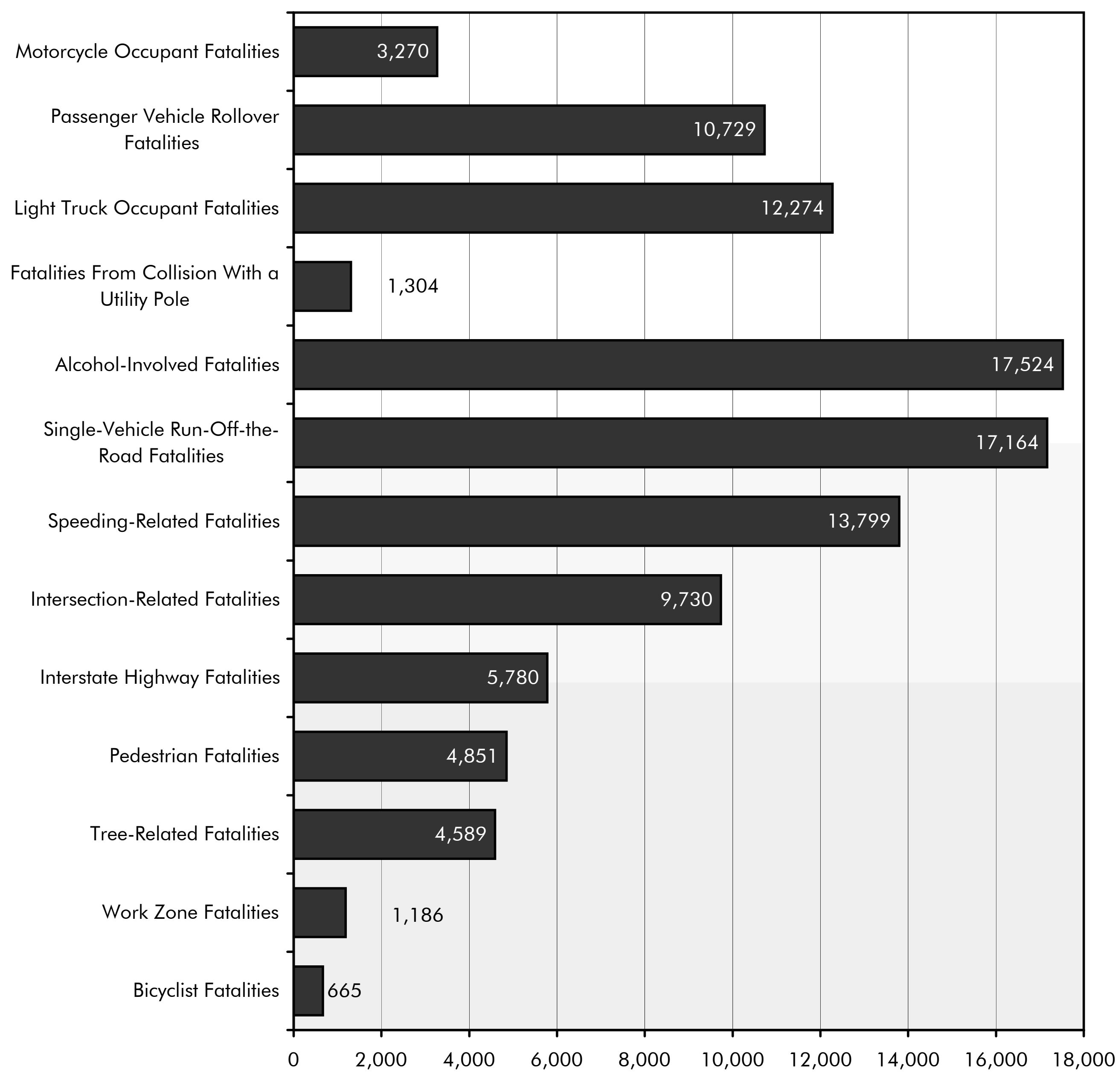
| | Crash Severity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fatal | | Injury | | Property Damage Only | | Total Crashes | |
| Year | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| 1994 | 36,254 | 0.6 | 2,123,000 | 32.7 | 4,336,000 | 66.8 | 6,496,000 | 100.0 |
| 1995 | 37,241 | 0.6 | 2,217,000 | 33.1 | 4,446,000 | 66.4 | 6,699,000 | 100.0 |
| 1996 | 37,494 | 0.6 | 2,238,000 | 33.1 | 4,494,000 | 66.4 | 6,770,000 | 100.0 |
| 1997 | 37,324 | 0.6 | 2,149,000 | 32.4 | 4,438,000 | 67.0 | 6,624,000 | 100.0 |
| 1998 | 37,107 | 0.6 | 2,029,000 | 32.0 | 4,269,000 | 67.4 | 6,335,000 | 100.0 |
| 1999 | 37,140 | 0.6 | 2,054,000 | 32.7 | 4,188,000 | 66.7 | 6,279,000 | 100.0 |
| 2000 | 37,526 | 0.6 | 2,070,000 | 32.4 | 4,286,000 | 67.0 | 6,394,000 | 100.0 |
| 2001 | 37,862 | 0.6 | 2,003,000 | 31.7 | 4,282,000 | 67.7 | 6,323,000 | 100.0 |
| 2002 | 38,491 | 0.6 | 1,929,000 | 30.5 | 4,348,000 | 68.8 | 6,316,000 | 100.0 |

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

# Types of Highway Fatalities

*Exhibit 5-9* displays the types of highway fatalities in 2002. The three most common fatalities were related to alcohol-impaired driving, single-vehicle run-off-the-road crashes, and speeding. Many of the fatalities shown in Exhibit 5-9 involve a combination of factors—speeding and alcohol, for example—so these should not necessarily be viewed in isolation; in other words, the exhibit counts multiple factors.

**Exhibit 5-9** *Highway Fatalities by Type, 2002**




* Some fatalities are listed under more than one source. For example: Some Speeding-Related Fatalities may also be included under Alcohol-Involved Fatalities and/or included in Single-Vehicle Run-Off-the-Road Fatalities.

Alcohol-impaired driving is a serious public safety problem in the United States. The NHTSA estimates that alcohol was involved in 41 percent of fatal crashes and 6 percent of all crashes in 2002. The 17,524 fatalities in 2002 represent an average of one alcohol-related fatality every 30 minutes.

*Exhibit 5-10* shows the number of fatalities attributable to alcohol between 1993 and 2002. The number of fatalities dropped from 17,908 in 1993 to 17,524 in 2002, although the pattern of alcohol-related fatalities has been uneven—declining between 1996 and 1999, then increasing between 1999 and 2002.

**Exhibit 5-10** *Alcohol-Related Fatalities, 1993–2002*

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| 17,908 | 17,308 | 17,732 | 17,749 | 16,711 | 16,673 | 16,572 | 17,380 | 17,400 | 17,524 |

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

There are three main groups involved in alcohol-impaired driving. In 2002, 35 percent of drivers between the ages of 21 and 34 who were involved in fatal crashes had been drinking. Recent studies show that these drivers tend to have much higher levels of intoxication than other age groups. Chronic drunk drivers are another large group. Drivers involved in fatal crashes with a blood alcohol concentration greater than 0.08 grams per deciliter were nine times as likely to have a prior conviction for driving while impaired than sober drivers. Finally, underage drinkers are disproportionately overrepresented in impaired driving statistics. Not only are they relatively new drivers, but also are inexperienced drinkers.

The second largest category of highway fatalities involves single-vehicle run-off-the-road crashes. In 2002, 17,164 fatalities occurred when drivers lost control and ran off the road. (Note that preliminary 2003 figures show a decrease in road-off-the-road-fatalities to 16,546.) Overall roadway departure crashes, including single-vehicle-run-off-the-road, contributed to over 59 percent of all fatalities in 2002.

Another type of highway fatality is related to speeding. In 2002, nearly 14,000 lives were lost in speeding-related crashes. Although much of the public concern about speeding-related crashes focuses on high-speed roadways, speeding is a safety concern on all roads. Almost half of speeding-related fatalities occur on lower functional systems.

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

**A.** About 13 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.

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 speeding-related crashes to all crashes decreases with increasing driver age. For example, in 2002, 39 percent of male drivers between the ages of 15 and 20 who were involved in fatal crashes were speeding at the time of the crash, while the comparable figure for male drivers between the ages of 35 and 44 was only 20 percent.

Research completed by NHTSA shows the correlation between speeding and alcohol consumption in fatal crashes. In 2002, 27 percent of underage *speeding* drivers involved in fatal crashes were intoxicated. By contrast, only 12 percent of underage *nonspeeding* drivers involved in fatal crashes were intoxicated.

Many speeding crashes also occur during bad weather. Speeding was a factor in 31 percent of the fatal crashes that occurred on dry roads in 2002 and in 33 percent of those that occurred on wet roads. Speeding was a factor in 53 percent of the fatal crashes that occurred when there was snow or slush on the road and in 60 percent of those that occurred on icy roads.

A fourth type of highway fatality occurs at intersections. Over half of the fatalities occurring at intersections are in urban areas, compared with 44 percent that occur in rural areas. 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 65 or older occurred at intersections.

# Crashes by Vehicle Type

*Exhibit 5-11* shows the number of occupant fatalities by vehicle type from 1993 to 2002. The number of occupant fatalities that involved passenger cars decreased from 21,566 in 1993 to 20,569 in 2002. Occupant fatalities involving light and large trucks, motorcycles, and other vehicles all increased during this period. *Exhibit 5-12* presents the number of occupant injuries by vehicle type from 1993 to 2002.

**Exhibit 5-11** *Fatalities for Vehicle Occupants by Type of Vehicle, 1993–2002*

| Type of Vehicle | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| Passenger Cars | 21,566 | 22,423 | 22,199 | 20,862 | 20,699 | 20,569 |
| Light Trucks | 8,511 | 9,568 | 10,249 | 11,265 | 11,526 | 12,274 |
| Large Trucks | 605 | 648 | 723 | 759 | 754 | 689 |
| Motorcycles | 2,449 | 2,227 | 2,116 | 2,483 | 2,897 | 3,270 |
| Other & Unknown Vehicles | 425 | 392 | 420 | 447 | 472 | 573 |
| **Total** | **33,556** | **35,258** | **35,707** | **35,816** | **36,348** | **37,375** |

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

**Exhibit 5-12** *Injuries for Vehicle Occupants by Type of Vehicle, 1993–2002*

| Type of Vehicle | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| Passenger Cars | 2,265,000 | 2,469,000 | 2,341,000 | 2,138,000 | 2,052,000 | 1,805,000 |
| Light Trucks | 601,000 | 722,000 | 755,000 | 847,000 | 887,000 | 879,000 |
| Large Trucks | 32,000 | 30,000 | 31,000 | 33,000 | 31,000 | 26,000 |
| Motorcycles | 59,000 | 57,000 | 53,000 | 50,000 | 58,000 | 65,000 |
| Buses | 17,000 | 19,000 | 15,000 | 22,000 | 18,000 | 19,000 |
| Other Vehicles | 4,000 | 4,000 | 6,000 | 7,000 | 10,000 | 6,000 |
| **Total** | **2,978,000** | **3,303,000** | **3,201,000** | **3,097,000** | **3,055,000** | **2,800,000** |

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

The number of occupant fatalities in light trucks increased sharply between 1993 and 2002. Fatalities in these vehicles increased from 8,511 in 1993 to 12,274 in 2002, or an increase of 44 percent. There were 879,000 light truck occupants injured in 2002, up from 601,000 in 1993. Light truck registration also has increased from 57 million in 1993 to 82 million in 2002. There were about 26 million more light trucks on the road in 2002 than in 1993. The number of occupant fatalities in large trucks increased 14 percent, from 605 in 1993 to 689 in 2002. There were 26,000 large truck occupants injured in 2002.

The number of motorcyclists who died in crashes increased 34 percent, from 2,449 in 1993 to 3,270 in 2002. There were 65,000 motorcyclists injured in 2002. *Exhibit 5-13* describes the number of motorcycle occupants killed or injured per registered vehicle between 1993 and 2002. Data for 2002 shows 46 percent of those motorcyclists killed in crashes were not wearing helmets. NHTSA estimates helmets saved the lives of 692 motorcyclists in 2002 and projects that an additional 449 lives could have been saved if all motorcyclists had worn helmets.

**Exhibit 5-13** *Motorcycle Occupants Killed or Injured per Registered Vehicle, 1993–2002*

| Year | Registered Vehicle | Motorcycle Occupants Killed | Motorcycle Occupants Injured |
|---|---|---|---|
| 1993 | 3,977,856 | 2,449 | 59,000 |
| 1994 | 3,756,555 | 2,320 | 57,000 |
| 1995 | 3,897,191 | 2,227 | 57,000 |
| 1996 | 3,871,599 | 2,161 | 55,000 |
| 1997 | 3,826,383 | 2,116 | 53,000 |
| 1998 | 3,879,450 | 2,294 | 49,000 |
| 1999 | 4,152,433 | 2,483 | 50,000 |
| 2000 | 4,346,068 | 2,862 | 58,000 |
| 2001 | 4,903,056 | 3,197 | 60,000 |
| 2002 | 5,004,156 | 3,270 | 65,000 |

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

Data from the last 10 years show that the mean age of motorcyclists killed and the mean engine size of motorcycles involved in fatal crashes are increasing. The mean age of motorcyclists killed has increased from 31.3 years in 1993 to 37.9 years in 2002. Similarly, the mean engine size of motorcycles involved in fatal crashes has increased from 820 cc in 1993 to 1,002 cc in 2002. The top age group of motorcyclists killed has shifted from those under 40 to motorcyclists 40 or older in recent years. The proportion of 40 or older motorcyclists killed has increased from 21 percent in 1993 to 45 percent in 2002. Similarly, the increased number of fatalities has been mainly on larger motorcycles (1,001 to 1,500 cc), from 683 in 1993 to 1,252 in 2002.

Motorcycle crashes are frequently speed-related. In 2002, for instance, about 38 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.

# Rollovers

The total number of passenger vehicle occupant fatalities in rollovers has shown a steady increase, from 8,561 in 1993 to 10,729 in 2002 (an increase of 25 percent), with increases in every vehicle category. However, over two-thirds of the increases in passenger vehicle occupant fatalities in rollovers between 1993 and 2002 have occurred in sport utility vehicles (SUVs).

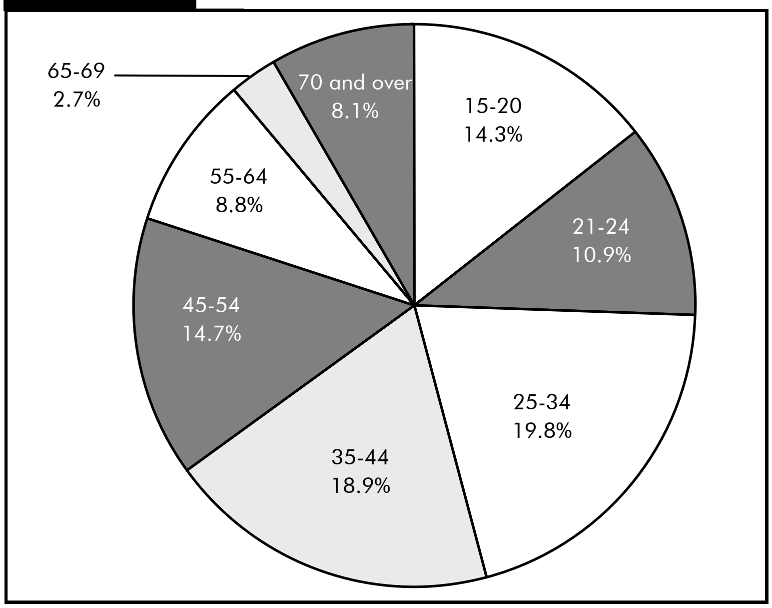
While the number of occupant fatalities in rollovers among passenger cars increased slightly, from 4,648 in 1993 to 4,794 in 2002 (a 3.1 percent increase), the number of occupant fatalities in rollovers among SUVs more than doubled from 934 in 1993 to 2,471 in 2002 (an increase of 165 percent). The number of occupant fatalities in rollovers among pickups for the same period has shown an increase of 15 percent (from 2,403 in 1993 to 2,755 in 2002) and among vans an increase of 29 percent (from 541 in 1993 to 699 in 2002).

Most of the increases in SUVs resulted from the increase in the number of registered SUVs, indicating the popularity of these vehicles.

# Crashes by Age Group

Another important way of examining highway crashes is by demographic segment. *Exhibit 5-14* shows the breakdown of drivers, by age, involved in fatal crashes in 2002.

**Exhibit 5-14** *Age of Drivers Involved in Fatal Crashes, 2002*




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

Drivers between the ages of 15 and 20 constitute 6.4 percent of the driving population, but 14 percent of total driver fatalities. In 2002, almost 30 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 6.8 percent of the driving population and 11 percent of drivers killed.

On the other end of the spectrum, drivers aged 70 or older accounted for 10 percent of the driving population n 2002. This age group accounted for 8 percent of the drivers involved in fatal crashes and 12 percent of the driver fatalities in 2002. Older drivers have a low fatality rate per capita, but a high fatality rate per mile driven. In fact, **drivers over 85 have the highest fatality rate on a per-mile-driven basis of all drivers—over nine times as high as the rate for drivers who are 25 to 69 years old.**

Older drivers tend to take shorter trips. They usually avoid driving during bad weather and at night; in 2002, 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. In two-vehicle fatal crashes involving an older driver and a younger driver, the vehicle driven by the older person was more than twice as likely to be the one that was struck.

There were 19.9 million drivers aged 70 or older in 2002, a 28 percent increase from 1993. The proportion of older drivers will continue to increase over the next two decades, presenting the Nation with new public safety challenges.

# Transit Safety

Public transit in the United States has been and continues to be a highly safe mode of transportation. This is evidenced by information on three indicators of transit safety—incidents, injuries, and fatalities—collected by the National Transit Database. These data are reported by transit operators for directly operated services and exclude information on purchased (contracted) transit.

In 2002, the definitions of an incident and an injury were revised. Prior to 2002, reportable transit safety incidents included all collisions and any other type of occurrence (e.g., derailment) that resulted in injury or death, or fire or property damage in excess of $1,000. In 2002, this $1,000 damage minimum was raised to $7,500 to align better with the $6,700 threshold adopted by the Federal Railroad Administration in 2003. Property damage includes damages to transit vehicles and facilities as well as to other nontransit vehicles that are involved in the incident. In 2002, the definition of an injury also was revised to be an occurrence that required immediate transportation for medical care away from the scene of the injury. Previously, any event for which the FTA received a claim was classified as an injury. These adjustments to incident and injury definitions have led to a decrease in reported incidents and injuries in 2002. The definition of fatalities has remained the same. 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 or while boarding, alighting, or waiting for transit vehicles to arrive.

**Q.** What constitutes a fatality on transit?

**A.** A fatality is a transit-related death confirmed within 30 days of a transit incident, which occurs under the categories of collision, derailment, fire, evacuation, security incident, vehicle leaving the roadway, or not otherwise classified.

Incidents, injuries, and fatalities for directly operated services in absolute terms and per 100 million passenger miles traveled (PMT) for all transit modes combined are provided in *Exhibit 5-15.* Since the definitions of both injuries and incidents were changed in 2002, no direct comparisons can be made with earlier years. Fatalities decreased from 292 in 2000 to 282 in 2002, and also fell when adjusted for PMT from 0.69 per 100 million PMT in 2000 to 0.66 per 100 million PMT in 2002.

*Exhibit 5-16* shows annual incident, injury, and fatality rates per 100 million PMT for the five largest transit modes. These rates span the averages for all modes as reported in Exhibit 5-16. Changes in occurrences on bus, heavy rail, and commuter rail modes have the largest effect on the averages reported in Exhibit 5-15. This is because, when combined, these modes account for a very high percentage of PMT, 93 percent in 2002.

Transit vehicles that share the roadway with other nontransit vehicles have historically had a higher number of incidents than transit vehicles that travel on fixed guideways. This relationship continued in 2002, even with the increase of the incident threshold to $7,500. However, consistent with the increase in the dollar value of the incident threshold, the number of reported incidents per 100 million PMT on demand response

## Exhibit 5-15 *Annual Transit-Related Incidents, Injuries, and Fatalities, 1993–2002: Directly Operated Service Only (Purchased Transportation not Included)*

| Year | Incidents Total | Incidents Per 100 Million PMT | Injuries Total | Injuries Per 100 Million PMT | Fatalities Total | Fatalities Per 100 Million PMT |
|---|---|---|---|---|---|---|
| 1993 | 66,233 | 192 | 53,057 | 154 | 270 | 0.78 |
| 1994 | 71,429 | 200 | 58,794 | 164 | 318 | 0.89 |
| 1995 | 62,938 | 176 | 57,589 | 161 | 274 | 0.77 |
| 1996 | 59,709 | 165 | 55,643 | 154 | 265 | 0.73 |
| 1997 | 62,009 | 165 | 56,535 | 151 | 275 | 0.73 |
| 1998 | 60,367 | 153 | 56,369 | 143 | 286 | 0.73 |
| 1999 | 59,781 | 146 | 56,416 | 138 | 299 | 0.73 |
| 2000 | 60,638 | 142 | 57,457 | 135 | 292 | 0.69 |
| 2001 | 59,041 | 134 | 54,842 | 125 | 268 | 0.61 |
| 2002 [1] | 24,247 | 57 | 19,367 | 46 | 282 | 0.66 |

Note: Includes all modes (Motor Bus, Trolleybus, Heavy Rail, Commuter Rail, Light Rail, Demand Response, Automated Guideway, Vanpool, Cable Car, Ferryboat, Inclined Plane, Jitney) and all incidents, injuries, and fatalities including those not directly associated with the operation of transit vehicles (suicides, personal casualties in parking lots and stations).

[1] Revised definitions of incidents and injuries.

*Source: National Transit Database/Safety Management Information Statistics.*

## Exhibit 5-16 *Transit-Related Incidents, Injuries, and Fatalities by Mode: Directly Operated Service Only (Purchased Transportation not Included)*

Annual Rates per 100 Million Passenger Miles by Mode, 1993–2002

| Incidents | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [1] |
|---|---|---|---|---|---|---|---|---|---|---|
| Bus | 277 | 296 | 264 | 252 | 242 | 243 | 232 | 235 | 215 | 76 |
| Heavy Rail | 147 | 150 | 136 | 119 | 126 | 110 | 95 | 92 | 88 | 51 |
| Commuter Rail | 33 | 42 | 38 | 34 | 44 | 30 | 31 | 24 | 25 | 20 |
| Light Rail | 168 | 170 | 148 | 141 | 115 | 101 | 99 | 99 | 91 | 76 |
| Demand Response | 766 | 801 | 785 | 964 | 627 | 633 | 757 | 881 | 715 | 225 |

| Injuries | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 [1] |
|---|---|---|---|---|---|---|---|---|---|---|
| Bus | 233 | 257 | 254 | 248 | 234 | 240 | 232 | 230 | 207 | 66 |
| Heavy Rail | 103 | 109 | 106 | 96 | 102 | 90 | 75 | 78 | 75 | 35 |
| Commuter Rail | 24 | 32 | 31 | 27 | 34 | 21 | 22 | 20 | 16 | 17 |
| Light Rail | 139 | 142 | 152 | 168 | 106 | 96 | 107 | 100 | 85 | 39 |
| Demand Response | 511 | 549 | 627 | 662 | 482 | 551 | 646 | 817 | 571 | 173 |

| Fatalities | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Bus | 0.51 | 0.65 | 0.50 | 0.63 | 0.65 | 0.64 | 0.57 | 0.51 | 0.51 | 0.43 |
| Heavy Rail | 0.81 | 0.80 | 0.75 | 0.64 | 0.64 | 0.44 | 0.65 | 0.56 | 0.42 | 0.53 |
| Commuter Rail | 1.35 | 1.52 | 1.21 | 1.01 | 1.13 | 1.16 | 1.16 | 0.99 | 0.99 | 1.36 |
| Light Rail | 2.13 | 1.56 | 1.75 | 0.63 | 0.29 | 2.06 | 1.43 | 2.24 | 1.48 | 0.92 |
| Demand Response | 1.57 | 1.52 | 4.04 | 8.26 | 3.00 | 2.07 | 0.48 | 3.77 | 0.42 | 0.00 |

Note: includes all incidents, injuries and fatalities including those not directly associated with the operation of transit vehicles (suicides, personal casualties in parking lots and stations).

[1] Definitions of incidents and injuries have been revised.

*Source: National Transit Database/Safety Management Information Statistics.*

vehicles was 75 percent lower in 2002 than in 2000, and the number on buses 68 percent lower, the number on heavy rail 45 percent lower, the number on commuter rail 14 percent lower, and the number on light rail was 23 percent lower. The most striking effect of the increased dollar value of incident threshold has been to reduce the number of incidents per 100 million PMT reported on buses to 76, the same number as reported for light rail.

The change in the definition of injury also has led to a considerable reduction in the number of injuries reported per 100 million PMT on both bus and demand response vehicles, by 71 percent and 79 percent, respectively, between 2000 and 2002. The number of injuries reported on rail modes also declined considerably as a result of the change in the injury definition. The number of reported injuries per 100 million PMT on heavy rail was 55 percent lower in 2002 than 2000, and the number on light rail was 61 percent lower. The number of injuries reported on commuter rail decreased very slightly as a result of the more stringent definition, from 20 per 100 million PMT in 2000 to 17 per 100 million PMT in 2002.

Although buses have historically had higher incident and injury rates, bus fatality rates have tended to be lower than those on other transit modes. Heavy rail also has had low fatality rates. Fatality rates for commuter and light rail have, on average, been higher than fatality rates for heavy rail. Demand response vehicles have widely fluctuating fatality rates, often well above those for other types of transit services. There were, however, no fatalities on directly operated demand response services in 2002.

# 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 2002 C&P report, which were based on 2000 data. Where the 2000 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2002 data.

**Exhibit 6-1** *Comparison of Highway and Transit Finance Statistics with Those in the 2002 C&P Report*

| | 2000 Data | | |
|---|---|---|---|
| **Statistic** | **2002 C&P Report** | **Revised as of 12/23/04** | **2002 Data** |
| Total Funding for Highways (all govts.) | $128.7 bil | $131.1 bil | $134.8 bil |
| Total Funding for Transit | $30.8 bil | | $36.5 bil |
| Total Public Funding for Transit | $21.0 bil | | $26.6 bil |
| Percent of Public Funding for Transit Funded by Federal Government | 25% | | 23.7% |
| Total Highway Expenditures (all govts.) | $127.5 bil | $122.7 bil | $135.9 bil |
| Percent of Total Highway Expenditures Funded by Federal Government | 21.7% | 22.4% | 24.1% |
| Total Highway Capital Outlay (all govts.) | $64.6 bil | $61.3 bil | $68.2 bil |
| Percent of Total Highway Capital Outlay Funded by Federal Government | 39.9% | 42.6% | 46.1% |
| Percent of Total Highway Capital Outlay Used for System Preservation | 52.0% | | 52.6% |
| Total Transit Capital Outlay | $9.0 bil | | $12.3 bil |
| Percent of Total Transit Capital Outlay Funded by Federal Government | 47% | | 40.6% |
| Percent of Total Transit Capital Outlay Used for Rail | 63% | | 71% |
| Total Highway-User Revenues (motor-fuel and vehicle taxes and tolls) | $100.6 bil | $99.9 bil | $100.5 bil |
| Highway-User Revenues Used for Roads | $81.0 bil | $81.3 bil | $79.6 bil |
| Total Transit Fares and Other System-Generated Revenue | $9.8 bil | | $9.9 bil |

# Highways and Bridges

All levels of government generated $134.8 billion in 2002 to be used for highways and bridges. In addition to this total, $1.1 billion was drawn from reserves, so cash outlays for highways and bridges in 2000 totaled $135.9 billion. Highway expenditures increased 10.8 percent between 2000 and 2002, from $122.7 billion to $135.9 billion. Highway expenditures grew more quickly than inflation over this period, rising 7.5 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 2000, highway capital expenditures by all levels of government grew 11.2 percent to $68.2 billion in 2002. The Federal government contributed $31.2 billion (46.1 percent) of total highway capital expenditures.

In 2002, 52.6 percent of highway capital outlay was used for system preservation, up marginally from 52.0 percent in 2000. 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 slightly, from $99.9 billion in 2000 to $100.5 billion in 2002. Of this total, $79.6 billion (79.2 percent) was used for highway programs.

**Q.** What accounts for the large revisions in the year 2000 highway expenditure data shown in Exhibit 6-1?

**A.** Much of the data reported in this chapter relies on Table HF-10 in *Highway Statistics*. The local data shown in this table are estimated, since local government financial data reporting lags a year behind that of State governments. These data are subsequently revised the following year, in Table HF-10A.

Typically these revisions are relatively small, and not significant in term of C&P report findings. However, in 2000 the initial estimate in Table HF-10 had predicted a local capital outlay figure of $16.7 billion, while the final Table HF-10A numbers issued the following year showed the actual figure was only $14.3 billion. State capital outlay was also revised downward by $0.9 billion. Based on these revised figures, the portion of total highway capital outlay funded by the Federal government in 2000 was 42.6 percent, which is significantly higher than the 39.9 percent figure based on the initial estimates.

# Transit

In 2002, $36.5 billion was available from all sources to finance transit investment and operations. 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 2002 Federal funding was $6.3 billion (17 percent of total transit funds), State and local funding was $26.6 billion (56 percent of total transit funds) and system-generated revenues were $9.9 billion (27 percent of total transit funds). Between 2000 and 2002 Federal funding increased by 15.4 percent, State and local funding increased by 22.0 percent and system-generated revenues by 0.6 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

**Q.** How was the $31.2 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)?

**A.** 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 Highway Trust Fund 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 $31.2 billion figure cited for the Federal contribution to total capital expenditures represents total Federal expenditures for highway purposes of $32.8 billion less direct Federal expenditures for noncapital purposes such as maintenance on Federally owned roads, administrative costs, and research.

current systems (also know as "New Starts"), and the modernization of existing fixed assets. In 2002, total public transit agency expenditures for capital investment were $12.3 billion in current dollars and accounted for 34.9 percent of total transit expenditures. Federals funds accounted for $5.0 billion of total transit agency capital expenditures ($4.2 billion in 2000), State funds for $1.4 billion ($1.0 billion in 2000), and local funds $5.9 billion ($3.8 billion in 2000).

In areas with populations over 200,000, Federal funds may not be spent on operating expenses. This limitation means that a higher proportion of Federal funds are spent on capital investments, while State, local, and system-generated funds are more likely to be spent on operating expenses. Nevertheless, as local governments significantly increased their funding for capital investments between 2000 and 2002, the Federal share of total capital expenditures fell from 47 percent in 2000 to 41 percent in 2002.

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2002, $24.2 billion was available for operating expenses and accounted for 65.1 percent of total available funds. Of this amount, $1.3 billion was available from the Federal government, $6.1 billion from State governments, $6.9 billion from local governments, and $9.9 billion from system-generated revenues. In 2002, transit operators' actual operating expenditures were $22.9 billion compared with $20.0 billion in 2000, an increase of 14.5 percent. This was a larger percentage increase than experienced in any other 2-year period since 1993. Between 2000 and 2002, operating expenses for demand response systems and light rail increased more rapidly than operating expenses for other modes both in total and on a per passenger mile basis.

# Highway and Bridge Finance

This section presents information on the revenue sources supporting public investment in highways and bridges and on the 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.

## Revenue Sources

*Exhibit 6-2* shows that all levels of government generated $134.8 billion in 2002 to be used for highways and bridges. Actual cash expenditures for highway and bridge purposes totaled $135.9 billion in 2002; $1.1 billion was drawn from reserves by various governmental units for additional expenditure on highways or bridges. The $4.2 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 2002.

**Exhibit 6-2** *Revenue Sources for Highways, 2002 (Billions of Dollars)*

| | Federal | State | Local | Total | Percent |
|---|---|---|---|---|---|
| **User Charges** | | | | | |
| Motor-Fuel Taxes | $25.4 | $27.8 | $1.0 | $54.2 | 40.2% |
| Motor-Vehicle Taxes and Fees | 1.5 | 16.7 | 0.7 | 18.8 | 14.0% |
| Tolls | 0.0 | 5.2 | 1.4 | 6.6 | 4.9% |
| **Subtotal** | **$26.8** | **$49.7** | **$3.1** | **$79.6** | **59.1%** |
| **Other** | | | | | |
| Property Taxes and Assessments | 0.0 | 0.0 | 6.5 | 6.5 | 4.8% |
| General Fund Appropriations | 1.5 | 4.7 | 14.1 | 20.3 | 15.1% |
| Other Taxes and Fees | 0.2 | 3.1 | 4.2 | 7.5 | 5.6% |
| Investment Income and Other Receipts | 0.0 | 2.9 | 5.2 | 8.1 | 6.0% |
| Bond Issue Proceeds | 0.0 | 8.0 | 4.7 | 12.7 | 9.5% |
| **Subtotal** | **$1.7** | **$18.7** | **$34.7** | **$55.2** | **40.9%** |
| **Total Revenues** | **$28.6** | **$68.4** | **$37.8** | **$134.8** | **100.0%** |
| Funds Drawn from or (Placed in) Reserves | $4.2 | $0.6 | ($3.7) | $1.1 | 0.8% |
| **Total Expenditures Funded During 2002** | **$32.8** | **$69.0** | **$34.1** | **$135.9** | **100.8%** |

*Source: Highway Statistics 2002, Table HF-10, and unpublished FHWA data.*

Highway-user charges, including motor-fuel taxes, motor-vehicle taxes and fees, and tolls, were the source of 59.1 percent of the $134.8 billion of total revenues for highways and bridges in 2002. The remaining 40.9 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. Were all revenues generated by motor-fuel taxes, motor-vehicle taxes and fees, and tolls in 2002 used for highways?**

**A.** No. The $79.6 billion identified as highway-user charges in Exhibit 6-2 represents only 79.2 percent of total highway-user revenues, defined as all revenues generated by motor-fuel taxes, motor-vehicle taxes, and tolls. *Exhibit 6-3* shows that combined highway-user revenues collected in 2002 by all levels of government totaled $100.5 billion.

**Exhibit 6-3** *Disposition of Highway-User Revenue*

| Portion used for: | Federal | State | Local | Total |
|---|---|---|---|---|
| Highways | 26.8 | 49.7 | 3.1 | 79.6 |
| Transit | 5.7 | 3.2 | 0.5 | 9.4 |
| Other | 1.3 | 10.0 | 0.2 | 11.5 |
| **Total Collected** | **33.8** | **62.9** | **3.8** | **100.5** |

*Source: Highway Statistics 2002, Table HF-10 and unpublished FHWA data.*

In 2002, $9.4 billion of highway-user revenues were used for transit, and $11.5 billion were used for other purposes, such as ports, schools, collection costs, and general government activities. The $1.3 billion shown as Federal highway-user revenues used for other purposes includes fuel tax proceeds deposited into the Leaking Underground Storage Tank (LUST) trust fund, as well as the portion of gasohol tax receipts that was retained by the general fund for deficit reduction.

The $5.7 billion shown as Federal highway-user revenues used for transit includes $4.6 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 program 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, 93.9 percent of highway revenues came from motor-fuel and motor-vehicle taxes in 2002. The remainder came from general fund appropriations, timber sales, lease of Federal lands, oil and mineral royalties, and motor carrier fines and penalties.

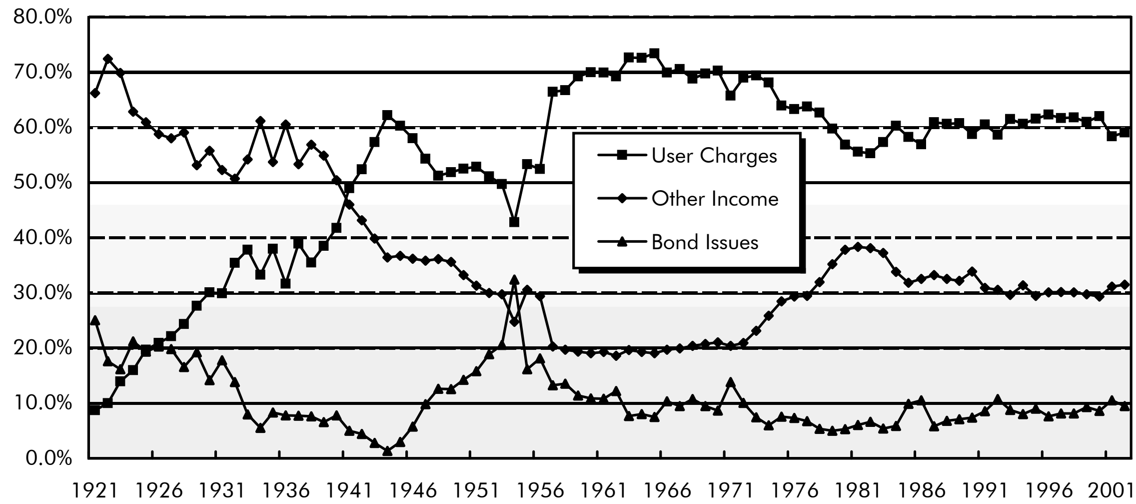
Highway-user charges also provided the largest share, 72.6 percent, of highway revenues at the State level in 2002. Bond issue proceeds were another significant source of funding, providing 11.7 percent of highway funds at the State level. The remaining 15.3 percent of State highway funding came from 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 8.2 percent of highway funding was provided by highway-user charges in 2002. Local general funds, property taxes, and other taxes and fees were the sources of 65.5 percent of local highway funding. Bond issue proceeds provided 12.5 percent of local highway funding, while investment income and miscellaneous receipts provided the remaining 13.8 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, dropping to 4.8 percent of total highway revenues in 2002. 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.

## Exhibit 6-4 *Highway Revenue Sources by Type, All Units of Government, 1921–2002*




| | 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 |

*Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics Tables HF-10A and HF-10, various years.*

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.

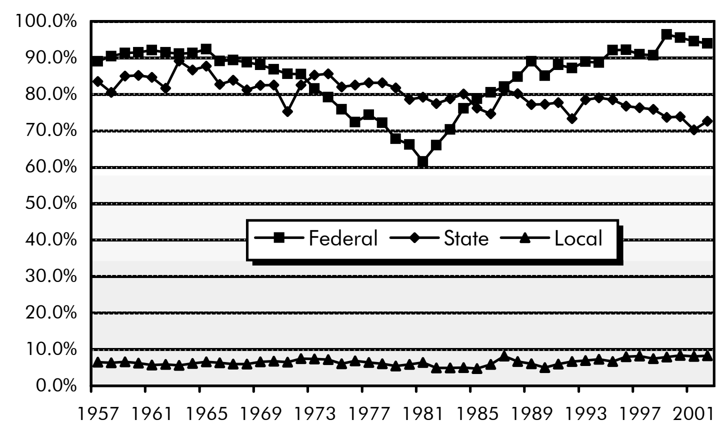
After peaking at an all-time high of 73.5 percent of highway revenues in 1965, the share represented by highway-user charges dropped to 55.2 percent in 1982. As shown in Exhibit 6-4, since that time, the percentage has rebounded and stabilized in a range of about 60 to 62 percent, though it was slightly below this range in 2001 and 2002.

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 has increased, reaching an all-time high of 96.4 percent in 1999, and remaining at nearly 94 percent in 2002.

Exhibit 6-5 shows that the share of State government highway funding contributed by highway-user charges has generally declined over time. From 1995 to 2002, the percentage dropped from 78.5 percent to 72.6 percent. Over the same period, States grew more reliant on debt financing, as bond proceeds grew from 8.6 percent to 11.7 percent, and exceeding 13 percent in 1999 and 2001.

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

**Exhibit 6-5** *Percent of Highway Revenue Derived from User Charges, for Each Level of Government, 1957–2002*




| 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% |

*Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.*

derived from highway-user charges has been slightly higher than it was historically, exceeding 8 percent each year from 2000 to 2002.

**Q.** **Why did the percentage of Federal revenue for highways derived from highway-user charges increase sharply between 1998 and 1999?**

**A.** 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 Federal fiscal year (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 2002 equaled $135.9 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 figures cited as "expenditures," "spending," or "outlays" in this report represent cash expenditures rather than authorizations or obligations).

While the Federal government funded $32.8 billion (24.1 percent) of total highway expenditures of $135.9 billion in 2002, 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 $1.8 billion (1.3 percent). The remaining $31.0 billion was in the form of transfers to State and local governments.

**Exhibit 6-6** *Direct Expenditures for Highways, by Expending Agencies and by Type*

| Billions of Dollars, 2002 | Federal | State | Local | Total | Percent |
|---|---|---|---|---|---|
| **Current Expenditures** | | | | | |
| **Capital Outlay** | | | | | |
| Funded by Federal Government | $0.4 | $29.6 | $1.5 | $31.5 | 23.1% |
| Funded by State or Local Govt's | 0.0 | 22.2 | 14.5 | 36.7 | 27.0% |
| **Subtotal** | **$0.4** | **$51.8** | **$16.0** | **$68.2** | **50.2%** |
| **Noncapital Expenditures** | | | | | |
| Maintenance | 0.2 | 9.7 | 15.8 | 25.7 | 18.9% |
| Highway and Traffic Services | 0.0 | 3.9 | 3.6 | 7.5 | 5.5% |
| Administration | 1.2 | 5.9 | 3.6 | 10.7 | 7.9% |
| Highway Patrol and Safety | 0.0 | 6.3 | 5.4 | 11.7 | 8.6% |
| Interest on Debt | 0.0 | 3.7 | 1.8 | 5.4 | 4.0% |
| **Subtotal** | **$1.4** | **$29.5** | **$30.1** | **$61.0** | **44.9%** |
| **Total, Current Expenditures** | **$1.8** | **$81.3** | **$46.1** | **$129.1** | **95.0%** |
| **Bond Retirement** | **$0.0** | **$4.4** | **$2.4** | **$6.8** | **5.0%** |
| **Total All Expenditures** | | | | | |
| Funded by Federal Government | 1.8 | 29.6 | 1.5 | 32.8 | 24.1% |
| Funded by State Governments | 0.0 | 54.4 | 14.6 | 69.0 | 50.8% |
| Funded by Local Governments | 0.0 | 1.7 | 32.4 | 34.1 | 25.1% |
| **Grand Total** | **$1.8** | **$85.7** | **$48.5** | **$135.9** | **100.0%** |

*Source: Highway Statistics 2002, Table HF-10 and unpublished FHWA data.*

State governments combined $29.6 billion of Federal funds with $54.4 billion of State funds and $1.7 billion of local funds to make direct expenditures of $85.7 billion (63.0 percent). Local governments combined $1.5 billion of Federal funds with $14.6 billion of State funds and $32.4 billion of local funds to make direct expenditures of $48.5 billion (35.7 percent).

**Q. What basis is used for distinguishing between capital expenditures and maintenance expenditures?**

**A.** 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. How are "maintenance" and "highway and traffic services" defined in this report?**

**A.** 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 the maintenance and repair of 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.

## *Types of Highway Expenditures*

Current highway expenditures can be divided into two broad categories: noncapital and capital. Noncapital highway expenditures include maintenance of highways, highway and traffic services, administration, highway law enforcement, highway safety, and interest on debt. Highway capital outlay consists of those expenditures associated with highway improvements, 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 $68.2 billion on capital outlay in 2002, or 50.2 percent of total highway expenditures. Highway capital outlay expenditures are discussed in more detail later in this chapter.

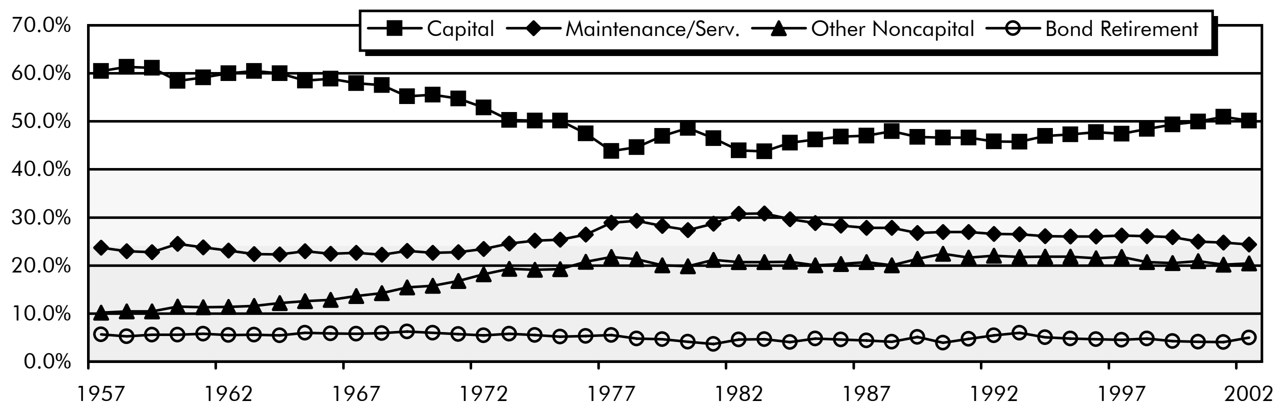
Current noncapital expenditures consumed $61.0 billion (44.9 percent), while the remaining $6.8 billion (5.0 percent) went for bond redemption. Most Federal funding for highways goes for capital items. Noncapital expenditures are funded primarily by State and local governments. In 2002, State and local noncapital expenditures were close to equal, as State governments spent $29.5 billion while local governments spent $30.1 billion. The majority of maintenance expenditures occurred at the local government level, or $15.8 billion (61.4 percent) of the $25.7 billion total.

## *Historical Expenditure and Funding Trends*

*Exhibits 6-7* and *6-8* provide historical perspective for the 2002 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.

The increased Federal funding for highways available under the Transportation Equity Act for the 21st Century (TEA-21) contributed to a 33.3 percent increase (from $102.0 billion to $135.9 billion) in total highway spending by all levels of government between 1997 and 2002. Capital outlay by all levels of government increased by 41.0 percent from $48.4 billion to $68.2 billion over the same period.

**Exhibit 6-7** *Expenditures for Highway by Type, All Units of Government, 1957–2002*




**(Billions of Dollars)**

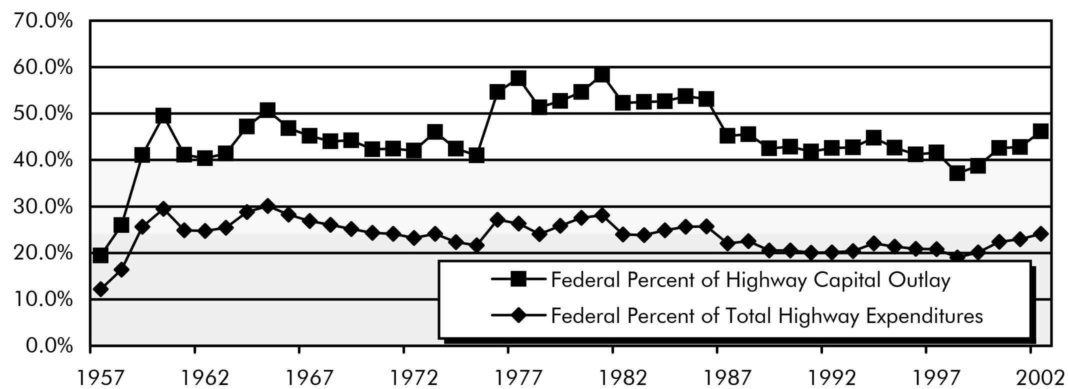
| Year | Capital Outlay | Maintenance and Services | Other Noncapital: Administration | Other Noncapital: Highway Patrol & Safety | Other Noncapital: Interest on Debt | Other Noncapital: Total Other Noncapital | Debt Retirement | Total |
|---|---|---|---|---|---|---|---|---|
| 1957 | $5.6 | $2.2 | $0.4 | $0.3 | $0.3 | $0.9 | $0.5 | $9.3 |
| 1961 | $6.8 | $2.7 | $0.5 | $0.3 | $0.4 | $1.3 | $0.7 | $11.5 |
| 1965 | $8.4 | $3.3 | $0.8 | $0.5 | $0.5 | $1.8 | $0.9 | $14.3 |
| 1969 | $10.4 | $4.3 | $1.1 | $1.1 | $0.7 | $2.9 | $1.2 | $18.8 |
| 1973 | $12.2 | $5.9 | $1.7 | $1.9 | $1.0 | $4.7 | $1.4 | $24.2 |
| 1977 | $13.1 | $8.6 | $2.4 | $2.8 | $1.3 | $6.5 | $1.6 | $29.8 |
| 1981 | $19.7 | $12.2 | $3.4 | $3.9 | $1.7 | $9.0 | $1.6 | $42.4 |
| 1985 | $26.6 | $16.6 | $4.2 | $5.2 | $2.1 | $11.5 | $2.8 | $57.5 |
| 1989 | $33.1 | $19.0 | $5.7 | $6.6 | $2.8 | $15.2 | $3.6 | $70.9 |
| 1993 | $39.5 | $22.9 | $7.9 | $7.2 | $3.7 | $18.8 | $5.2 | $86.4 |
| 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 |

*Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.*

The percentage of total highway expenditures that went for capital outlay peaked at 61.3 percent in 1958. 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 has climbed back up, exceeding 50 percent for the first time since 1975 in 2001 and 2002.

Exhibit 6-8 shows that the portion of total highway funding provided by the Federal government rose from 20.8 to 24.1 percent from 1997 to 2002. The Federal share of capital funding also increased significantly (from 41.6 to 46.1 percent) over this same period. Federal cash expenditures for capital purposes increased 56.3 percent from 1997 to 2002, while State and local capital investment increased by 29.7 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 translate immediately into increased cash outlays

**Exhibit 6-8** *Funding for Highways by Level of Government, 1957–2002*




| | Funding for Total Highway Expenditures Billions of Dollars | | | | Percent | Funding for Capital Outlay Billions of Dollars | | Percent |
|---|---|---|---|---|---|---|---|---|
| Year | Federal | State | Local | Total | Federal | Federal | Total | Federal |
| 1957 | $1.1 | $6.1 | $2.0 | $9.3 | 12.2% | $1.1 | $5.6 | 19.4% |
| 1961 | $2.9 | $6.2 | $2.4 | $11.5 | 24.8% | $2.8 | $6.8 | 41.1% |
| 1965 | $4.3 | $7.3 | $2.7 | $14.3 | 30.1% | $4.2 | $8.4 | 50.7% |
| 1969 | $4.7 | $10.4 | $3.7 | $18.8 | 25.1% | $4.6 | $10.4 | 44.2% |
| 1973 | $5.8 | $13.8 | $4.6 | $24.2 | 24.1% | $5.6 | $12.2 | 46.0% |
| 1977 | $7.8 | $15.1 | $6.9 | $29.8 | 26.3% | $7.5 | $13.1 | 57.6% |
| 1981 | $11.9 | $20.1 | $10.4 | $42.4 | 28.1% | $11.5 | $19.7 | 58.4% |
| 1985 | $14.7 | $27.9 | $14.9 | $57.5 | 25.7% | $14.3 | $26.6 | 53.8% |
| 1989 | $14.5 | $36.4 | $19.9 | $70.9 | 20.5% | $14.1 | $33.1 | 42.5% |
| 1993 | $17.6 | $46.5 | $22.3 | $86.4 | 20.4% | $16.9 | $39.5 | 42.7% |
| 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% |

*Sources: Highway Statistics Summary to 1995, Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.*

**Q. How does the pattern of Federal shares of capital outlay compare with what was predicted in prior reports?**

**A.** The 1999 C&P report had predicted that the Federal share would fall below the 41 to 46 percent range observed from 1987 to 1997, but would subsequently return to that range. This prediction was based on projections of HTF cash flows, recognizing that the ramp up of Federal funding under TEA-21 would take some time to 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 to 2002, as the increased obligation authority provided under TEA-21 began to translate into higher cash outlays.

The Federally funded portion of capital outlay by all levels of government rose above 40 percent in 1959, peaking at 58.3 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 has subsequently returned to it rising to 42.6 percent in 2000 (based on revised data, as discussion in the introduction to this Chapter) and 46.1 percent in 2002. Preliminary information suggests this percentage is likely to fall a bit in 2003.

**Q. Do the relative Federal, State, and local shares of funding described in this chapter equate to a comparable relative degree of influence?**

**A.** No. As discussed earlier, there are significant intergovernmental transfers of funds occurring 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.

Spending by all levels of government on maintenance and traffic services increased by 23.9 percent from 1997 to 2002, 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 24.4 percent, its lowest level since 1972. Spending on other noncapital expenditures including highway law enforcement and safety, administration and research, and interest payments also grew more slowly than overall highway spending from 1997 to 2002, falling from 21.8 percent of total spending to 20.4 percent.

Expenditures for highway law enforcement and safety were the slowest-growing category of highway spending from 1997 to 2002, at just 19.6 percent. 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 2002.

## Constant Dollar Expenditures

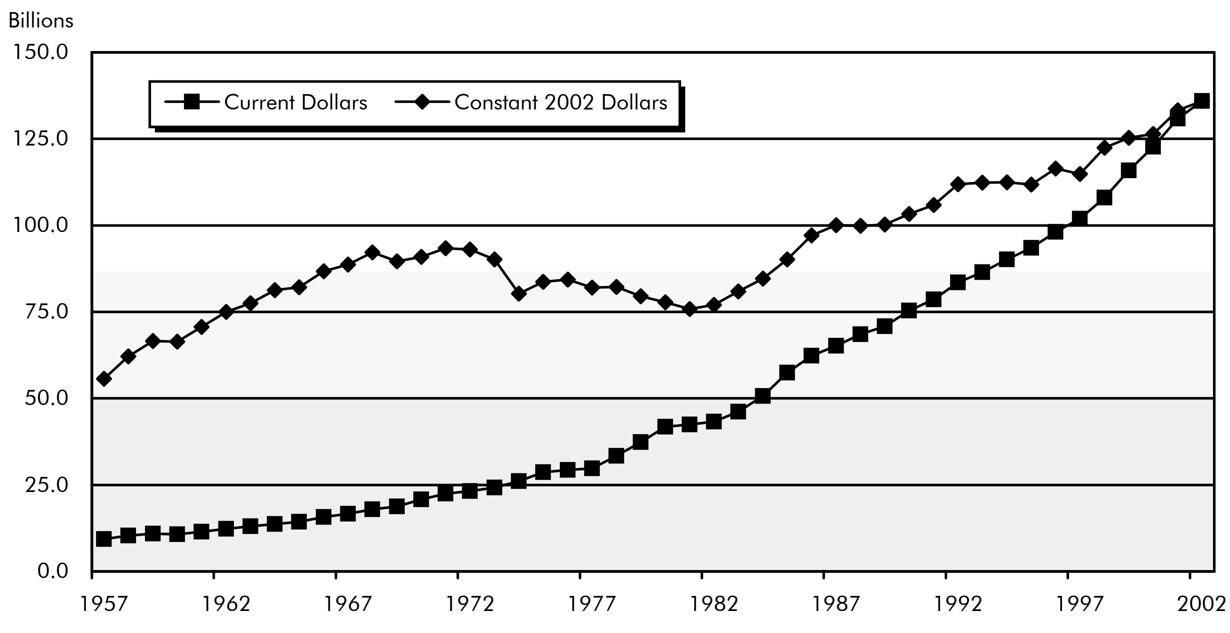
Highway expenditures grew more quickly than inflation between 1997 and 2002. As noted earlier, total highway expenditures increased 33.3 percent from $102.0 billion to $135.9 billion between 1997 and 2002, which equates to an average annual growth rate of 5.9 percent. Over the same period, it is estimated that highway construction costs increased at an annual rate of 2.5 percent, and other costs rose at an annual rate of 2.3 percent. In constant dollar terms, total highway expenditures grew by 18.4 percent between 1997 and 2002.

**Q.** What indices are used to convert current dollars to constant dollars in this report?

**A.** For capital outlay expenditures, the FHWA Construction Bid Price Index is used. For all other types of highway expenditures, the CPI is used.

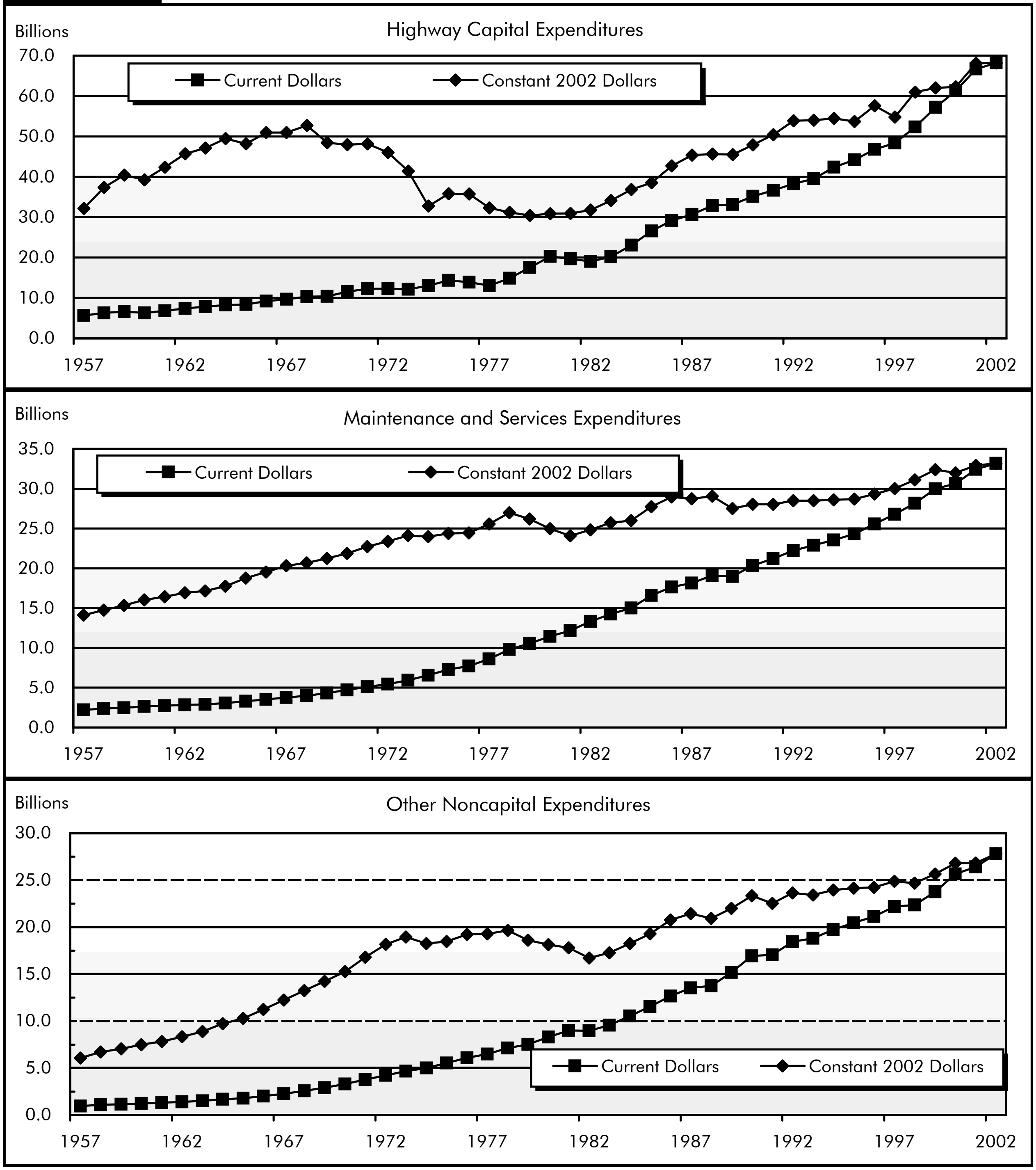
*Exhibit 6-9* shows that highway expenditures have grown in current dollar terms in each of the years from 1957 through 2002. In constant dollar terms, total highway expenditures by all levels of government reached a plateau in 1971. From 1972 to 1981, highway spending did not keep pace with inflation. 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 2002.

**Exhibit 6-9** *Total Highway Expenditures in Current and Constant 2002 Dollars, All Units of Government, 1957–2002*




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 noncapital expenditures in both current and constant dollar terms. Over this 21-year period, highway capital outlay grew at an average annual rate of 6.1 percent from $19.0 billion to $68.2 billion. In constant dollar terms, this equates to a 120.4 percent increase. Over this same period, maintenance and traffic services grew by 37.8 percent in constant dollar terms, and other noncapital expenditures grew by 56.3 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 3.3 percent. *Exhibit 6-10* compares current dollar and constant dollar spending for capital outlay, maintenance and traffic services, and other noncapital expenditures (including highway law enforcement and safety, administration and research, and interest payments).

**Exhibit 6-10** *Highway Capital, Maintenance, and Other Noncapital Expenditures in Current and Constant 2002 Dollars, All Units of Government, 1957–2002*



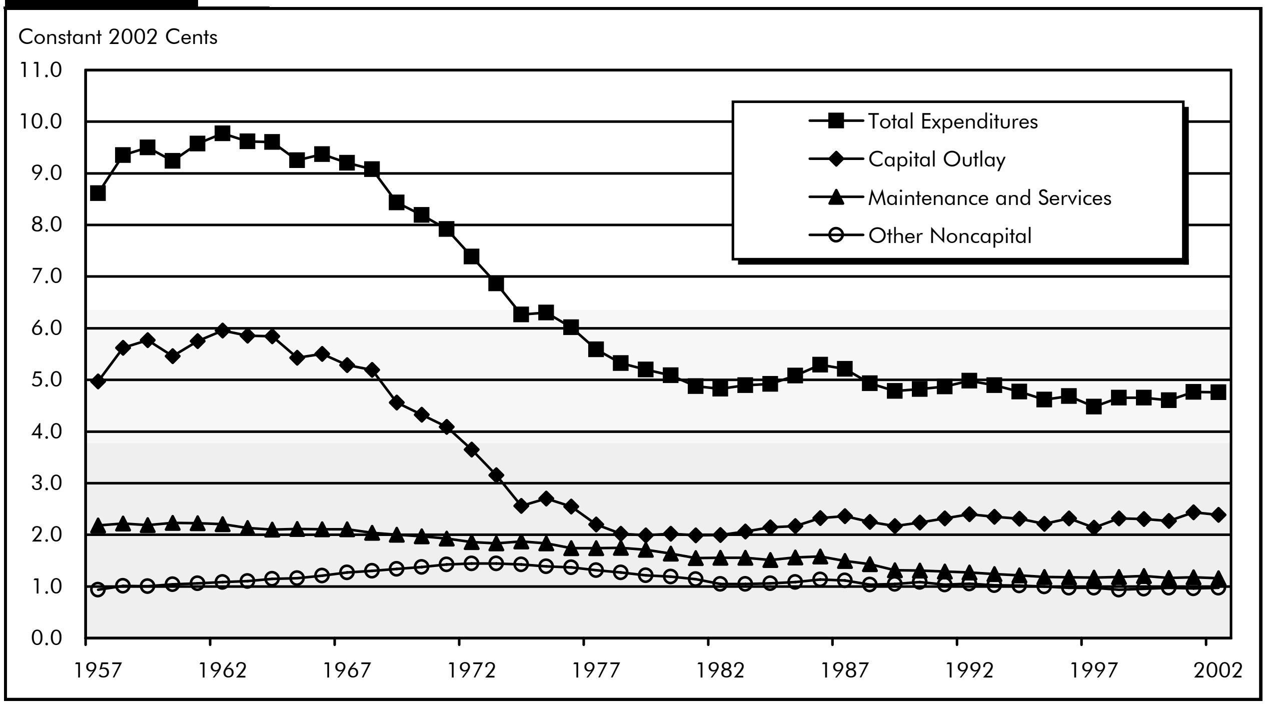

## *Constant Dollar Expenditures per VMT*

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 preservation 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 2000, expenditures per VMT rose from 4.0 cents to 4.8 cents. Expenditures per VMT in constant dollars also rose slightly in this period, increasing 6.2 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 1990s.

Capital outlay per VMT increased 11.7 percent between 1997 and 2002 in constant dollar terms. The 2001 and 2002 levels of approximately 2.4 cents per VMT were two of the three highest since 1976. As shown in *Exhibit 6-11,* over time, spending on maintenance and traffic services and other noncapital items has not kept pace with capital spending on a constant dollar per VMT basis. However, both have been very stable since 1995, at approximately 1.18 and 0.97 cents per VMT, respectively.

**Exhibit 6-11** *Highway Expenditures per Vehicle Mile Traveled, All Units of Government, 1957–2002*




# Highway Capital Outlay Expenditures

State governments directly spent $51.8 billion on highway capital outlay in 2002. As discussed earlier in the chapter, and as shown in Exhibit 6-6, this figure includes the $29.6 billion received in grants from the Federal government for highways. *Exhibit 6-12* shows how States applied this $51.8 billion to different functional systems and also includes an estimate of how the total $68.2 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 $8,190 per lane-mile in 2000, 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

**Exhibit 6-12** *Highway Capital Outlay by Functional System, 2002*

| 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 | $6.6 | $6.6 | $49,070 | 2.4 |
| Other Principal Arterial | 8.6 | 8.7 | 34,013 | 3.4 |
| Minor Arterial | 4.1 | 4.6 | 15,852 | 2.6 |
| Major Collector | 2.7 | 3.9 | 4,540 | 1.8 |
| Minor Collector | 0.4 | 1.2 | 2,263 | 2.0 |
| **Subtotal** | **$22.5** | **$25.0** | **$11,997** | **2.5** |
| **Urban Arterials and Collectors** | | | | |
| Interstate | 10.5 | 10.5 | 140,004 | 2.6 |
| Other Freeway and Expressway | 4.8 | 5.0 | 114,550 | 2.6 |
| Other Principal Arterial | 7.6 | 9.3 | 49,648 | 2.3 |
| Minor Arterial | 3.1 | 5.5 | 23,668 | 1.6 |
| Collector | 0.8 | 2.6 | 13,620 | 1.8 |
| **Subtotal** | **$26.8** | **$32.9** | **$45,105** | **2.2** |
| **Subtotal, Rural and Urban** | **$49.3** | **$57.9** | **$20,566** | **2.3** |
| **Rural and Urban Local** | **$2.4** | **$10.3** | **$1,863** | **2.7** |
| **Total, All Systems** | **$51.8** | **$68.2** | **$8,190** | **2.4** |
| **Funded by Federal Government** | **$29.6** | **$31.5** | **$3,779** | **1.1** |

*Source: Highway Statistics 2002 and unpublished FHWA data.*

principal arterials to 1.6 cents on urban minor arterials. On a cents-per-VMT basis, capital outlay for rural roads is about 15 percent higher than for urban roads.

## *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 Preservation, System Expansion, and System Enhancement.

*Exhibit 6-13* shows the distribution of the $49.3 billion in State expenditures among these three categories. Detailed data on Federal Government and local expenditures are unavailable, so the combined $57.9 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 $68.2 billion invested on all systems in 2002, it was assumed that expenditure patterns were roughly equivalent to those observed for arterials and collectors.

In 2002, about $35.8 billion was spent on system preservation (52.6 percent of total capital outlay). As defined in this report, system preservation 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.

**Exhibit 6-13** *Highway Capital Outlay by Improvement Type, 2002 (Billions of Dollars)*

| Direct State Expenditures on | System Preservation | System Expansion: New Roads and Bridges | System Expansion: Existing Roads | System Enhancement | Total |
|---|---|---|---|---|---|
| **Arterials and Collectors** | | | | | |
| Right-of Way | | $1.7 | $1.7 | | $3.4 |
| Engineering | $3.7 | 1.2 | 1.2 | $0.6 | 6.7 |
| New Construction | | 6.1 | | | 6.1 |
| Relocation | | | 1.0 | | 1.0 |
| Reconstruction—Added Capacity | 1.6 | | 3.6 | | 5.2 |
| Reconstruction—No Added Capacity | 3.2 | | | | 3.2 |
| Major Widening | | | 2.4 | | 2.4 |
| Minor Widening | 0.4 | | | | 0.4 |
| Restoration and Rehabilitation | 8.1 | | | | 8.1 |
| Resurfacing | 0.5 | | | | 0.5 |
| New Bridge | | 0.8 | | | 0.8 |
| Bridge Replacement | 3.7 | | | | 3.7 |
| Major Bridge Rehabilitation | 2.2 | | | | 2.2 |
| Minor Bridge Work | 2.1 | | | | 2.1 |
| Safety | | | | 1.3 | 1.3 |
| Traffic Management/Engineering | | | | 0.8 | 0.8 |
| Environmental and Other | | | | 1.4 | 1.4 |
| **Total, State Arterials and Collectors** | **$25.5** | **$9.8** | **$9.9** | **$4.1** | **$49.3** |
| **Total, Arterials and Collectors, All Jurisdictions (estimated)*** | | | | | |
| Highways and Other | 20.9 | 10.0 | 11.5 | 5.0 | 47.4 |
| Bridge | 9.6 | 1.0 | | | 10.5 |
| **Total, Arterials and Collectors** | **$30.4** | **$11.0** | **$11.5** | **$5.0** | **$57.9** |
| **Total Capital Outlay on All Systems (estimated)*** | | | | | |
| Highways and Other | 24.5 | 11.8 | 13.6 | 5.9 | 55.8 |
| Bridges | 11.3 | 1.1 | | | 12.4 |
| **Total, All Systems** | **$35.8** | **$12.9** | **$13.6** | **$5.9** | **$68.2** |
| **Percent of Total** | **52.6%** | **18.9%** | **19.9%** | **8.6%** | **100.0%** |

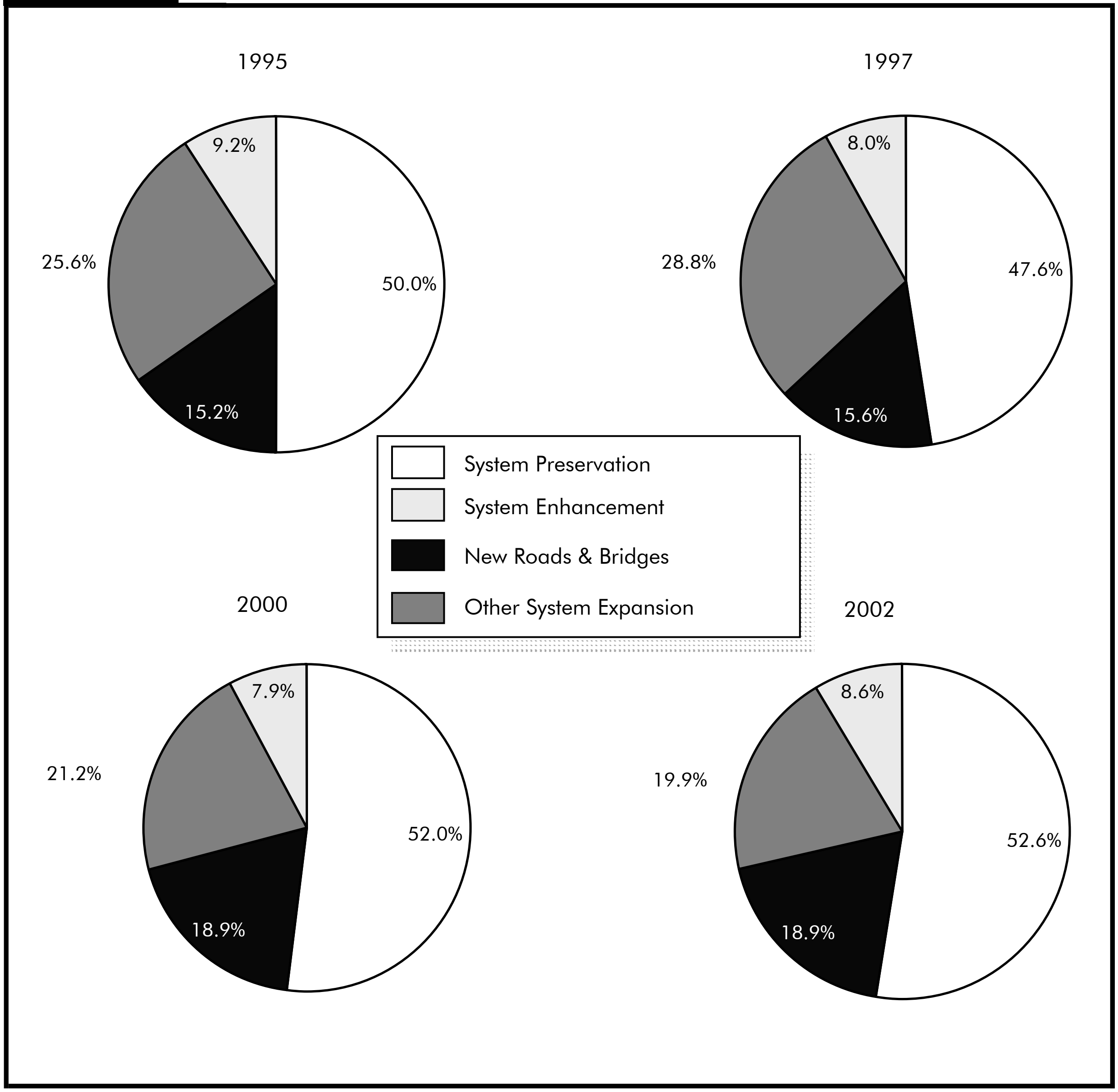
*Improvement type distribution was estimated based on State arterial and collector data.

*Sources: Highway Statistics 2002, Table SF-12A and unpublished FHWA data.*

About $12.9 billion (18.9 percent of total capital outlay) was spent on the construction of new roads and bridges in 2002. An additional $13.6 billion (19.9 percent) is estimated to have been used to add lanes to existing roads. Another $5.9 billion (8.6 percent) was spent on system enhancement, including safety enhancements, traffic operations improvements, and environmental enhancements.

*Exhibit 6-14* depicts the change, over time, in the share of capital outlay devoted to these major categories. After declining between 1995 and 1997, the overall share of highway capital improvements going toward system preservation increased significantly from 1997 to 2000, reaching 52.0 percent. From 2000 to 2002, the preservation share continued to increase slightly, to 52.6 percent. The share devoted to system enhancements increased between 2000 and 2002, but is slightly lower than the 1995 level.

**Exhibit 6-14** *Highway Capital Outlay by Improvement Type, 1995, 1997, 2000, and 2002*



**Q.** **How are "system preservation," "system expansion," and "system enhancement" defined in this report?**

**A.** System preservation 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 preservation does not include routine maintenance costs.

Note that system preservation as defined in this report does not include routine maintenance. As shown in Exhibit 6-6, an additional $25.7 billion was spent by all levels of government in 2002 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 preservation 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.

Expenditures for new roads and bridges relative to other improvement expenditures were steady between 2000 and 2002, at 18.9 percent. Other system expansion decreased significantly, however (19.9 percent in 2002 versus 21.2 percent in 2000, and down from 28.8 percent in 1997). As a result, overall outlays for system expansion continued to decrease proportionally, compared with preservation and enhancements.

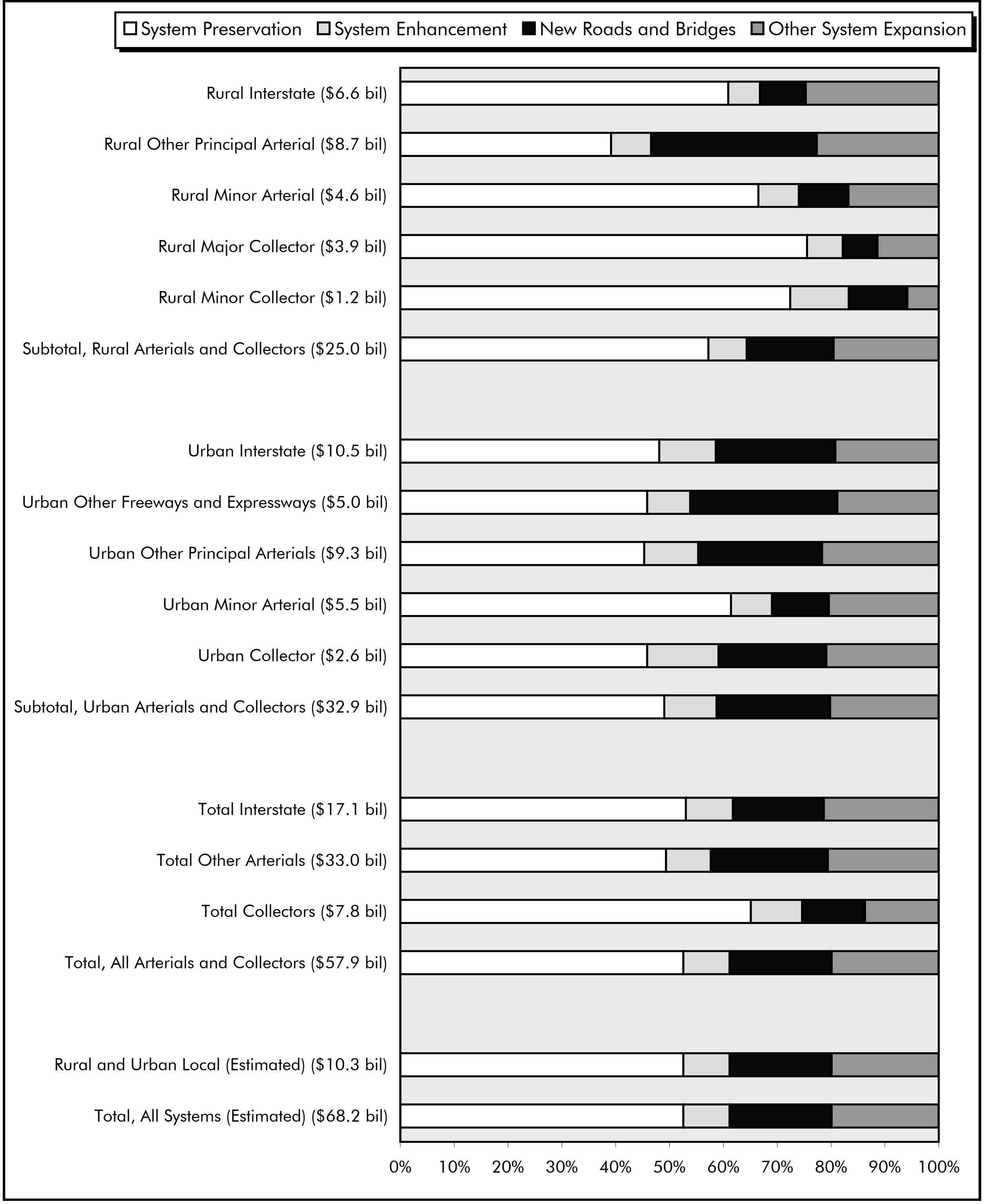
*Exhibit 6-15* shows significant variations in the types of capital expenditures made by States on different functional systems. The portion of capital outlay devoted to system preservation ranges from 39.1 percent on rural other principal arterials to 75.5 percent on rural major collectors. Overall, system preservation's share on arterials and collectors in rural areas (57.2 percent) was greater than in urban areas (49.0 percent), but the difference was much smaller than in 2000.

System expansion expenditures also vary significantly by functional class. The portion of capital used for construction of new roads and bridges is highest on rural other principal arterials, at 30.8 percent, while rural interstates have the largest share going to other system expansion improvements (24.7 percent). Rural other principal arterials have over 53 percent of capital investment devoted to system expansion. Total system expansion shares are lower on collectors (25.3 percent) than on interstates (38.2 percent) and other arterials (42.3 percent).

**Q.** **Are there other definitions of the term "system preservation" in common use?**

**A.** Yes. One alternative definition currently in use within the asset management community is "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.

**Exhibit 6-15** *Distribution of Capital Outlay by Improvement Type and Functional System, 2002*



# Transit Finance

## Transit Funding

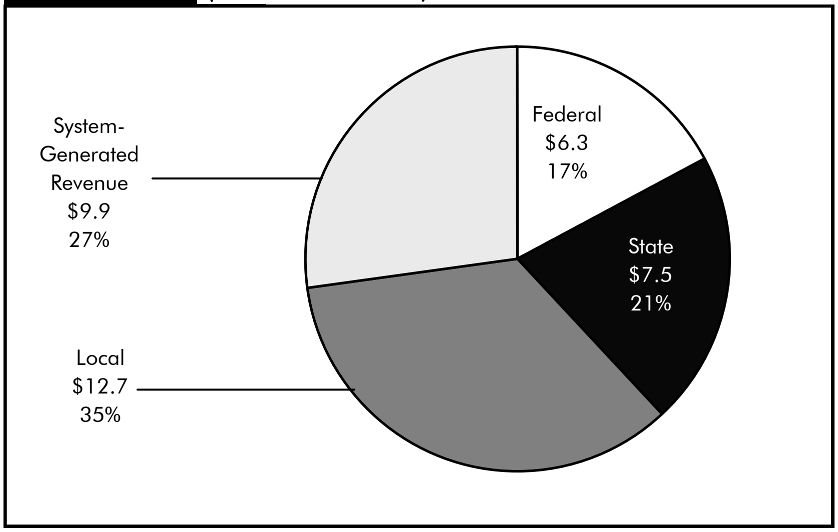
In 2002, $36.5 billion was available from all sources to finance transit investment and operations. Transit funding comes from two major sources: *public funds* allocated by Federal, State, and local governments; and *system-generated revenues* earned for the provision of transit services. Federal funding 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. *Exhibit 6-17* breaks down the sources of total transit funding. The most notable change in transit funding between 2000 and 2002 was a 73 percent increase in public funding from local sources from $2.7 billion to $4.7 billion.

**Exhibit 6-16** *Revenue Sources for Transit Financing, 2002 (Millions of Dollars)*

| | Federal | State | Local | Total | Percent |
|---|---|---|---|---|---|
| **Public Funds** | **$6,296** | **$7,546** | **$12,748** | **$26,590** | **72.9%** |
| General Fund | 1,259 | 2,118 | 2,641 | 6,017 | 16.5% |
| Fuel Tax | 5,037 | 620 | 105 | 5,762 | 15.8% |
| Income Tax | | 247 | 105 | 352 | 1.0% |
| Sales Tax | | 2,005 | 4,183 | 6,188 | 17.0% |
| Property Tax | | 22 | 502 | 524 | 1.4% |
| Other Dedicated Taxes | | 881 | 493 | 1,374 | 3.8% |
| Other Public Funds | | 1,653 | 4,720 | 6,372 | 17.5% |
| **System-Generated Revenue** | | | | **9,890** | **27.1%** |
| Passenger Fares | | | | 8,130 | 22.3% |
| Other Revenue | | | | 1,760 | 4.8% |
| **Total All Sources** | | | | **$36,480** | **100.0%** |

*Source: National Transit Database.*

**Exhibit 6-17** *2002 Public Transportation Revenue Sources (Billions of Dollars)*




*Source: National Transit Database.*

**Q. What type of dedicated funding does mass transit receive from Federal highway-user fees?**

**A.** Prior to FY 1983, all funding for transit was from general revenue sources. In 1983, the Mass Transit Account (MTA) was established within Highway Trust Fund (HTF), funded by 1.0 cent of the Federal motor-fuel tax. In 1990, the portion of the Federal fuel tax dedicated to MTA was increased to 1.5 cents, in 1995 to 2.0 cents, in 1997 to 2.85 cents, and in 1998 to 2.86 cents (retroactive to October 1, 1997) with the passage of 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 naptha, have also been dedicated to the MTA. (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 MTA has also received 2.13 cents of the user fee on liquefied petroleum gas and 1.86 cents of the user fee on liquefied natural gas. (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 MTA does not receive any of the nonfuel revenues (such as heavy vehicle use taxes) that accrue to the HTF.

# Level and Composition of Public Funding

In 2002, public funds of $26.6 billion were available for transit and accounted for 73 percent of total transit funding. Of this amount, Federal funding was $6.3 billion, accounting for 24 percent of total public funding and for 17 percent of all available funding from both public and nonpublic sources. [Note that the $6.3 billion Federal funding amount is for transit capital and operating expenses only, and is lower than total Federal funding allocated to FTA.] State funding was $7.5 billion, accounting for 28 percent of total public funds and 21 percent of funding from all sources. Local jurisdictions provided the bulk of transit funds, $12.7 billion in 2002, or 48 percent of total public funds and 35 percent of all funding. System-generated revenues were $9.9 billion, 27 percent of all funding.

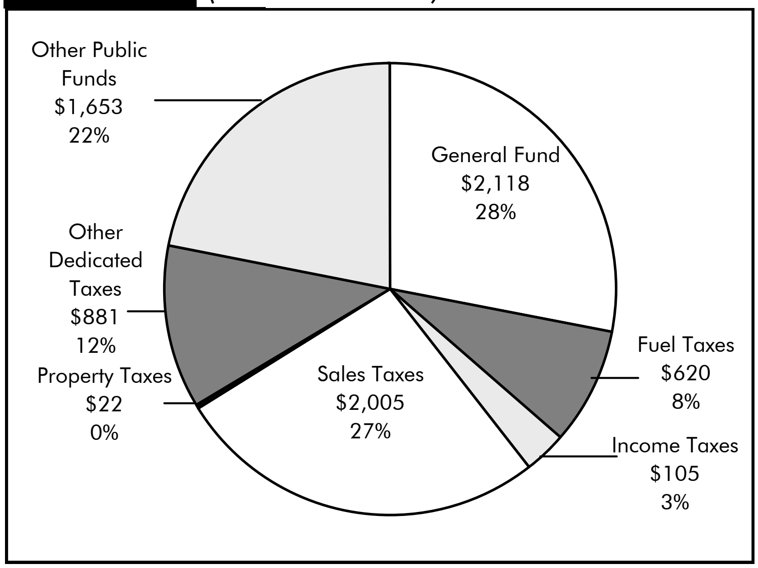
# Federal Funding

Federal funding for transit comes from two sources, the general revenues of the U.S. government and revenues credited to MTA of HTF generated from fuel taxes. The MTA, a transit trust fund for capital projects in transit, is the largest source of Federal funding for transit and accounts for approximately 80 percent of total Federal funds for transit. Allocations from the Federal general fund contribute the remaining 20 percent. Total funding from MTA in nominal dollars increased from $0.5 billion in 1983 to $5.0 billion in 2002.

# 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 2002, 28 percent of State funds and 21 percent of local funds came from general revenues. Allocations from other public funds accounted for 22 percent of total State and 36 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 2002, they accounted for 27 percent of total State and 33 percent of total local funding for transit. Dedicated income and property taxes provide more modest levels of funding at both the State and local levels. Dedicated income taxes are a more important source of transit funds at the State level, whereas dedicated property taxes are more important at the local level.

**Exhibit 6-18** *2002 State Sources of Transit Financing (Millions of Dollars)*

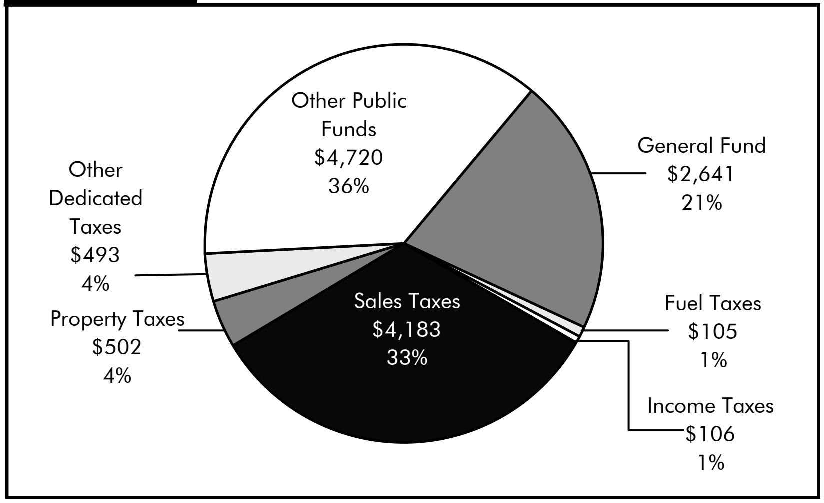



*Source: National Transit Database.*

# Level and Composition of System-Generated Funds

In 2002, system-generated funds were $9.9 billion and provided 27.1 percent of total transit funding. Passenger fares contributed $8.1 billion, accounting for 82 percent of system-generated funds and 22 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 other revenues.

**Exhibit 6-19** *2002 Local Sources of Funding for Transit (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 about 13 percent of total public funding for transit in 2002 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. Since 2000, the increase in public funding for transit has picked up at the Federal, State, and local levels. Between 2000 and 2002, Federal funding increased at an average annual rate of 9.4 per cent, and State and local funding at an average annual rate of 13.6 percent [*Exhibit 6-20*].

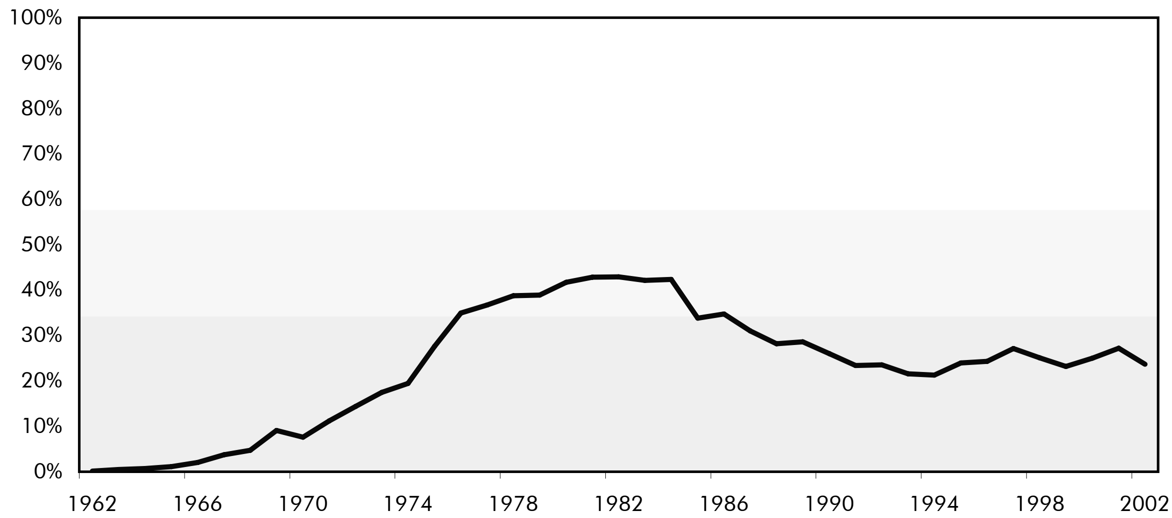
**Exhibit 6-20** *Growth in Public Funding for Public Transportation by Government Jurisdiction*

| 1960–2002 | Average Annual Growth Rate | | |
|---|---|---|---|
| Year | Federal | State and Local | Total |
| 1960–70 | na | 8.2% | 9.0% |
| 1970–80 | 38.9% | 11.9% | 17.2% |
| 1980–90 | 0.4% | 7.8% | 5.3% |
| 1990–00 | 4.3% | 4.8% | 4.7% |
| 2000–02 | 9.4% | 13.6% | 12.5% |

*Source: National Transit Database.*

Federal funding for transit, as a percentage of total public funding for transit from Federal, State, and local sources combined, reached a peak of 43.0 percent in the early 1980s [*Exhibit 6-21*]. However, by 1990, the Federal government provided only 26 percent of the total public funding available for transit. This lower percentage was 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 government has provided between 21 and 27 percent of total public funding for transit; in 2002, it provided 24 percent of these funds.

**Exhibit 6-21** *Federal Share of Public Funding for Transit, 1962–2002*




*Source: National Transit Database.*

# Funding in Current and Constant Dollars

Total public funding for transit in current dollars reached its highest level of $26.6 million in 2002, a 27 percent increase over 2000. Federal funding in current dollars increased by 20 percent from $5.3 billion in 2000 to $6.3 billion in 2002; and State and local funding in current dollars increased by 28 percent from $15.7 billion in 2000 to $20.3 billion in 2002. Total funding for transit in constant dollars increased by 22 percent between 2000 and 2002; funding in constant dollars from Federal sources increased by 15 percent, and from State and local sources by 22 percent [*Exhibits 6-22* and *6-23*].

# Flexible Funding

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, 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 2002, $1.1 billion was "flexed" from highways to transit, down from $1.6 billion in 2000. Since the program's beginning in FY 1991, through FY 2002, a total of $8.8 billion has been transferred from highways to transit.

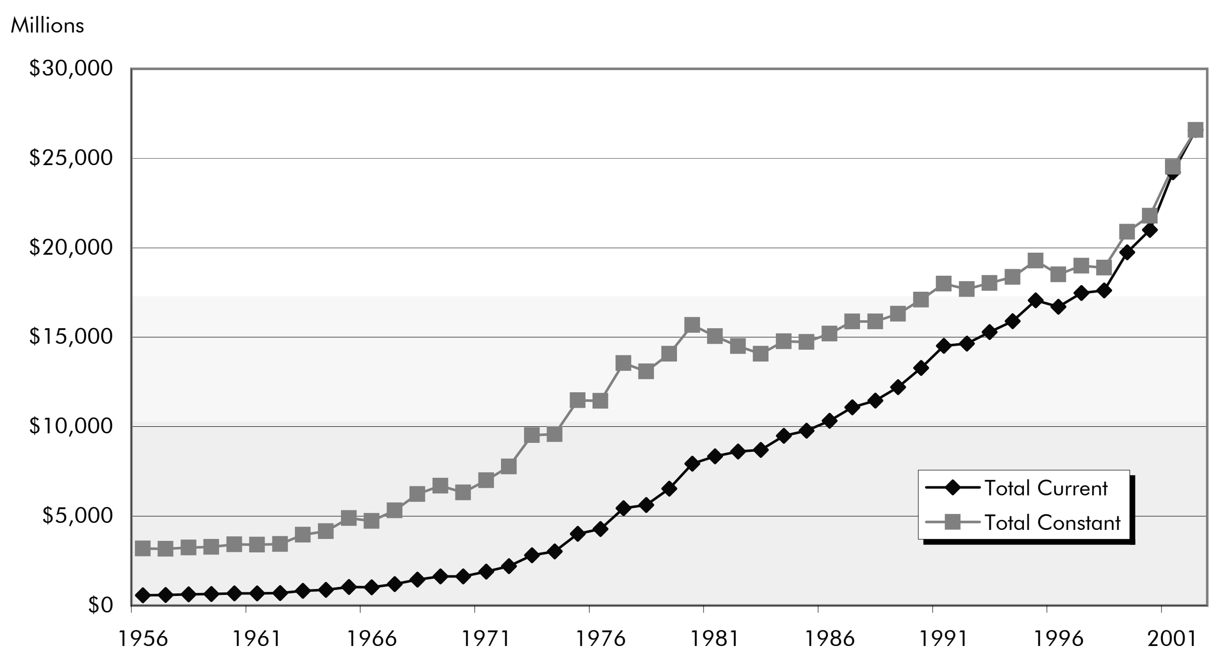
## Exhibit 6-22 *Public Funding for Transit by Government Jurisdiction, Selected Years, 1960–2002*

| Year | Federal (Millions of Current Dollars) | State and Local (Millions of Current Dollars) | Total (Millions of Current Dollars) | Federal (Millions of Constant 2000 Dollars[1]) | State and Local (Millions of Constant 2000 Dollars[1]) | Total (Millions of Constant 2000 Dollars[1]) | Federal Share Current Dollars |
|---|---|---|---|---|---|---|---|
| 1960 | $0 | $683 | **$683** | $0 | $3,422 | **$3,422** | 0.0% |
| 1970 | 124 | 1,499 | **1,623** | 482 | 5,830 | **6,312** | 7.6% |
| 1980 | 3,307 | 4,617 | **7,924** | 6,544 | 9,137 | **15,681** | 41.7% |
| 1990 | 3,458 | 9,823 | **13,281** | 4,453 | 12,648 | **17,101** | 26.0% |
| 1991 | 3,395 | 11,116 | **14,511** | 4,208 | 13,777 | **17,985** | 23.4% |
| 1992 | 3,448 | 11,195 | **14,643** | 4,164 | 13,521 | **17,685** | 23.5% |
| 1993 | 3,297 | 11,991 | **15,287** | 3,889 | 14,144 | **18,033** | 21.6% |
| 1994 | 3,380 | 12,522 | **15,902** | 3,902 | 14,459 | **18,361** | 21.3% |
| 1995 | 4,082 | 12,971 | **17,053** | 4,613 | 14,659 | **19,272** | 23.9% |
| 1996 | 4,060 | 12,643 | **16,703** | 4,498 | 14,008 | **18,506** | 24.3% |
| 1997 | 4,742 | 12,728 | **17,470** | 5,154 | 13,833 | **18,986** | 27.1% |
| 1998 | 4,421 | 13,200 | **17,620** | 4,738 | 14,146 | **18,883** | 25.1% |
| 1999 | 4,586 | 15,166 | **19,752** | 4,850 | 16,039 | **20,889** | 23.2% |
| 2000 | 5,259 | 15,739 | **20,999** | 5,456 | 16,330 | **21,788** | 25.0% |
| 2001 | 6,586 | 17,631 | **24,216** | 6,670 | 17,856 | **24,526** | 27.2% |
| 2002 | 6,296 | 20,294 | **26,590** | 6,296 | 20,294 | **26,590** | 23.7% |

[1] Deflated with GDP Chained Price Index reported in The Budget of the US Government 2004.

*Source: National Transit Database/Office of Management and Budget.*

## Exhibit 6-23 *Current and 2002 Constant Dollar Public Funding for Public Transportation, 1956–2002*




*Source: National Transit Database.*

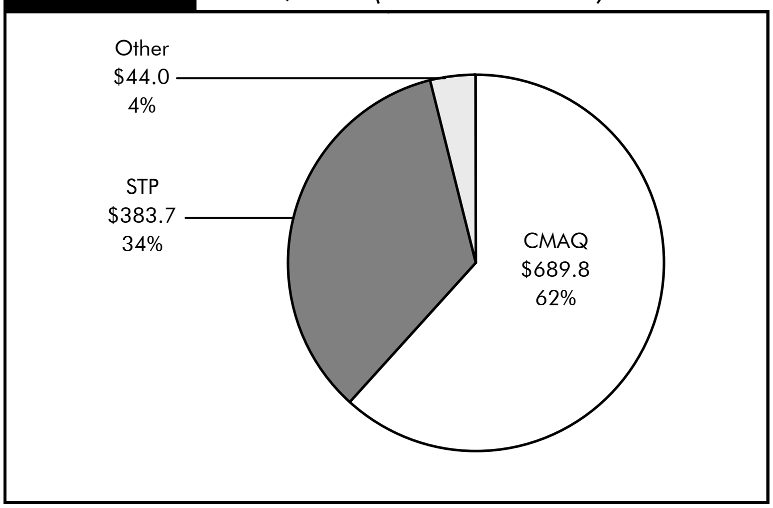
Flexible funds may be transferred from FHWA to FTA under the following programs:

- ***Surface Transportation Program (STP).*** Flexible funds allocated from STP, the largest flexible fund program, may be used for all transit projects eligible for funding under current FTA programs with the exclusion of operating assistance for Section 5307 and 5311 programs (Title 49, United States Code [USC]). STP funds flexed from highways to transit were 46 percent lower in 2002 than in 2000, falling from $708.4.0 million to $383.7 million (*Exhibit 6-24*).

- ***Congestion Mitigation and Air Quality Improvement Program (CMAQ):*** Flexible funds from CMAQ funds may be used to support transit projects to reduce vehicle emissions in areas that are not meeting air quality standards. The amount of CMAQ funds flexed to transit declined from $864.0 million in 2000 to $689.8 million in 2002, a drop of 20 percent.

- ***FHWA Other:*** Flexible funds may be allocated to FTA projects earmarked under ISTEA and TEA-21 as innovative demonstration, congestion relief, and intermodal projects. Funds flexed for these purposes increased by 65 percent, from $26.7 million in 2000 to $44.0 million in 2002. These funds account for a very small proportion of the total flexed, 4 percent in 2002.

**Exhibit 6-24** *Sources of FHWA Flexible Fund Transfers to FTA, 2002 (Millions of Dollars)*




*Source: Federal Transit Administration, Office of Resource Management and State Programs.*

These funds are transferred to the following FTA programs:

- ***Urbanized Area Formula Program (Section 5307).*** Funds are allocated to urban areas for planning costs and for capital investment in transit. Urbanized areas with populations of less than 200,000 may also use these funds for operating assistance.

- ***Nonurbanized Area Formula Program (Section 5311).*** Funds are allocated to support services to residents outside urban areas based on the size of States' nonurban populations. Program funds may be used for capital, operating, and administrative assistance.

- ***Elderly and Persons with Disabilities Program (Section 5310).*** Funds are allocated for the provision of specialized transit services for the elderly and disabled.

**Q.** What programs are included in the FTA Formula Grants Program?

**A.** The ***FTA Formula Grants Program*** is composed of the ***Urbanized Area Formula Program (Section 5307)***, the ***Nonurbanized Area Formula Program (Section (5311),*** and the ***Elderly and Persons with Disabilities Formula Program (Section 5310).*** It is the largest assistance program administered by FTA and totaled $3.6 billion in FY 2002. Allocations are made according to population. The Urbanized Area Formula Program receives 91.23 percent of the funding available under the FTA Formula Grants Program; the Nonurbanized Area Formula Program, 6.37 percent; and the Elderly and Persons with Disabilities Program, 2.40 percent. More than 90 percent of the funds allocated under the Urbanized Area Formula Program go to urbanized areas with populations of 200,000 or more. Nonurbanized areas are defined as rural areas and urban areas with populations under 50,000.

Urbanized area (Section 5307) funding can be used for capital improvements, including preventive maintenance and planning activities as long as non-Federal funding covers 20 percent or more of these expenses. Up to 10 percent of each agency's Section 5307 funding can be used to pay for Americans with Disabilities Act of 1990 (ADA) paratransit costs, provided again with the stipulation that a non-Federal match of at least 20 percent is made. Section 5307 funding is allocated on the basis of population, population density, and performance factors, including passenger miles traveled.

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 2002, a total of $1.7 million was transferred. During the 11 years of the flexible fund program from FY 1992 to FY 2002, $39.6 million has been transferred to FHWA. This amount is less than one-half of one percent of total flexible funding.

## Capital Funding and Expenditures

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 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).

Capital investment funds for transit are also generated through the issuance of bonds. *Certificates of participation* (COPs) are tax-exempt bonds issued by State entities that are generally secured by revenues that are expected to be earned from the equipment that the COP funds are used to purchase. The U.S. Department of Transportation (DOT) has also developed three innovative financing programs to facilitate funding for transportation projects, including transit projects. These programs, the Transportation Infrastructure and Finance Innovation Act of 1998 (TIFIA), State Infrastructure Bank (SIB) Pilot Program, and Grant Anticipation Revenue Vehicle (GARVEE) bonds, which are discussed at the end of this chapter, contribute to the financing of transit capital investment. Three TIFIA loans have been awarded to finance transit projects in San Juan, New York, and Washington, D.C. Letters of interest in TIFIA loans have also been received for transit projects in Illinois, California, Nevada, and the State of Washington. Under the SIB program, seven SIBs have awarded $45 million to assist 12 transit projects valued in excess of $135 million. The loans have supported a diverse spectrum of projects, including bus purchases, rail modernization, intermodal facilities, a historic landmark rehabilitation, and rural transportation improvements. Many of the loans have assisted communities with local project match requirements, which has enabled local governments to accelerate the implementation of transit infrastructure and services that might otherwise have been postponed because of a lack of available match funding. GARVEE-type bonds, called Transit Grant Anticipation Notes (GANs), have been issued by transit agencies in New Jersey, California, Pennsylvania, and Arizona to fund transit projects ranging from the purchase of new technology buses to the construction of new and rehabilitation of light rail and rapid rail lines. In each case, the bond issue was used to borrow against future Federal-aid funding to accelerate the project and thus reduce its cost.

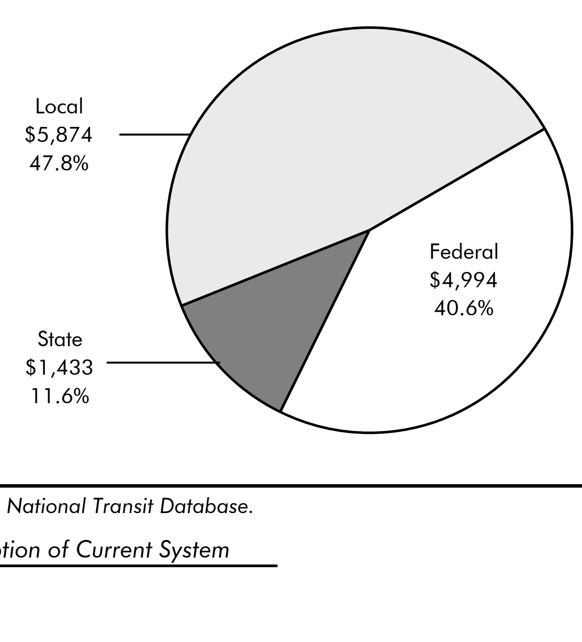
In 2002, total public transit agency expenditures for capital investment were $12.3 billion in current dollars and accounted for 34.9 percent of total transit expenditures. Federals funds accounted for $5.0 billion of total transit agency capital expenditures, State funds for $1.4 billion, and local funds $5.9 billion. The share of capital funding from State and local governments increased between 2000 and 2002 and the share from the Federal government fell. Federal funds accounted for 40.6 percent of all funding for capital investment in 2002, compared with 47.2 percent in 2000, and 41.6 percent in 1993. State sources accounted for 11.6 percent of all capital funding in 2002, compared with 10.7 percent in 2000, and 23.0 percent in 1993. Local funding for capital investment accounted for 47.8 percent of all funding for capital investment in 2002, compared with 42.0 percent in 2000, and 35.5 percent in 1993. The decrease in the share of Federal funds for capital investment and increase in shares of State and local funds reflect the fact that both State and local funding for transit increased by more than 20 percent between 2000 and 2002, compared with an 8.1 percent increase in Federal funding over the same period [*Exhibits 6-25* and *6-26*].

**Exhibit 6-25** *Sources of Funds for Transit Capital Expenditures, 1990–2002 (Millions of Dollars)*

| | 1993 | 1995 | 1997 | 1999 | 2000 | 2002 | Average Annual Growth 2002/1993 | 2002/2000 |
|---|---|---|---|---|---|---|---|---|
| **Federal** | $2,383 | $3,314 | $4,138 | $3,726 | $4,275 | $4,994 | 8.6% | 8.1% |
| Share | 41.6% | 47.3% | 54.2% | 44.1% | 47.2% | 40.6% | | |
| **State** | $1,317 | $989 | $1,007 | $858 | $973 | $1,433 | 0.9% | 21.3% |
| Share | 23.0% | 14.1% | 13.2% | 10.2% | 10.7% | 11.6% | | |
| **Local** | $2,033 | $2,706 | $2,492 | $3,860 | $3,808 | $5,874 | 12.5% | 24.2% |
| Share | 35.5% | 38.6% | 32.6% | 45.7% | 42.0% | 47.8% | | |
| **Total** | **$5,733** | **$7,008** | **$7,636** | **$8,443** | **$9,056** | **$12,301** | **8.9%** | **16.5%** |

*Source: National Transit Database.*

**Exhibit 6-26** *2002 Sources of Transit Capital Investment Funds (Millions of Dollars)*




*Source: National Transit Database.*

As shown in *Exhibit 6-27,* rail modes take a higher percentage of total capital investment than bus modes because of the higher cost of building fixed guideways and rail stations. In 2002, $8.7 billion, or 71 percent of total transit capital expenditures, was invested in rail modes of transportation, compared with $3.6 billion, or 29 percent of the total, in nonrail modes.

**Exhibit 6-27** *Transit Capital Expenditures by Mode and by Type, 2002 (Millions of Dollars)*

| | Guideway | Systems | Stations | Facilities | Rolling Stock | Other Vehicles | Other | Total | Percent of Total |
|---|---|---|---|---|---|---|---|---|---|
| **Rail** | **2,973** | **132** | **1,178** | **1,497** | **2,243** | **39** | **613** | **8,676** | **71%** |
| Commuter Rail | 625 | 64 | 290 | 650 | 590 | 7 | 144 | **2,371** | **19%** |
| Heavy Rail | 1203 | 30 | 796 | 679 | 1424 | 28 | 406 | **4,564** | **37%** |
| Light Rail | 1136 | 37 | 90 | 167 | 227 | 4 | 63 | **1,723** | **14%** |
| Other Rail [1] | 9 | 0 | 2 | 1 | 3 | 0 | 1 | **17** | **0%** |
| **Nonrail** | **283** | **184** | **264** | **697** | **1823** | **36** | **338** | **3,625** | **29%** |
| Bus | 208 | 170 | 213 | 535 | 1543 | 33 | 325 | **3,028** | **25%** |
| Demand Response | 0 | 11 | 3 | 19 | 128 | 2 | 10 | **173** | **1%** |
| Ferryboat | 0 | 2 | 44 | 126 | 49 | 0 | 1 | **222** | **2%** |
| Trolleybus | 75 | 1 | 2 | 16 | 93 | 0 | 1 | **188** | **2%** |
| Other Nonrail [2] | 0 | 1 | 2 | 0 | 10 | 0 | 1 | **14** | **0%** |
| **Total** | **3,257** | **316** | **1,442** | **2,194** | **4,066** | **75** | **952** | **12,301** | **100%** |
| **Percent of Total** | **26%** | **3%** | **12%** | **18%** | **33%** | **1%** | **8%** | **100%** | |

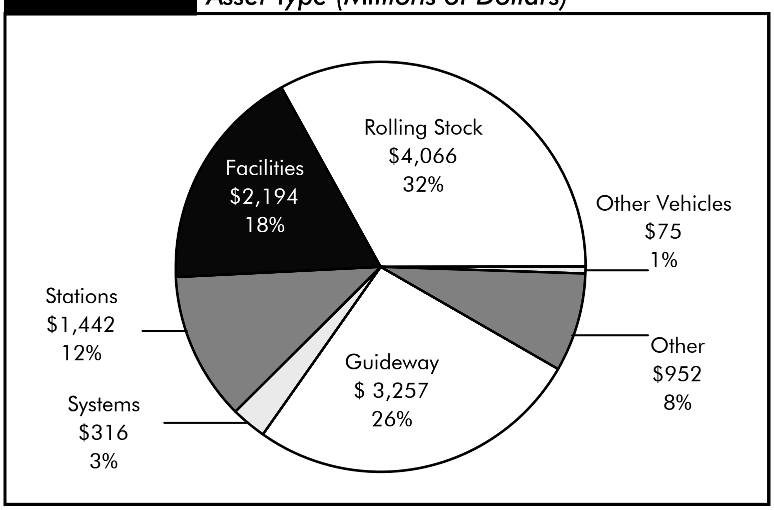
[1] Automated rail, Alaska rail, cable car, inclined plane, monorail

[2] Jitney, publico, and vanpool.

*Source: National Transit Database.*

*Exhibit 6-28* shows the capital investment expenditures by asset type in 2002. Investment in *rolling stock* in 2002 was $4.1 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. *Guideway* investment in 2002 was $3.3 billion. Guideway is composed of at-grade rail, elevated and subway structures, tunnels, bridges, track and power systems for all rail modes, and for paved highway lanes dedicated to buses. Investment in *facilities* in 2002 was $2.2 billion. Facilities include the purchase, construction, and rehabilitation of maintenance facilities, including design and engineering, demolition, and land acquisition. It also includes investment in transit malls, transfer facilities, intermodal terminals, shelters, passenger stations, depots, terminals, high occupancy vehicle facilities, transit ways, and park-and-ride facilities. Additional investments in a range of equipment—crime

**Exhibit 6-28** *2002 Transit Capital Expenditures by Asset Type (Millions of Dollars)*




*Source: National Transit Database*

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—are also included. Investment in *stations* in 2002 was $1.4 billion. Stations include platforms, shelters, and parking and crime prevention and security equipment at stations. Investment in *systems* in 2002 was $316 million. 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).

In 2002, $952 million billion was for *other capital.* Other capital includes service vehicles, 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), fare collection equipment, and revenue vehicle movement control equipment. Other capital also includes shelters located at on-street bus stops.

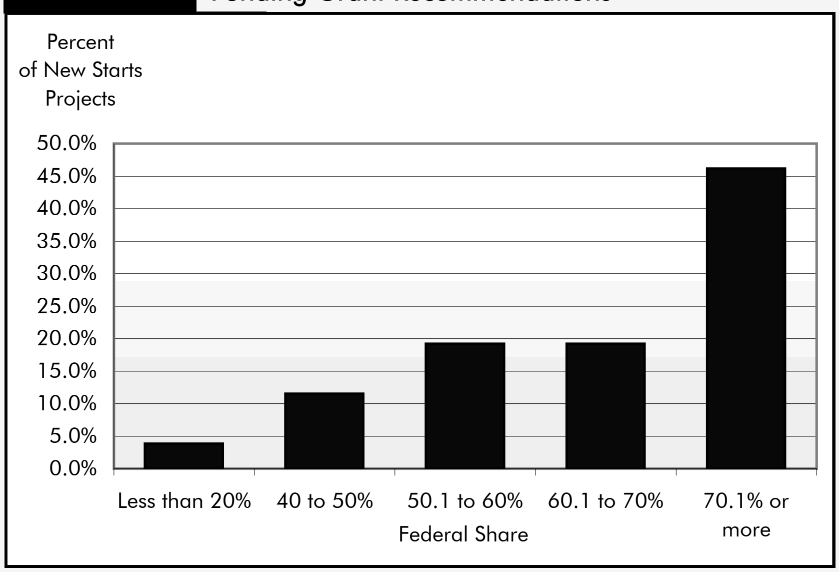
*New Starts*

*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. Projects involving the construction of new fixed guideway systems are known as "New Starts."*

*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 compose up to 80.0 percent of a New Start funding requirement. Generally, however, the Federal share of such projects now averages about 50 percent of the total project cost [*Exhibit 6-29*] .*

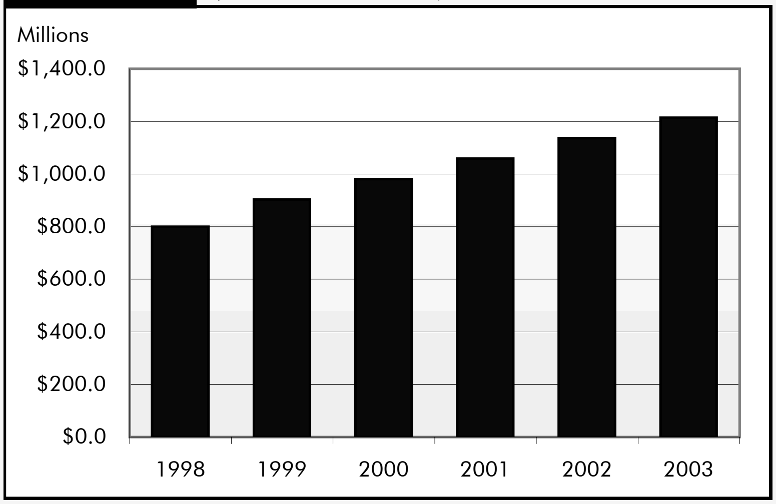
**Exhibit 6-29** ***Federal Share of FY 2005 Existing Full Funding Grant Recommendations***




*Source: FTA, Annual Report on New Starts for FY 2005.*

*Total Federal funding for New Starts authorized by TEA-21 from 1998 through 2003 is $6.1 billion. Annual funding for New Starts has increased from $800.0 million in 1998 to $1.2 billion in 2003 [Exhibit 6-30].*

**Exhibit 6-30** *New Starts Funding, 1998–2003 (Millions of Dollars)*

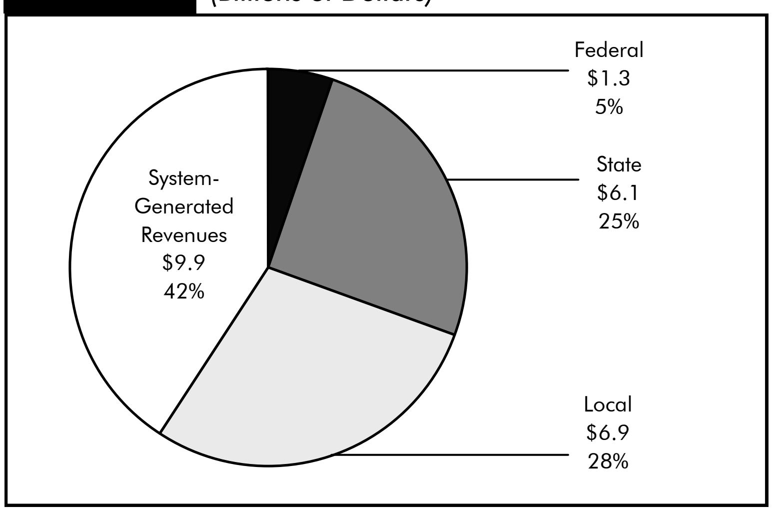



*Source: FTA.*

# Operating Expenditures

Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing transit service. In 2002, $24.2 billion was available for operating expenses and accounted for 65.1 percent of total available funds. Of this amount, $1.3 billion was provided by the Federal government, $6.1 billion was provided by State governments, $6.9 billion by local governments, and $9.9 billion by system-generated revenues [*Exhibits 6-31* and *6-32*]. Since 1993, the percentage of funds attributable to each source has fluctuated within a small range. From 2000 to 2002, the percentage of funds available from State sources increased, while the percentage of funds available from local sources decreased.

**Exhibit 6-31** *2002 Sources of Transit Operating Funds (Billions of Dollars)*




*Source: National Transit Database.*

**Exhibit 6-32** *Sources of Funds for Transit Operating Expenses[1] 1993–2002 (Millions of Dollars)*

| | 1993 | 1995 | 1997 | 1999 | 2000 | 2001 | 2002 | Average Annual Growth 2002/1993 | Average Annual Growth 2002/2000 |
|---|---|---|---|---|---|---|---|---|---|
| **Federal** | $911 | $768 | $604 | $860 | $984 | $1,117 | $1,302 | 4.0% | 15.0% |
| Share | 5.7% | 4.6% | 3.3% | 3.9% | 4.5% | 4.8% | 5.4% | | |
| **State** | $2,936 | $3,599 | $3,661 | $3,819 | $4,351 | $5,127 | $6,113 | 8.5% | 18.5% |
| Share | 18.4% | 21.8% | 20.0% | 17.4% | 20.1% | 21.8% | 25.3% | | |
| **Local** | $4,927 | $5,146 | $5,568 | $6,097 | $6,513 | $7,147 | $6,874 | 3.8% | 2.7% |
| Share | 30.8% | 31.1% | 30.4% | 27.8% | 30.0% | 30.4% | 28.4% | | |
| **System-generated** | $7,206 | $7,015 | $8,477 | $11,128 | $9,832 | $10,112 | $9,890 | 3.6% | 0.3% |
| | 45% | 42% | 46% | 51% | 45% | 43% | 41% | | |
| **Total** | **$15,981** | **$16,527** | **$18,310** | **$21,905** | **$21,680** | **$23,503** | **$24,179** | **4.7%** | **5.6%** |

[1] These are sources of funds for operating expenses.
They differ slighlty from the amounts disbursed for operating expenses provided in Exhibits-6-31 and 6-32.

*Source: National Transit Database.*

TEA-21 mandated that Federal funding to transit systems in urbanized areas with populations over 200,000 be used only for operating expenses for preventive maintenance. Formula grant funding to transit systems in urbanized areas with populations of less than 200,000 was still allowed to fund operating expenses.

As a result of the 2000 census, 56 areas were reclassified as urbanized areas with populations of more than 200,000. Transit agencies operating in these areas were slated to lose their eligibility to use Federal formula funding to finance transit operations starting in FY 2002. To help these agencies adjust their financing arrangements, the Transit Operating Flexibility Act (Pub.L. 107-232) was passed in September 2002, which amended Section 5307 of 49 USC to allow transit systems that were in urbanized areas that grew to more than 200,000 in the 2000 Census to continue using their formula funds for operating as well as capital expenses for one more year, despite their change in status.

# Operating Expenditures by Transit Mode

In 2002, transit operators' actual operating expenditures were $22.9 billion [*Exhibit 6-33*]. These expenditures increased at an average annual rate of 7.0 percent between 2000 and 2002, more rapidly than during any other 2-year period since 1993. Operating expenditures for light rail and demand response systems increased more rapidly than operating expenditures for other modes, each at an average annual rate of about 15.0 percent. (As shown in Exhibit 6-37 and Exhibit 6-39, between 2000 and 2002 operating expenditures per revenue vehicle mile and operating expenditures per passenger mile for light rail and demand response systems increased more rapidly than for bus, heavy rail, or commuter rail.) Operating expenditures for heavy rail increased at an average annual rate of 4.2 percent between 2000 and 2002; operating expenditures for commuter rail increased at an average annual rate of 5.7 percent; operating expenditures for buses increased as an average annual rate of 7 percent; and operating expenditures for the remaining modes combined as "Other" increased at an average annual rate of 8.2 percent.

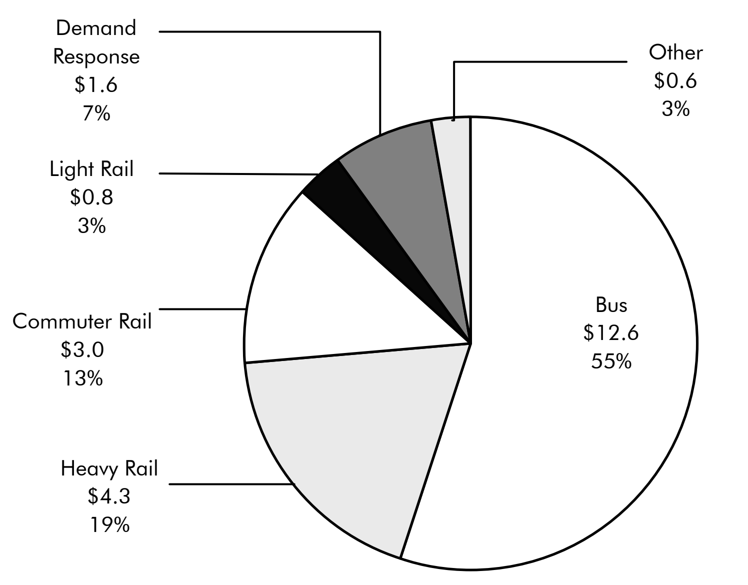
**Exhibit 6-33** *Disbursements for Transit Operations by Mode, Directly Operated Services, 1988–2002 (Millions of Dollars)*

| Year | Bus | Heavy Rail | Commuter Rail | Light Rail | Demand Response | Other | Total |
|---|---|---|---|---|---|---|---|
| 1993 | $8,866 | $3,669 | $2,203 | $314 | $561 | $358 | **$15,971** |
| 1994 | 9,168 | 3,786 | 2,353 | 412 | 712 | 401 | **16,832** |
| 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** |
| **Percent of Total** | | | | | | | |
| 1993 | 55.5% | 23.0% | 13.8% | 2.0% | 3.5% | 2.2% | **100.0%** |
| 2002 | 54.9% | 18.6% | 13.1% | 3.4% | 7.1% | 2.8% | **100.0%** |
| **Average Annual Growth Rate** | | | | | | | |
| 2002/2000 | **7%** | **4.2%** | **5.7%** | **14.6%** | **15.5%** | **8.2%** | **7.0%** |
| 2002/1993 | **4.0%** | **1.7%** | **3.5%** | **10.6%** | **12.6%** | **6.7%** | **4.1%** |

*Source: National Transit Database.*

Operating expenditures for demand response vehicles have more than tripled over the past decade, from $561 million in 1993 to $1.6 billion in 2002, reflecting increased services to the elderly and persons with disabilities pursuant to the ADA and new programs targeted toward the provision of services to these groups. Although these expenditures appeared to be stabilizing, with a marginal decline from 1999 to 2000, between 2000 and 2002 they increased by 33 percent.

**Exhibit 6-34** *2002 Disbursements for Transit Operations by Mode (Billions of Dollars)*

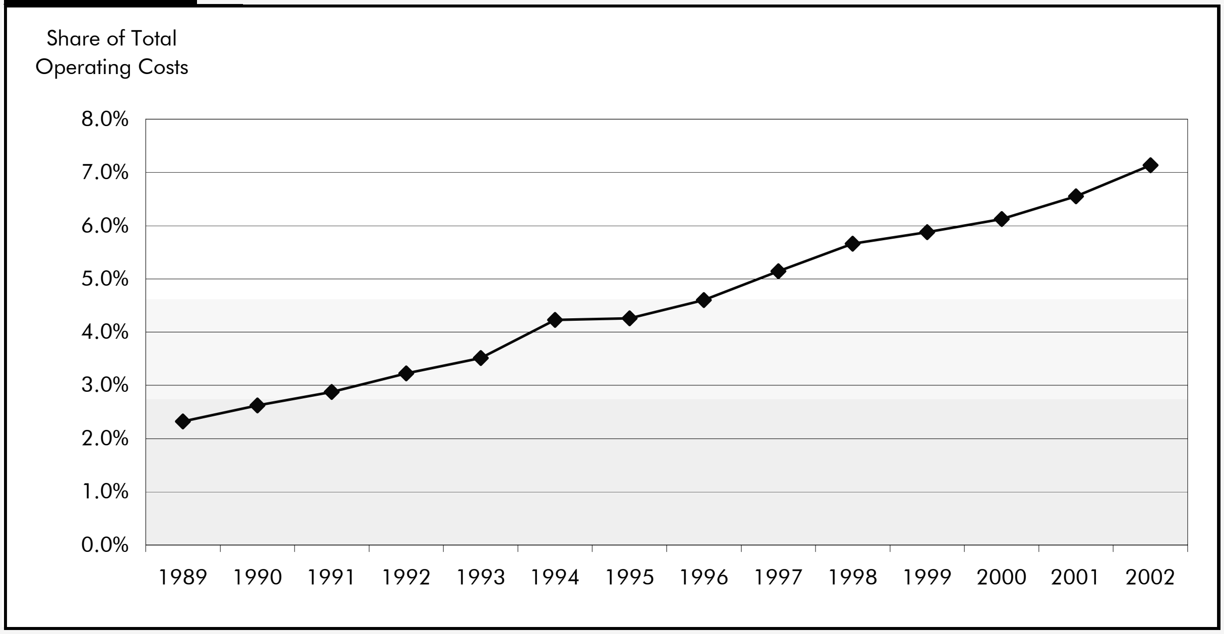



*Source: National Transit Database.*

Buses accounted for the largest percentage of transit operating expenditures, $12.6 billion in 2002, or 55 percent of the operating expenditure total. Heavy rail accounted for $4.3 billion, or 19 percent of the total; and commuter rail accounted for $3.0 billion, or 13 percent of the total. In 2002, demand response systems accounted for 7.1 percent of total transit operating expenses, compared with 3.5 percent in 1993. Light rail and other transit vehicles accounted for 3 percent each [*Exhibit 6-34*].

*The ADA directed transit agencies gradually to make all their services accessible. Until systems reached full accessibility, ADA directed transit agencies to offer parallel demand response services. Once transit accessibility was achieved, ADA stipulated that the right to parallel transit services would remain only for those unable to use accessible transit services. In the years since ADA, the need for demand responsive services has far exceeded the expectations of transit planners. As shown in Exhibit 6-35, the share of transit expenses going to demand responsive services tripled, from 2.3 percent before ADA (1989) to 7.1 percent in 2002.*

**Exhibit 6-35** *Demand Response Services Share of Transit Total Operating Costs*




*Source: National Transit Database.*

# Operating Expenses by Type of Cost

In 2002, $11.8 billion, or 51.5 percent of total transit operating expenses, were for vehicle operations [*Exhibit 6-36*]. Expenditures on vehicle maintenance were $4.7 billion or 20.3 percent of the total; expenditures on nonvehicle maintenance were $2.4 billion or 10.6 percent of the total; and expenditures on general administration were $4.0 billion or 17.6 percent of the total. Expenditures increased for vehicle operations at an average annual rate of 7 percent between 2000 and 2002, for vehicle maintenance at an average annual rate of 6 percent, for nonvehicle maintenance at an average annual rate of 7 percent, and for general administration at an average annual rate of 9 percent.

**Exhibit 6-36** *Disbursements for Transit Operations—All Modes by Function, Directly Operated Services, 2002 (Millions of Dollars)*

| Mode | Vehicle Operations | | Vehicle Maintenance | | Nonvehicle Maintenance | | General Administration | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bus | $7,095 | 56.4% | $2,687 | 56.4% | $562 | 4.5% | $2,241 | 17.8% | $12,586 | 100.0% |
| Heavy Rail | 1,754 | 41.1% | 762 | 17.8% | 1,095 | 25.7% | 657 | 15.4% | 4,267 | 100.0% |
| Commuter Rail | 1,145 | 38.2% | 721 | 24.1% | 555 | 18.5% | 573 | 19.1% | 2,995 | 100.0% |
| Light Rail | 330 | 42.4% | 178 | 22.9% | 130 | 16.7% | 140 | 18.0% | 778 | 100.0% |
| Demand Response | 1,094 | 66.9% | 199 | 12.2% | 35 | 2.1% | 308 | 18.8% | 1,636 | 100.0% |
| Other | 370 | 57.5% | 106 | 16.5% | 57 | 8.9% | 110 | 17.1% | 643 | 100.0% |
| **Total** | **$11,788** | **51.5%** | **$4,654** | **20.3%** | **$2,435** | **10.6%** | **$4,029** | **17.6%** | **$22,905** | **100.0%** |

*Source: National Transit Database.*

Bus and rail operations have inherently different cost structures. While 67 percent of total operations expenditures for demand response transit and 56 percent of total operations expenditures for buses were spent for actual operation of the vehicles, only about 40 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.

# Financial Efficiency

Operating expense per vehicle revenue mile (VRM) is one measure of financial or cost efficiency. It calculates the expense of operating a transit vehicle in revenue service. In 2002, operating expense per VRM for all transit modes combined was $6.68 [*Exhibit 6-37*]. Operating costs per VRM for all modes combined increased marginally between 1993 and 2002 (at an average annual rate of 0.9 percent), but more rapidly between 2000 and 2002 (at an average annual rate of 3.4 percent). Demand response systems have experienced the most rapid increases in operating costs per VRM, at an average annual rate of 3.4 percent between 1993 and 2002 and at an average annual rate of 7.2 percent between 2000 and 2002.

**Exhibit 6-37** *Operating Expenses per Vehicle Revenue Mile, 1993–2002*

| Year | Bus | Heavy Rail | Commuter Rail | Light Rail | Demand Response | Other [1] | Total |
|---|---|---|---|---|---|---|---|
| 1993 | $5.62 | $7.26 | $10.83 | $11.65 | $2.31 | $9.97 | $6.16 |
| 1994 | 5.78 | 7.34 | 11.23 | 12.38 | 2.61 | 6.46 | 6.17 |
| 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 |
| **Average (1993–2002)** | **$6.11** | **$6.79** | **$10.66** | **$11.92** | **$2.78** | **$5.84** | **$6.24** |
| **Average Annual Rate of Change** | | | | | | | |
| **2002/2000** | **3.9%** | **2.0%** | **3.4%** | **6.2%** | **7.2%** | **5.2%** | **3.4%** |
| **2002/1993** | **2.1%** | **-0.3%** | **0.7%** | **1.2%** | **3.4%** | **-6.2%** | **0.9%** |

[1] Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, publico, trolleybus, and vanpool.

*Source: National Transit Database.*

Operating expense per capacity-equivalent VRM is a better measure of comparing cost efficiency among modes because it adjusts for passenger-carrying capacities [*Exhibit 6-38*]. Rail systems are more cost efficient in providing service than nonrail systems, once investment in rail infrastructure has been completed. Based on operating costs alone, heavy rail is the most efficient at providing transit service and demand response systems are the least efficient. [Note that annual changes in operating expense per capacity-equivalent VRM and unadjusted VRM are the same for modes that reported separately.]

**Exhibit 6-38** *Operating Expenses per Capacity-Equivalent Vehicle Revenue Mile, 1993–2002*

| Year | Bus | Heavy Rail | Commuter Rail | Light Rail | Demand Response | Other [1] | Total |
|---|---|---|---|---|---|---|---|
| 1993 | $5.62 | $3.08 | $4.65 | $4.62 | $12.83 | $7.25 | $4.69 |
| 1994 | 5.78 | 3.11 | 4.82 | 4.91 | 14.50 | 6.98 | 4.75 |
| 1995 | 5.81 | 2.76 | 4.36 | 4.39 | 14.15 | 7.22 | 4.69 |
| 1996 | 5.91 | 2.73 | 4.45 | 4.77 | 15.31 | 7.20 | 4.72 |
| 1997 | 6.09 | 2.73 | 4.26 | 4.70 | 16.01 | 7.28 | 4.80 |
| 1998 | 6.12 | 2.72 | 4.25 | 4.62 | 16.22 | 7.44 | 4.84 |
| 1999 | 6.31 | 2.79 | 4.54 | 4.51 | 16.93 | 7.16 | 5.02 |
| 2000 | 6.25 | 2.88 | 4.64 | 4.57 | 15.05 | 7.58 | 5.01 |
| 2001 | 6.49 | 3.00 | 4.84 | 5.05 | 15.97 | 8.47 | 5.25 |
| 2002 | 6.75 | 3.00 | 4.96 | 5.15 | 17.30 | 8.53 | 5.44 |
| **Average (1993–2002)** | **$6.11** | **$2.88** | **$4.58** | **$4.73** | **$15.43** | **$7.51** | **$4.92** |
| **Average Annual Rate of Change** | | | | | | | |
| **2002/2000** | **3.9%** | **2.0%** | **3.4%** | **6.2%** | **7.2%** | **6.1%** | **4.1%** |
| **2002/1993** | **2.1%** | **-0.3%** | **0.7%** | **1.2%** | **3.4%** | **1.8%** | **1.7%** |

[1] Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, publico, trolleybus, and vanpool.

Source: National Transit Database.

# Cost Effectiveness

Operating expenses per passenger mile is an indicator of the cost effectiveness of providing a transit service [*Exhibit 6-39*]. It shows the relationship between service inputs as expressed by operating expenses and service consumption as expressed by passenger miles traveled. Operating expenses per passenger mile for all transit modes combined increased at an average annual rate of 2.0 percent between 1993 and 2000 (from $0.42 to $0.50), at a rate close to the 1.9 percent average annual increase in the gross domestic product (GDP) deflator. This indicates that, on average, the cost effectiveness of transit services in relationship to the rest of the economy has remained relatively constant. Operating expenses per passenger mile for heavy rail declined at an average annual rate of 1.5 percent between 1993 and 2002 (from $0.36 to $0.31). Operating expenses per passenger mile for commuter rail were the same in 1993 and 2002, although they had been lower in the intervening years. The increase in operating expenses per passenger mile for buses, light rail, and demand response services was higher on an average annual basis between 1993 and 2002 than the GDP deflator. In the case of buses, operating expenses per passenger mile increased at an average annual rate of 2.6 percent (from $0.51 in 1993 to $0.64 in 2002), and in the case of light rail at 2.2 percent (from $0.45 to $0.54). Operating expenses per passenger mile is highest for demand response services. It increased at an average annual rate of 6.4 percent between 1993 and 2000.

# 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.

**Exhibit 6-39** *Operating Expenses per Passenger Mile Traveled by Mode, 1993–2002*

| Year | Bus | Heavy Rail | Commuter Rail | Light Rail | Demand Response | Other [1] | Total |
|---|---|---|---|---|---|---|---|
| 1993 | $0.51 | $0.36 | $0.32 | $0.45 | $1.44 | $0.57 | $0.42 |
| 1994 | 0.53 | 0.35 | 0.29 | 0.50 | 1.89 | 0.49 | 0.41 |
| 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 |
| **Average (1993–2002)** | **$0.57** | **$0.31** | **$0.29** | **$0.47** | **$2.07** | **$0.49** | **$0.44** |
| **Average Annual Rate of Change** | | | | | | | |
| **2002/2000** | **4.9%** | **4.9%** | **5.2%** | **10.9%** | **9.8%** | **6.0%** | **6.0%** |
| **2002/1993** | **2.6%** | **-1.5%** | **-0.1%** | **2.2%** | **6.4%** | **-0.4%** | **2.0%** |

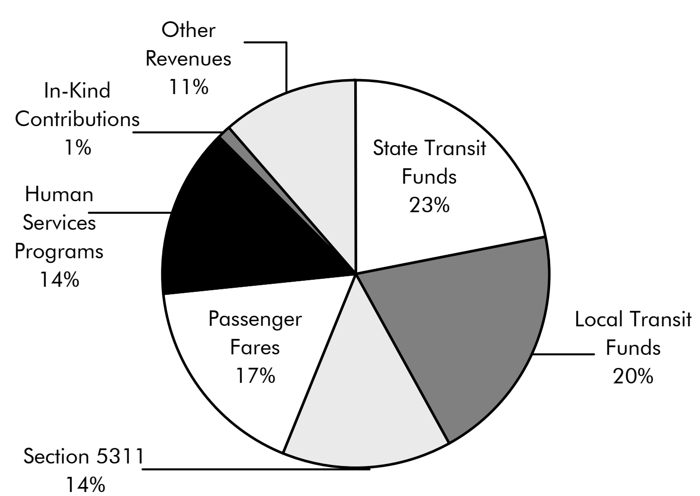
[1] Automated guideway, cable car, ferryboat, inclined plane, jitney, monorail, publico, trolleybus, and vanpool.

*Source: National Transit Database.*

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 6-40*]. State and local governments cover, respectively, 23 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 6-40** *Rural Transit Operators' Budget Sources for Operating Expenditures, 2000*




*Source: Status of Rural Public Transportation, 2000, Community Transportation Association of America, April 2001.*

# Innovative Finance

**Q.** What is innovative finance?

**A.** Though broadly defined as a combination of special funding initiatives, in the transportation industry the term "innovative finance" has become synonymous with techniques that are specifically designed to supplement the traditional methods used to finance highways. USDOT innovative finance initiatives are intended to augment rather than replace traditional financing techniques.

"Innovative finance" refers to a series of administrative and legislative initiatives, undertaken in recent years, which have removed barriers and added flexibility to Federal participation in transportation finance. Policy makers recognized they could 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 Federal-aid transportation funding, and are thus frequently referred to collectively as "innovative finance."

Over the past decade, innovative finance has undergone several transformations. Since its inception with the passage of ISTEA, innovative finance has laid foundations for several new concepts designed to fund transportation investment. TEA-21 continued the development of innovative financing concepts, including credit assistance, innovative debt financing, and public-private partnerships. The current status of these programs is described in more detail below.

## Credit Assistance

Federal credit assistance for transportation projects takes various forms. Direct loans to project sponsors may provide the necessary capital to advance a project and/or reduce the amount of capital borrowed from other sources. Credit enhancement, including loan guarantees or lines of credit, makes Federal funds available on a contingency basis, thereby reducing the risk to investors and allowing project sponsors to borrow at lower interest rates. The projects themselves may often involve partnerships between the public and private sectors. Two of the most significant Federal credit assistance programs, introduced in recent years, are the Transportation Infrastructure and Finance Innovation Act (TIFIA) and the State Infrastructure Bank (SIB) programs.

### *Transportation Infrastructure and Finance Innovation Act (TIFIA)*

The Transportation Infrastructure and Finance Innovation Act (passed as part of TEA-21) authorized the USDOT to establish a new credit program by offering eligible applicants the opportunity to compete for direct loans, loan guarantees, and lines of credit for up to one-third of the cost of large infrastructure construction projects of national significance, 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 have eligible costs that total at least $100 million or exceed 50 percent of a State's Federal-aid highway apportionments for the most recent fiscal year, whichever is less. This dollar threshold reflects congressional intent to assist major projects that can attract substantial private capital with limited Federal investment. Intelligent Transportation System projects are subject to a lower threshold, a minimum of $30 million. As of spring 2004, the TIFIA credit program has provided credit assistance of more than $3.5 billion for 11 projects accounting for more than $15 billion in infrastructure investment. These TIFIA projects include highway toll roads and bridges, transit systems, rail stations, ferry terminals, and intermodal facilities.

**Q. What are some other innovative finance techniques being used as part of the Federal-aid Highway Program?**

**A.** 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 projects using their own funds before any Federal funds have been obligated. An advance construction 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 advance construction 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 projects.

### *State Infrastructure Banks (SIBs)*

Section 350 of the National Highway System Designation Act of 1995 (P.L. 104-59) authorized DOT to establish the State Infrastructure Bank Pilot Program. This program provides increased financial flexibility for infrastructure projects by offering direct loans and other credit enhancement products such as 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. TEA-21 legislation limited the use of TEA-21 funds for SIB capitalization purposes to five States, of which only two are operating under the TEA-21 provisions; the remaining 31 States that participate in the SIB program operate under National Highway System rules and may not capitalize SIBs with TEA-21 funds. However, existing SIB programs continue to offer loan products. As of March 2004, 32 states have entered into 373 loan agreements with a total value of just under $4.8 billion.

SIB loans are being used to fund both highway and transit projects. Seven SIBs have made loans of almost $45 million to assist 12 transit projects valued in excess of $135 million. The loans have supported a diverse spectrum of projects, including bus purchases, rail modernization, the development of intermodal facilities, a historic landmark rehabilitation, and rural transportation improvements. Many of the loans have assisted communities with local project match requirements. This has enabled local governments to accelerate the implementation of transportation infrastructure and services that might otherwise have been postponed because of a lack of available match funding.

# 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. Previously, 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 June 2004, the amount of GARVEE debt issued nationally had reached just over $5 billion.

## Public-Private Partnerships

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. There is a long history of private 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.

**Q. What is a public-private partnership?**

**A.** 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.

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.

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; development of a PPP Web site containing links to many PPP resources, both domestic and international; case studies of how States and local governments have overcome institutional barriers to PPP implementation; and creation of Special Experimental Program 15 (SEP-15) that provides States the flexibility to waive certain Title 23 rules and regulations on an experimental basis to evaluate alternative approaches to PPP project delivery.

More information on public-private partnerships can be found in the U.S DOT's December 2004 *Report to Congress on Public-Private Partnerships,* available at http://www.fhwa.dot.gov/reports/pppdec2004/index.htm.

**Q.** **What are some examples of recent public-private partnerships in the United States?**

**A.** Recent examples of public-private partnerships include the following:

- The lease of the Chicago Skyway (a major 8-mile-long bridge connecting two Interstates). A consortium of private firms paid the City of Chicago $1.83 billion for the rights to operate and collect tolls on the Skyway for 99 years. The lease agreement establishes maximum toll rates and sets performance standards that must be maintained on the facility.
- The Virginia Asset Management program, through which the State has contracted with a private sector firm to provide long-term maintenance and restoration of 1,250 miles of Interstate Highways.
- The Dulles Greenway in northern Virginia. The design, construction, financing, and operation of this limited access highway has been entirely private, with operational responsibilities for the road scheduled to revert to the State after 42.5 years.
- The 4,000-mile Trans-Texas Corridor system, which will be built with public-private partnerships. An initial segment between Dallas and San Antonio will include private investment of $6 billion to fully design, construct, and operate a four-lane toll road for up to 50 years, plus a payment of $1.2 billion to the State for the toll facility franchise rights. The State may use these monies to fund road improvements or high-speed and commuter rail projects along the corridor.

# Investment/ Performance Analysis

# Part II

# Introduction

Chapters 7 through 10 present and analyze estimates of future capital investment requirements 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 requirement estimates shown in these chapters reflect the total capital investment required from **all sources** to achieve certain levels of performance. **They do not, however, directly address which revenue sources might be used to finance the investment required by 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 Requirements,** provides estimates of future capital investment requirements under different scenarios. The "Cost to Maintain" scenarios for highways and bridges and for transit are designed to show the investment required 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 Requirements,** 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 requirements under different scenarios. It also compares the current mix of highway and transit capital spending by type of improvement (especially preservation 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 conditions, 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 investment requirements. The investment requirement 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 in this introduction.

Unlike Chapters 1 through 6, which largely include highway and transit statistics drawn from other sources, the investment requirement 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 requirements have evolved over time, to incorporate new research, new data sources, and improved estimation techniques relying on economic principles. The methodologies used to estimate investment requirements for highways, bridges, and transit are discussed in greater detail in Appendices A, B, and C.

The move from a purely engineering approach to one incorporating economic analysis 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 Requirement Scenarios

The 20-year capital investment requirement 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 requirement 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.**

While this report identifies the amount of additional spending above current levels that would be required to achieve certain performance benchmarks, it makes no assumptions about the types of revenues required to support this additional spending. This is significant, as 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). For example, if investment in urban freeways were to be increased dramatically, more drivers would tend to use the newly improved routes. However, if fuel taxes were simultaneously increased to pay for the improvements, this would raise the cost of driving generally, possibly causing some marginal trips to be deterred. If tolls were simultaneously imposed on urban freeways to pay for the improvements, this would likely discourage additional marginal trips and encourage some drivers to switch to nontolled routes. Research is underway to quantify the potential impacts of alternative financing mechanisms on future investment requirements, and is discussed in Part V. The possible implications of congestion pricing in particular are discussed in more detail below.

# Highway and Bridge Investment Requirements

Estimates of investment requirements for highways and bridges are generated independently by separate models and techniques, and the results are combined for the key investment scenarios. The **Cost to Maintain** Highways and Bridges combines two different scenarios: 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 (Cost to Improve)** Highways and Bridges combines the comparable scenarios from HERS and NBIAS.

As in the 2002 edition of the C&P report, the costs reported for the two scenarios also include adjustments made using external procedures. By doing so, capital investment requirements for elements of system preservation, system expansion, and system enhancement that are not modeled in NBIAS or HERS can be estimated. The investment requirements shown should thus reflect the realistic size of the total highway capital investment program that would be required in order to meet the performance goals specified in the scenarios.

Investment requirements are also reported and analyzed in Chapters 7 and 8 by highway functional class and by improvement type.

## *Investment Requirements for Highway Preservation and Capacity Expansion*

Investment requirements for highway preservation and capacity expansion 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 investment requirements related to capacity are modeled in HERS; NBIAS considers only investment requirements related to bridge preservation and bridge replacement.

The Transportation Equity Act for the 21st Century (TEA-21) required that this report include information on the investment requirement backlog. It also required that this report provide greater comparability with previous versions of the C&P report. As in the 2002 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 its benefit/cost ratio (BCR) is greater than or equal to 1.0; i.e., the benefits of making the improvement are greater than or equal to the cost of the improvement. Appendix A includes data showing the separate effects of changes in modeling techniques and changes in the underlying data on the 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.

The **Maintain User Costs** scenario shown in Chapter 7 and the other benchmarks shown in Chapter 9 were developed by imposing a budget constraint on the HERS analysis. Under this procedure, potential highway improvements are implemented (in descending order of BCR) until the funding constraint is reached. The funding constraints are then lowered until the point where these key indicators would be maintained at current levels, rather than improving. For the **Maintain User Costs** scenario, the funding constraint was lowered until the point where highway user costs (travel time costs, vehicle operating costs, and crash costs) in 2022 would match the baseline highway user costs calculated from the 2002 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 2022 would match that observed in 2002.

One concern that has been raised with this scenario is whether this level of funding would be adequate to meet the specified performance goal. 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. The actual amount required to achieve this performance objective would be higher if some projects with lower BCRs were carried out instead of projects with higher BCRs. This issue is discussed in a Q/A box on page 7-12, titled "How closely does the HERS model simulate the actual project selection process of State and local highway agencies?"

The **Maximum Economic Investment** scenario would correct all highway deficiencies when it is economically justified. This scenario would address the existing highway investment backlog, as well as other deficiencies that will develop over the next 20 years due to pavement deterioration and travel growth.

This scenario implements all improvements with a BCR greater than or equal to 1.0. Under this scenario, key indicators such as pavement condition, total highway user costs, and travel time would all improve. However, it should be noted that simply increasing spending to the **Maximum Economic Investment** level would not 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.

Further information on changes in the highway investment methodology is provided in Appendix A.

## *Investment Requirements for Bridge Preservation*

The bridge section begins with a discussion of the NBIAS model, which was used for the first time in the 2002 edition of the C&P report. Unlike previous bridge models, NBIAS incorporates benefit-cost analysis into the bridge investment requirement evaluation.

This section discusses the current investment backlog and two future investment requirement scenarios. As noted earlier, the amounts reported in this section relate only to bridge preservation and replacement. All investment requirements related to highway and bridge capacity are estimated using the HERS model.

The investment backlog for bridges is calculated as the total investment 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 required 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.

The NBIAS model and other changes in bridge investment requirements modeling in this report are presented in Appendix B.

## *Investment Requirements for System Enhancements*

The FHWA currently does not have a model for estimating requirements for future investment in system enhancements. As a result, the methodology employed in Chapter 7 assumes that such investments will remain constant in the future as a share of the overall highway capital program, increasing or decreasing with the level of investment in system preservation and expansion. The purpose of this adjustment is to allow the total highway and bridge capital investment requirements 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 estimation of nonmodeled highway investment requirements.

# Transit Investment Requirements

The transit section of Chapter 7 begins with a discussion of the Transit Economic Requirements Model (TERM), used to develop the investment requirement scenarios for this report. The TERM uses separate modules to analyze different types of investments: those that maintain and improve the physical condition of existing assets, those that 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 are included in TERM's estimated investment requirements. The TERM methodology is presented in greater detail in Appendix C.

The **Cost to Maintain** scenario maintains equipment and facilities in their current state of repair and maintains current operating performance while accommodating future transit growth. These investments are modeled at the transit agency level and on a mode-by-mode basis. The **Cost to Improve** scenario determines the additional investment requirements to improve the condition of transit assets to a "good" rating and improve the performance of transit operations to targeted levels. A cost-benefit analysis is performed on these investments on an urbanized area basis.

Breakdowns of transit investment requirements by type of improvement, type of asset, and urbanized area size are also presented for both the **Cost to Maintain** and the **Cost to Improve** scenarios.

# Comparisons Between Reports

The investment requirement 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>. Future investment requirements 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 estimates of investment requirements between reports. However, the effects are likely to be different for the "Maintain" and "Improve" scenarios.

<u>Cost to Improve</u>. If the condition 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 condition 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.

<u>Cost to Maintain</u>. The "Maintain" scenarios for both highways and transit are tied to the condition and performance of the system in the base year. If conditions and performance are improving over time, however, the "target level" of the "Maintain" scenarios will be likewise increasing between reports (resulting in a "raised bar" for these scenarios). As a result, the Cost to Maintain is likely to increase over time for this reason. Conversely, if system condition and performance are deteriorating over time, then the "Maintain" scenarios in subsequent reports would represent a declining standard that is being maintained.

<u>Expansion of the Asset Base</u>. As the Nation's highway and transit systems expand over time, the cost of maintaining this larger asset base will also tend to increase. For assets with useful lifetimes of less than 20 years, future expansions will also affect the 20-year investment requirement estimates.

Changes in Technology. Changes in transportation technology may cause the price of capital assets to increase or decrease over time and thus affect the estimates of capital investment requirements.

Changes in Scenario Definitions. Although the C&P report series has consistently reported investment requirements for "Improve" and "Maintain" 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 requirement 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 Investments

## *Background*

The methods and assumptions used to estimate future highway, bridge, and transit investment requirements 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 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. The HERS was first utilized to develop one of the two highway investment requirement 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, which was used to develop both of the transit investment requirement scenarios. The TERM incorporates benefit-cost analysis into its determination of transit investment levels.

The 2002 C&P report introduced the NBIAS, incorporating economic analysis into bridge investment requirements modeling for the first time.

### *Economic Focus Versus 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).

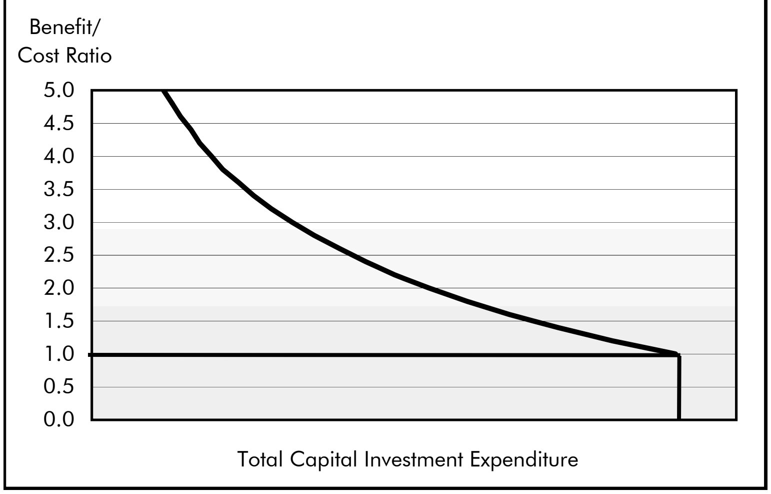
Traditional engineering-based analytical tools focus mainly on estimating transportation agency costs and the value of resources required to maintain or improve the condition and performance of infrastructure. This type of analytical approach can provide valuable information about the cost effectiveness of transportation system investments from the public agency perspective, including predicting 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.

One way to conceptualize the goal of the HERS, TERM, and NBIAS models is shown in *Exhibit II-1.* For some investment projects, the benefits to transportation system users and others greatly exceed the costs of that investment, resulting in large net benefits and a high BCR. As additional projects are considered and implemented, however, the gap between benefits and costs of subsequent projects diminishes. Thus, their BCRs progressively decline, eventually reaching a point (at a BCR of 1.0) where selecting additional investment projects will no longer increase net benefits from the overall investment program. 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) will not be selected or implemented by any of the three models.

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

**Exhibit II-1** *Economically Efficient Investment Requirements*




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.

## *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, however, 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 transit investment requirements (or vice versa). Opportunities for future development of HERS, TERM, and NBIAS, including efforts to allow feedback between the models, are discussed in Part V.

## *Uncertainty in Transportation Investment Requirements Modeling*

The three investment requirement models used in this report are deterministic rather than probabilistic, meaning that they provide a single projected value of total investment requirements 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 are likely to cancel each other out, but to the extent that they do not, "true" investment requirements 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.

## Congestion Pricing and Investment Requirements

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 cost (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.

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 "internalizing" the congestion externality, reducing peak traffic volumes (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; users' valuation of travel time; and the rate of interest.

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, thereby reducing congestion generally and the attendant costs that highway users impose on one another. In other words, the efficient level of investment in highway capacity is likely to be larger under the current system of highway user charges (primarily fuel taxes) than would be the case with full-cost pricing of highway use. The current situation is sometimes referred to as a "second-best" solution to the problem of optimal highway investment.

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 having to stop or slow 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.

The implications of inefficient pricing for the highway investment requirements estimated in this report are difficult to quantify precisely. The HERS model selects economically efficient improvements to sample highway sections at prices that reflect only costs currently borne privately by highway users (including fuel taxes). In the case of the "Maximum Economic Investment" scenario, the discussion above would indicate that the level of investment under this scenario would be reduced to some degree if efficient road pricing were widespread, with a stronger impact on capacity investment than on preservation improvements. The "Maintain User Costs" scenario, however, is defined based on a performance target, which makes the impact of imposing a more efficient pricing structure less clear. The key issue is how any increases in tolls or fees would be considered with respect to the user cost target. From an economic point of view, taxes and tolls would be excluded from the computation of user costs in evaluating the benefits of improvements, treating them instead as transfer payments, and would thus be excluded from calculations determining whether the target has been reached. Charging users higher prices for traveling during high-demand periods would simply reduce peak traffic volumes and thus the need for additional investment. However, imposing congestion-based tolls would raise the actual out-of-pocket costs experienced by users, and an argument can be made that they *should be* included in the performance target, to avoid a "Maintain" scenario in which drivers are effectively worse off in 20 years than they are today. In this case, offsetting the cost of the congestion-based tools would require additional investment in system improvements. At the same time, however, travel would be reduced as a result of the tolls, with a corresponding impact on investment requirements. The net effect on estimated investment requirements for such a scenario could thus be either higher or lower with more efficient pricing if tolls are included in the calculation of the performance target.

The FHWA has research underway that will attempt to address some of these issues regarding pricing and its consequences for efficient investment levels by incorporating new capabilities into the HERS model. The initial products of this research effort should be available in time for inclusion in the 2006 edition of the C&P report. The "Pricing Effects" section in Part V of this report provides a further discussion of this and other ongoing research activities that will be reflected in future editions of this report. This section also references a separate ongoing research effort commissioned by the DOT's Office of Economic and Strategic Analysis under the Assistant Secretary for Transportation Policy, which is focused on developing quantitative illustrations of some of the impacts that widespread implementation of congestion pricing could have on future highway travel and investment.

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 could be related to the underpricing of transit service during rush hours. However, also as with highways, practical considerations may limit the ability of transportation authorities to price transit service more efficiently. Further, 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.

# CHAPTER 7

# Capital Investment Requirements

# Summary

*Exhibit 7-1* compares the 20-year average annual investment requirements in this report with those presented in the 2002 C&P report. The first column shows the projection for 2001 to 2020 based on 2000 data shown in the 2002 C&P report, stated in 2000 dollars. The second column restates these highway and transit values in 2002 dollars, to offset the effect of inflation. The third column shows new average annual investment requirement projections for 2003 to 2022 based on 2002 data.

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 requirements for highways and bridges are drawn from the Highway Economic Requirements System (HERS), which estimates highway preservation and highway and bridge capacity expansion investment; the National Bridge Investment Analysis System (NBIAS), which estimates future bridge preservation requirements; and external adjustments to reflect functional classes and improvement types not directly modeled. Transit investment requirements for urbanized area operators that report to the National Transit Database (NTD) are estimated from the Transit Economic Requirements Model (TERM). Requirements for rural and special services are estimated separately based on the number of vehicles, the percentage of overage vehicles, vehicle replacement costs, and actual and industry-recommended replacement ages.

**Exhibit 7-1** *Highway, Bridge, and Transit Investment Requirement Projections Compared with Data from the 2002 C&P Report*

| Statistic | 2001–2020 Projection (Based on 2000 Data) 2002 Report | Adjusted for Inflation | 2002–2022 Projection (Based on 2002 Data) |
|---|---|---|---|
| **Average Annual Investment Requirements** | **2000 $** | **2002 $** | **2002 $** |
| **Cost to Maintain** | | | |
| Highways and Bridges | $75.9 bil | $77.1 bil | $73.8 bil |
| Transit | $14.8 bil | $15.4 bil | $15.6 bil |
| **Cost to Improve** | | | |
| Highways and Bridges (Maximum Economic Investment Level) | $106.9 bil | $108.5 bil | $118.9 bil |
| Transit | $20.6 bil | $21.4 bil | $24.0 bil |

This chapter focuses on the estimated investment requirements for the "Improve" and "Maintain" scenarios noted in Exhibit 7-1. Chapter 9 includes an analysis of the projected impacts of these and other future investment levels on conditions and performance. Chapter 10 includes a sensitivity analysis, showing how the estimated investment requirements would change under different assumptions about the values of key model parameters.

Background information on the development of the future investment requirements estimates, and the motivation for using economic analysis as the basis for the estimates, is presented in the introduction to Part II. That section also discusses uncertainty in the investment requirement modeling process and the relationship between pricing and investment requirements. As noted there, increased adoption of congestion pricing (which is not accounted for in the investment estimates presented in this chapter) would be expected to lead to more efficient operation of the highway network, lower levels of congestion, and some delay or reduction in future capital investment requirements. 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 V of this report examines some fundamental data and analytical issues relating to the types of investment/performance analysis reflected in this chapter.

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 and some of the other key parameters in the highway and transit investment requirement analytical processes would have on the projections identified in Exhibit 7-1. Highway travel growth forecasts are also discussed in Chapter 9.

# Highways and Bridges

The average annual **Maximum Economic Investment** for ("Cost to Improve") highways and bridges is projected to be $118.9 billion for 2003 to 2022. This figure represents an "investment ceiling" above which it would not be cost beneficial to invest. Accounting for inflation (using FHWA's Construction Bid Price Index), this estimate is 9.5 percent greater than the "Cost to Improve" for 2001 to 2020 reported in the 2002 C&P report. The average annual **"Cost to Maintain"** highways and bridges is projected to be $73.8 billion for 2003 to 2022, which is 4.3 percent lower than the estimate in the 2002 C&P report for 2001 to 2020, again accounting for inflation. 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 2002 levels.

**Q.** What is the Federal share of the highway and transit investment requirements identified in this report?

**A.** The investment requirements identified 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.

The changes in projected investment requirements from the 2002 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 the addition of new procedures designed to reflect the impact that certain types of operational strategies and Intelligent Transportation Systems (ITS) deployments may have on system performance, revised pavement deterioration models and updated improvement cost estimates, and the consideration of work zone delay in the benefit calculations.

Considering operations strategies and investments, which are considerably less costly in terms of initial outlays than conventional capacity investments, results in a lower estimate of the amount of investment necessary to achieve a given level of performance. Updated, increased assumptions about the unit costs of capacity investments tend to make such improvements relatively less attractive at lower funding levels, but still cost beneficial overall, resulting in an increased cost of implementing all such investments. Including work zone delay in the calculations furthers this trend by making major projects with lengthy construction times relatively less attractive as well in benefit-cost terms, especially for scenarios based on relatively lower overall levels of investment. Further information on these methodological changes is found later in this chapter, as well as in Appendix A.

**Q.** A figure of $375 billion in needed 6-year Federal highway and transit spending has been widely cited as coming from the 2002 C&P report? What is the comparable number from this report?

**A.** Though widely cited as coming directly from the 2002 C&P report, **the $375 billion figure did not appear anywhere within the report itself.** The investment requirement scenarios presented in the C&P report are long-term, 20-year estimates shown in constant base-year dollars. These scenarios are intended to be illustrative of how alternative investment levels might impact the future conditions and performance of the transportation system, and the report does not endorse any particular level of investment. The estimates are not intended to correspond to any specific legislative period or cycle, and no assumptions are made about what level the Federal share of capital investment under any particular scenario would or should be. Outside analysts can and do make use of the statistics presented in the C&P report to draw their own conclusions about these types of issues, but any such analysis would require a series of additional assumptions that are not reflected in this document.

The NBIAS model was first used for estimating future investment requirements for bridge preservation in the 2002 C&P report. Since that time, the model has been significantly enhanced. The most notable change was the extension of all aspects of the analysis to the individual bridge level; previously, the model had evaluated bridge replacements on a case-by-case basis, but had assessed routine repair and rehabilitation actions on a more aggregated basis. The new approach, coupled with revised estimates of bridge engineering and construction costs, has revealed additional opportunities for cost-beneficial bridge preservation investment. Further information on NBIAS is presented later in this chapter, as well as in Appendix B.

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 2000 and 2002 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. Improvements in the methodology used to model highway investment, allowing for more flexibility in choosing expansion options, also resulted in more cost-beneficial projects being found by the models, and in higher estimated costs for some of these projects on heavily congested roads in major urban areas.

# Transit

The estimated average annual **"Cost to Maintain"** transit asset conditions and operating performance is estimated to be $15.6 billion, compared with $14.8 billion in 2000 dollars presented in the last report. Eighty-seven percent of transit investment requirements will be in urban areas with populations of over 1 million, reflecting the fact that 91 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 2022 is estimated to be $24.0 billion, compared with $20.6 billion in 2000 dollars for the 2000 to 2020 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 62 percent of the total amount needed to improve conditions and performance, or $14.9 billion annually, are estimated to be for rail infrastructure. Vehicles and guideway elements are estimated to require the largest amount of the total capital investment of all rail assets between 2003 and 2022, followed in descending order of investment requirements by stations, power systems, and facilities.

Forty-two percent of the total amount needed to maintain conditions and performance, or $6.5 billion dollars annually, and 39 percent of the total amount needed to improve conditions and performance, or $9.1 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 2003 and 2022, followed in descending order of investment requirements by facilities, guideway elements (dedicated lanes for buses), power systems, and stations.

Since the 2002 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 downward very slightly from 1.6 percent to 1.5 percent per year based on updated information collected from an expanded list of metropolitan planning organizations (MPOs). Changes in investment requirements 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.

# Highway and Bridge Investment Requirements

This section presents the projected investment requirements for highways and bridges for two primary performance targets. The "Maximum Economic Investment" scenario (Cost to Improve Highways and Bridges) identifies the level of investment that would be required to significantly improve system performance in an economically justifiable manner. The "Cost to Maintain Highways and Bridges" represents the annual investment necessary to maintain the current level of highway system performance. 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 requirements 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 models used to develop them. However, it is useful to combine them. This aggregation is particularly helpful when trying to compare these scenarios 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 requirements outlined in this section.

The average annual **"Maximum Economic Investment for Highways and Bridges"** over the 20-year period 2003 to 2022 is projected to be **$118.9 billion** in 2002 dollars. The average annual **"Cost to Maintain Highways and Bridges"** is projected to be **$73.8 billion** (also in 2002 dollars).

Note that these projections implicitly assume the continuation of current tax and fee structures. As pointed out in the "Congestion Pricing and Investment Requirements" section in the Introduction to Part II of this report, any shifts in financing mechanisms that significantly alter the costs incurred by individual users would have an effect on these results. The 2006 edition of the C&P report will begin to address this phenomena in a more quantitative manner. Note also 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.

## 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 7-2.* The estimated investment requirements for urban arterials and collectors total $69.2 billion, or 58.2 percent of the total average annual "Maximum Economic Investment for Highways and Bridges." Investment requirements on rural arterials and collectors are $32.4 billion (or 27.3 percent of the total), while the investment requirements for rural and urban local roads and streets total $17.2 billion (14.5 percent).

**Exhibit 7-2** *Average Annual Maximum Economic Investment for Highways and Bridges (Billions of 2002 Dollars)*

| Functional Class | System Preservation Highway | System Preservation Bridge | System Preservation Total | System Expansion | System Enhancements | Total |
|---|---|---|---|---|---|---|
| **Rural Arterials & Collectors** | | | | | | |
| Interstate | $2.6 | $0.7 | $3.3 | $2.5 | $0.7 | $6.4 |
| Other Principal Arterial | $4.3 | $1.0 | $5.3 | $1.7 | $1.1 | $8.1 |
| Minor Arterial | $4.2 | $1.0 | $5.2 | $1.0 | $0.6 | $6.8 |
| Major Collector | $6.1 | $1.5 | $7.6 | $0.6 | $0.5 | $8.7 |
| Minor Collector | $1.2 | $0.6 | $1.8 | $0.4 | $0.2 | $2.4 |
| **Subtotal** | **$18.4** | **$4.8** | **$23.2** | **$6.1** | **$3.1** | **$32.4** |
| **Urban Arterials & Collectors** | | | | | | |
| Interstate | $4.9 | $2.1 | $7.0 | $15.9 | $1.9 | $24.9 |
| Other Freeway & Expressway | $2.1 | $0.7 | $2.8 | $8.3 | $0.7 | $11.8 |
| Other Principal Arterial | $5.6 | $1.3 | $6.8 | $7.7 | $1.6 | $16.2 |
| Minor Arterial | $3.8 | $0.9 | $4.6 | $5.4 | $0.7 | $10.7 |
| Collector | $2.1 | $0.4 | $2.5 | $2.5 | $0.6 | $5.7 |
| **Subtotal** | **$18.4** | **$5.3** | **$23.7** | **$39.8** | **$5.6** | **$69.2** |
| Rural & Urban Local | $6.4 | $2.3 | $8.8 | $6.9 | $1.5 | $17.2 |
| **Total** | **$43.2** | **$12.5** | **$55.7** | **$52.9** | **$10.2** | **$118.9** |

*Source: Highway Economic Requirements System and National Bridge Investment Analysis System*

This scenario combines the "Maximum Economic Investment" scenarios from the Highway Economic Requirements System (HERS) and the National Bridge Investment Analysis System (NBIAS) with external adjustments to the two models.

# Cost to Maintain Highways and Bridges

*Exhibit 7-3* shows the average annual "Cost to Maintain Highways and Bridges" by type of improvement and functional class. The estimated investment requirements for urban arterials and collectors under this scenario total $41.4 billion, or 56.1 percent of the average annual "Cost to Maintain Highways and Bridges." Investment requirements for rural arterials and collectors total $21.6 billion (29.3 percent), while the investment requirements for rural and urban local roads and streets total $10.8 billion (14.5 percent).

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 two models.

# Investment Requirements by Improvement Type

Exhibits 7-2 and 7-3 also show investment requirements by type of improvement. The investment requirements are classified into three categories (defined in Chapter 6): system preservation, system expansion, and system enhancement. System preservation, as defined in this report, consists of the *capital* investment required to preserve the condition of the pavement and bridge infrastructure. This includes the costs of resurfacing, rehabilitation, and reconstruction, but does not include routine maintenance costs. System expansion includes the costs related to increasing system capacity by widening existing facilities or

**Exhibit 7-3** *Average Annual Investment Required to Maintain Highways and Bridges (Billions of 2002 Dollars)*

| Functional Class | System Preservation Highway | System Preservation Bridge | System Preservation Total | System Expansion | System Enhancements | Total |
|---|---|---|---|---|---|---|
| **Rural Arterials & Collectors** | | | | | | |
| Interstate | $2.2 | $0.5 | $2.7 | $1.8 | $0.4 | $5.0 |
| Other Principal Arterial | $3.2 | $0.7 | $3.9 | $1.2 | $0.7 | $5.8 |
| Minor Arterial | $2.7 | $0.7 | $3.4 | $0.6 | $0.4 | $4.3 |
| Major Collector | $3.3 | $1.0 | $4.4 | $0.3 | $0.3 | $5.0 |
| Minor Collector | $0.7 | $0.4 | $1.2 | $0.2 | $0.1 | $1.5 |
| **Subtotal** | **$12.2** | **$3.4** | **$15.5** | **$4.2** | **$1.9** | **$21.6** |
| **Urban Arterials & Collectors** | | | | | | |
| Interstate | $3.8 | $1.6 | $5.5 | $7.1 | $1.2 | $13.8 |
| Other Freeway & Expressway | $1.9 | $0.6 | $2.4 | $3.6 | $0.4 | $6.5 |
| Other Principal Arterial | $4.7 | $0.9 | $5.6 | $4.1 | $1.0 | $10.7 |
| Minor Arterial | $3.0 | $0.6 | $3.7 | $3.0 | $0.5 | $7.1 |
| Collector | $1.4 | $0.2 | $1.7 | $1.3 | $0.4 | $3.3 |
| **Subtotal** | **$14.9** | **$4.0** | **$18.9** | **$19.0** | **$3.5** | **$41.4** |
| Rural & Urban Local | $4.0 | $1.5 | $5.5 | $4.3 | $1.0 | $10.8 |
| **Total** | **$31.1** | **$8.9** | **$40.0** | **$27.5** | **$6.4** | **$73.8** |

*Source: Highway Economic Requirements System and National Bridge Investment Analysis System*

adding new roads and bridges. System enhancements include targeted safety enhancements, traffic control improvements, and environmental improvements. Appendix A describes how the investment requirements modeled by HERS and NBIAS were allocated among the three types of improvements.

*Exhibit 7-4* displays investment requirements by improvement type for rural and urban areas, for each scenario.

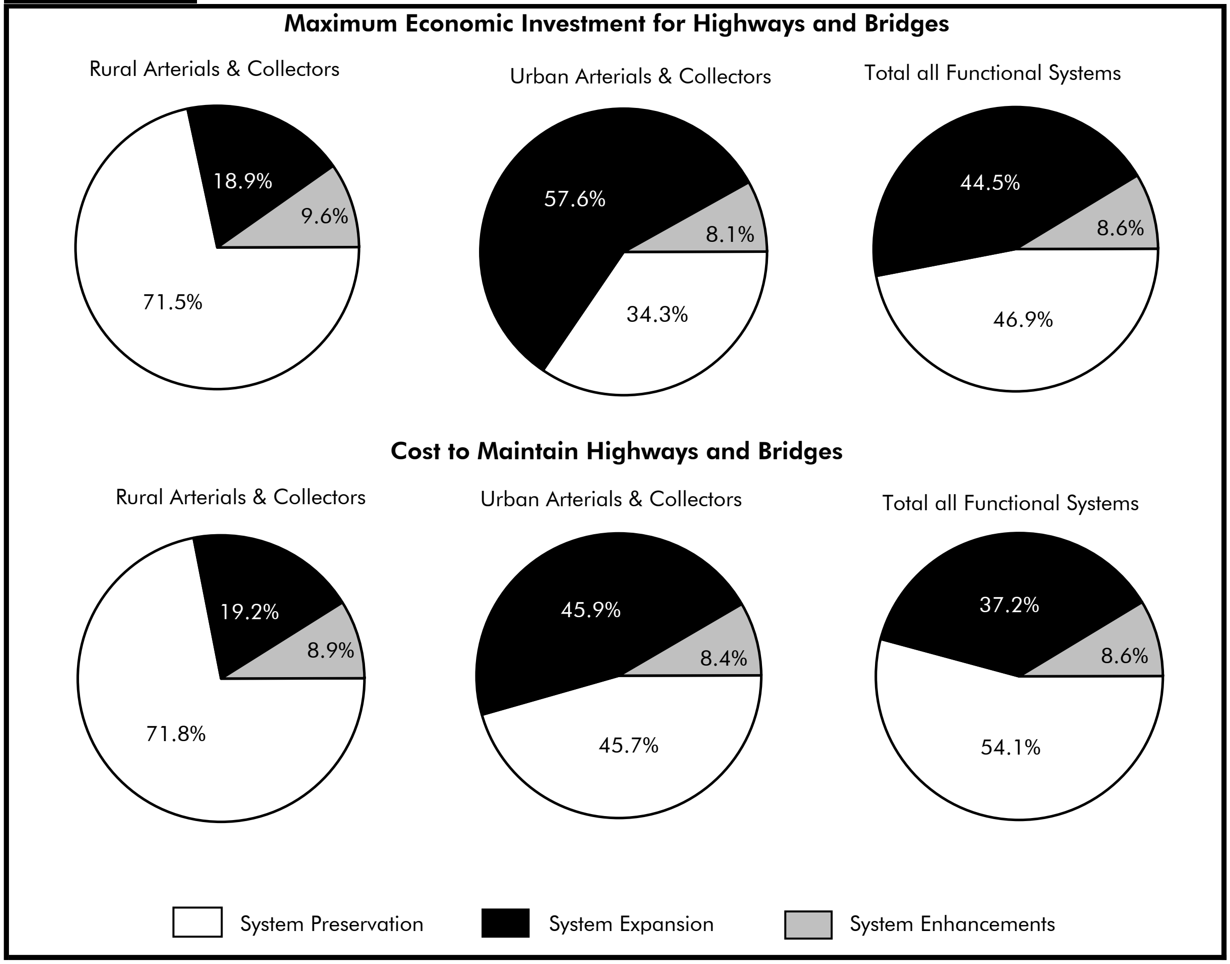
## System Preservation

Average annual system preservation investment requirements are estimated to be $55.7 billion under the "Maximum Economic Investment" scenario and $40.0 billion under the "Cost to Maintain" scenario. These totals constitute 46.9 and 54.1 percent, respectively, of the totals for the two scenarios. Exhibits 7-2 and 7-3 also indicate that bridge preservation investments represent about 22 percent of total preservation investment requirements under each scenario. As shown in Exhibit 7-4, system preservation makes up a much larger share of total investment requirements in rural areas than in urban areas.

## System Expansion

The $52.9 billion in average annual investment requirements for system expansion represent 44.5 percent of the total "Maximum Economic Investment for Highways and Bridges." Comparable figures for the "Cost to Maintain" scenario are $27.5 billion and 37.2 percent. Exhibits 7-2 through 7-4 indicate that system expansion requirements are much larger in urban areas than in rural areas, both in the total amount and as a share of overall investment requirements, under both investment scenarios.

**Exhibit 7-4** *Highway and Bridge Investment Requirements: Distribution by Improvement Type*




*Source: Highway Economic Requirements System and National Bridge Investment Analysis System.*

**Q. Can highway capacity be expanded without adding new lanes or new roads and bridges?**

**A.** Yes. In some cases, effective highway capacity can be increased by improving the utilization of the existing infrastructure. The investment requirements estimates presented in this edition of the report now consider the impact of some of the most significant such 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 12.

The methodology used to estimate system expansion requirements also allows high-cost capacity improvements to be considered as an option for segments with high volumes of projected future travel, but have been coded by States as infeasible for conventional widening. Conceptually, such improvements might consist of new highways or bridges in the same corridor (or tunneling or double-decking on an existing alignment), but the capacity upgrades could also come through other transportation improvements, such as a parallel fixed guideway transit line or mixed-use high occupancy vehicle/bus lanes.

### *System Enhancements*

Investment requirements for system enhancements represent 8.6 percent of both the "Maximum Economic Investment for Highways and Bridges" ($10.2 billion) and the "Cost to Maintain Highways and Bridges" ($6.4 billion). Investment requirements for 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.

# Sources of the Highway and Bridge Investment Requirements Estimates

The estimates of investment requirements for highways and bridges under the "Improve" and "Maintain" scenarios were derived from three sources:

- Highway and bridge capacity expansion and highway preservation investments were modeled using HERS.
- Bridge preservation 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.

The model scenarios used in HERS and NBIAS to construct the "Improve" and "Maintain" scenarios are discussed in greater detail below. *Exhibit 7-5* shows the sources of the highway and bridge investment requirements estimates.

### *External Adjustments*

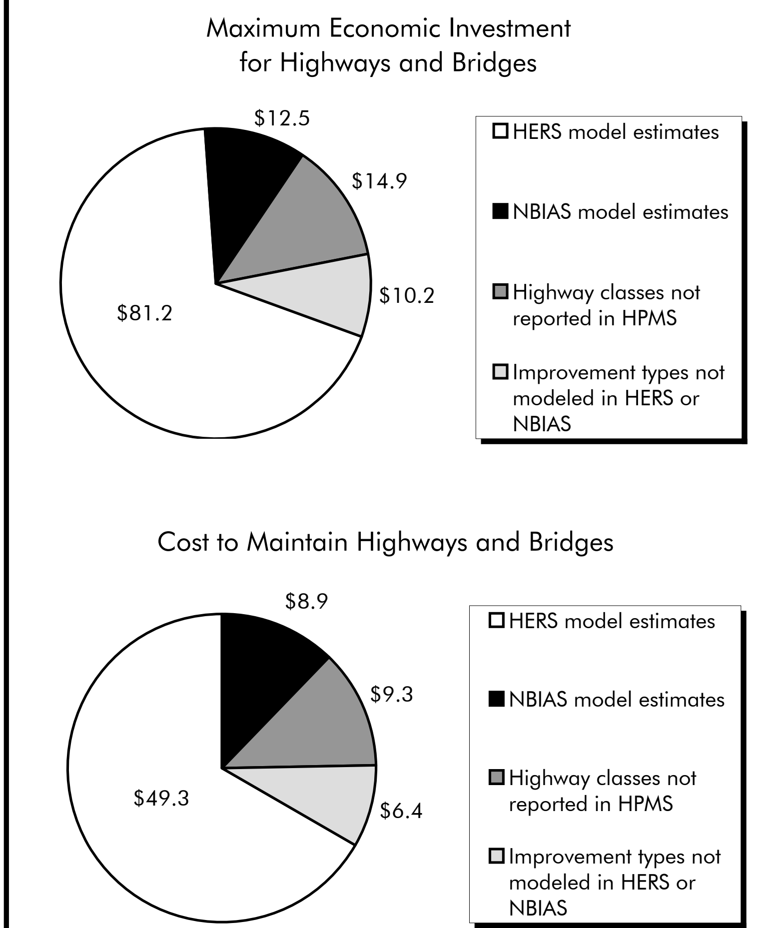
External adjustments were made to the directly modeled improvements generated by HERS and NBIAS in two areas:

- **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 requirements for bridge preservation 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 preservation and system expansion were applied.

**Q.** Why does the analysis assume that the share of future highway investments for non-modeled items would remain the same?

**A.** No data are currently available that would justify an assumption that this percentage would change. If this percentage of highway capital expenditures used for rural minor collectors, rural and urban local roads, and/or system enhancements were to rise in the future, then the investment requirements presented in this chapter would be understated. If this percentage falls over time, then the investment requirements shown would be overstated.

**Exhibit 7-5** *Sources of the Highway and Bridge Investment Requirements Estimates (Billions of 2002 Dollars)*




- **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 consider system enhancements. Estimates for this improvement type were applied across all functional classes.

The adjustment procedures assume that the share of total highway investment requirements 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 total investment requirements that are modeled in HERS and NBIAS is slightly higher than was the case in the 2002 C&P report. This is largely attributable to the fact that the share of combined highway capital expenditures by State and local governments estimated to have been devoted to local roads and rural minor collectors decreased between 2000 and 2002.

# Highway Economic Requirements System

The investment requirements shown in this report for highway preservation 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 111,000 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. Does HERS identify a single "correct" level of highway investment?**

**A.** 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 requirements 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."

**Q. How closely does the HERS model simulate the actual project selection processes of State and local highway agencies?**

**A.** The HERS model is intended to approximate, rather than replicate, the decision processes used by State and local governments. HERS does not have access to the full array of information that local governments would use in making investment decisions. This means that the model results may include some highway and bridge improvements that simply are not practical because of factors the model doesn't consider. 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 whether this will result in an equitable distribution of projects among the States or within each State. In actual practice, 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.

The HERS model initiates the investment requirements analysis by 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. The HERS model 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 fuller description of the project selection and implementation process used by HERS.

One of the key features of HERS as an economics-based model involves its treatment of travel demand. Recognizing that drivers will respond to changes in the relative price of driving and adjust their behavior accordingly, HERS explicitly models the relationship between the amount of highway travel and the price of that travel. This concept, sometimes referred to as travel demand elasticity, is applied to the forecasts of future travel found in the HPMS sample data. The HERS model assumes that the forecasts for each sample highway segment represent a future in which average conditions and performance are maintained, thus holding highway user costs at current levels. Any change in user costs relative to the initial conditions calculated by HERS will thus have the effect of either inducing or suppressing future travel growth on each segment. Consequently, for any highway investment requirement 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. Appendix A includes a further discussion of how travel demand elasticity is implemented in HERS.

While HERS was primarily designed to analyze highway segments, and the HERS outputs are described as "highway" investment requirements 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 investment requirements related to capacity are modeled in HERS; the NBIAS model considers only investment requirements related to bridge preservation.

## *Operations Investments*

For this report, the HERS model has been adapted to take 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, and the amount of capital investment required to reach given performance benchmarks. The types of operations investments and strategies 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).

**Q.** What are the costs associated with the operations strategies and investments included in the HERS investment analyses?

**A.** 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 capital cost of new deployments** under the existing trends scenario used for these analyses is $1.5 billion over 20 years (in 2002 dollars). These costs are included in the investment requirements estimates included in this report.

**Estimated operating and maintenance costs** for the operations strategies over the same 2003 to 2022 time period are $10.9 billion, including $2.9 billion for new deployments and $8.0 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 investment requirements.

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.

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 impact of a more aggressive deployment scenario, as well as one showing the impact of ignoring operations entirely in the analysis.

Appendix A includes a more complete description of the operations strategies, their impacts on performance, and the implementation within HERS.

## HERS Investment Scenarios

Two HERS investment scenarios were developed in order to generate the HERS-modeled portion of the two highway and bridge investment requirements scenarios. The HERS portion of the "Cost to Improve Highways and Bridges" was drawn from the HERS "Maximum Economic Investment" scenario, and the HERS "Maintain User Costs" scenario fed into the "Cost to Maintain Highways and Bridges." *Exhibit 7-6* shows the estimated investment requirements under the two HERS scenarios. The impact of the various levels of investment on user costs and other indicators of highway condition and performance is presented in Chapter 9.

The "Maximum Economic Investment" scenario is of interest mainly because it defines the upper limit of highway investment that could be economically justified. It was used to generate the highway preservation and system capacity expansion components of the "Maximum Economic Investment for (Cost to Improve) Highways and Bridges." In this scenario, all improvements with a benefit-cost ratio greater than or equal to 1.0 are implemented in HERS. While this scenario does not target any particular level of desired system performance, it would eliminate the existing highway investment backlog and address 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 HERS "Maximum Economic Investment" scenario is $81.2 billion.

The second major highway investment requirement scenario in this report is the "Maintain User Costs" scenario. It was used to generate the highway preservation and system capacity expansion components of the "Cost to Maintain Highways and Bridges." This scenario gives the level of investment sufficient to allow total highway user costs per VMT at the end of the 20-year analysis period to match the base year levels. 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 $49.3 billion.

**Exhibit 7-6** *HERS Investment Requirement Scenarios, 2003–2022 (Billions of 2002 Dollars)*

| Combined Highway/Bridge Scenario | Average Annual Investment | HERS Scenario | HERS-Derived Component [1] |
|---|---|---|---|
| Maximum Economic Investment for Highways and Bridges | $118.9 | Maximum Economic Investment | $81.2 |
| Cost to Maintain Highways and Bridges | $73.8 | Maintain User Costs | $49.3 |

[1] 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.

**Q. How is the HERS model used to produce investment requirements estimates for the various funding scenarios?**

**A.** The HERS model selects projects on the basis of their benefits and costs as calculated within the model. The HERS model can thus assign a benefit-cost ratio (BCR) to each selected improvement. The total investment over the 20-year forecast horizon is then estimated by establishing a list of cost-beneficial projects. For the "Maximum Economic Investment" scenario, all projects on the list are implemented. For other scenarios, projects are implemented in order of ranked BCR until a funding constraint is reached. By varying the funding constraint in different HERS runs and examining the output for different indicators, the user can then determine the level of investment that will achieve certain levels of condition and performance. It is important to note that these estimates represent the economically efficient levels of investment that would meet the targets, rather than the minimum amount of investment necessary to meet the same criteria.

The "Maintain User Costs" concept was originally introduced in the 1997 C&P report to provide a new highway system performance benchmark based on economic criteria. It focuses on highway users, rather than the traditional engineering-based criteria, which are oriented more toward highway agencies. This scenario is also an important technical point in the operation of HERS, since the VMT growth rates in the model are partly dependent on changes in user costs, owing to the operation of the travel demand elasticity feature.

The impact of this and other levels of investment on individual highway user cost components (as well as other measures of conditions and performance) are 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 $398 billion of investment could be justified based solely on the current conditions and operational performance of the highway system. Approximately 80 percent of the backlog is in urban areas, with the remainder in rural areas. About 60 percent of the backlog relates to capacity deficiencies on existing highways; the remainder results from pavement deficiencies.

This $398 billion backlog represents a subset of the "Maximum Economic Investment" scenario described above. Based on the average annual

**Q. How does the HERS backlog estimate compare with what was reported in the 2002 C&P report?**

**A.** The estimated backlog is significantly higher than the $271.7 billion shown in the 2002 C&P report. This is due to several factors. First, as noted above, highway capital expenditures have been below the Cost to Maintain in recent years. 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. Second, as discussed in Appendix A, the HERS model has recently been modified to consider a broader range of alternative widening options, while the costs per lane mile of various highway improvements have been revised upward. While the higher costs would cause certain potential improvements to fall below the 1.0 BCR threshold, this is more than offset by the increased costs of other improvements whose BCR would remain above this level, and the broader range of potential improvements that the model can now evaluate.

The overall "Cost to Improve Highways and Bridges," of which the backlog is a subset, is also higher than that estimated in the 2002 C&P report for similar reasons.

investment requirements identified in Exhibit 7-6, the total 20-year investment requirements under this scenario for capital improvements modeled by HERS would be approximately $1.6 trillion. This indicates that approximately 25 percent of the potential cost-beneficial improvements projected over the 20-year period could be implemented immediately if sufficient funding were available, while the remaining 75 percent would address deficiencies that are expected to develop between now and 2022.

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 enhancements.

# National Bridge Investment Analysis System

The estimates of future capital investment requirements relating to bridge preservation shown in this report are derived primarily from NBIAS, the successor to the Bridge Needs and Investment Process Model (BNIP) last used in the 1999 C&P report. The NBIAS incorporates analytical methods from the Pontis Bridge Management System. Pontis, first developed by FHWA in 1989, is now owned by the American Association of State Highway and Transportation Officials, which licenses the system to over 45 State transportation departments and other agencies.

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. The NBIAS also builds certain economic criteria into its analytical procedures that are not currently included in Pontis. The NBIAS is discussed in more detail in Appendix B.

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. As described in Appendix B, NBIAS has recently been modified to apply preservation policies at the individual bridge level and can now directly analyze costs and benefits of performing preservation work with the cost of completely replacing the bridge.

## *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 $62.6 billion could be invested immediately in a cost-beneficial fashion to replace or otherwise address currently existing bridge deficiencies.

**Q. How does the NBIAS backlog estimate compare with what was reported in previous editions of the C&P report?**

**A.** The estimated backlog is higher than the $54.7 billion shown in the 2002 C&P report, but lower than the $87.3 billion shown in the 1999 C&P report computed using BNIP. The recent modifications to NBIAS to allow maintenance, repair, and replacement needs on an individual bridge level have allowed it to identify a broader range of potentially cost-beneficial improvements. The current estimate remains lower than what was projected by BNIP, as the reported backlog does not reflect potential improvements unless they pass a benefit-cost test.

**Q. How does the NBIAS definition of the bridge deficiencies compare with the information on structurally deficient bridges reported in Chapter 3?**

**A.** 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.

## *Bridge Investment Requirements Scenarios*

The investment requirement scenarios for bridges have been renamed in this report to more accurately describe the manner in which they were computed in NBIAS, as the old names were more consistent with the BNIP engineering-based approach.

The "Maximum Economic Investment" scenario is the bridge preservation 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. As shown in *Exhibit 7-7,* **the average annual investment required under this scenario is estimated to be $12.5 billion**, which is 10.5 percent of the $118.9 billion average annual investment required to improve highways and bridges over a 20-year period.

The "Maintain Economic Backlog" scenario is the bridge component of the "Cost to Maintain Highways and Bridges." This scenario identifies the level of annual investment that would be required so that the cost of addressing all bridge deficiencies in 2022 would remain the same as in 2002. 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. **The average annual investment required under this scenario is estimated at $8.9 billion**, or 12.1 percent of the $73.8 billion average annual investment required to maintain highways and bridges over a 20-year period.

**Exhibit 7-7** *NBIAS Investment Requirement Scenarios, 2003–2022 (Billions of 2002 Dollars)*

| Combined Highway/Bridge Scenario | Average Annual Investment | NBIAS Scenario | NBIAS-Derived Component [1] |
|---|---|---|---|
| Maximum Economic Investment for Highways and Bridges | $118.9 | Maximum Economic Investment | $12.5 |
| Cost to Maintain Highways and Bridges | $73.8 | Maintain Economic Backlog | $8.9 |

[1] 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 NBIAS.

# Transit Investment Requirements

The FTA uses the Transit Economic Requirements Model (TERM), a model based on engineering and economic concepts, to estimate total capital investment needs for the US transit industry. TERM was developed to improve the quality of these FTA estimates. The 1997 C&P report was the first edition of the report providing investment requirements based on TERM.

This edition of the C&P report uses TERM to project the dollar amount of capital investment that will be required by the transit sector to meet various asset condition and operational performance goals by 2022. These capital investment requirement 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 downward very slightly since the last report, by 0.1 percent per year, based on updated information collected from an expanded list of MPOs. All investments identified by TERM are subject to a benefit-cost test, which requires that all investments incorporated in the model have a benefit-cost ratio that is greater than 1. The benefit-cost component of TERM has been updated and refined since the 2002 report to be much more responsive to changes in infrastructure costs. The investment requirement estimates presented here have, therefore, been subjected to a much more rigorous benefit-cost test than projected investment requirements based on TERM provided in earlier editions of this report. (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 capital investment requirements for transit for four combinations of the following 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 each asset type to at least a "good" level at the end of the 20-year period (2022).

- **Improve Performance**

  The performance of the Nation's transit system is improved as additional investments 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. *Earlier versions of TERM assumed that all additional investment undertaken to increase speed would be in light rail services. For this report, TERM has assumed that investment to increase speed in urbanized areas with populations under 1 million is made in BRT.*

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* provides estimates of the total annual capital investment that will be necessary to meet the four investment scenarios. These estimates combine those calculated by TERM with FTA staff estimates of rural and special service investment requirements. Annual investment requirements for transit are estimated to be $15.6 billion to maintain the conditions and performance of the Nation's transit system at its 2002 level (compared with $14.8 billion in 2000 dollars and $15.4 billion in 2002 dollars in the last report). To improve the average condition level of transit assets to "good" by 2022, as well as to improve performance by increasing vehicle speeds as experienced by passengers and reducing occupancy rates to threshold levels, would require an additional $8.4 billion per year for a total average annual capital investment of $24.0 billion (compared with $20.6 billion in 2000 dollars and $21.4 billion in 2002 dollars in the last report). *These investment requirements assume a 1.5 percent average annual increase in ridership over the 20-year projection period compared with the 1.6 percent average annual increase in ridership assumed in the 2002 edition of this report.* Investment requirements have increased principally as a result of upward revisions, on average, for rail capital costs. The impact of this cost increase has been most noticeable for the improve scenario, which shifts capital investment from bus to light rail. Since the last report, FTA has undertaken two major studies updating light and heavy rail capital cost information.

**Exhibit 7-8** *Summary of Average Annual Transit Investment Requirements, 2003–2022 (Billions of 2002 Dollars)*

| Conditions | Performance | Average Annual Cost |
|---|---|---|
| Maintain | Maintain | $15.6 |
| Improve | Maintain | $17.1 |
| Maintain | Improve | $22.5 |
| Improve | Improve | $24.0 |

*Source: Transit Economic Requirements Model and FTA staff estimates.*

As shown in *Exhibit 7-9,* replacement and rehabilitation costs are estimated to be $10.3 billion annually to maintain conditions and performance, and $11.7 billion annually to improve conditions and performance. The incremental $1.4 billion needed for asset rehabilitation and replacement under the "Improve Conditions" scenarios results from the extra investment required to rehabilitate and replace additional assets to attain an overall physical condition of "good". Asset expansion costs needed to meet the projected 1.5 percent average annual increase in ridership growth are estimated to range between $5.3 billion under the "Maintain Conditions and Performance" scenario to $5.7 under the "Improve Conditions and Performance" scenario. The amount needed to improve performance (by increasing passenger speeds and reducing crowding in systems not operating at "good" performance threshold levels) is estimated to be $6.6 billion annually.

**Exhibit 7-9** *Annual Transit Investment Requirements by Type of Improvement (Billions of 2002 Dollars)*

| Type of Improvement | Maintain Conditions & Performance | Improve Conditions & Maintain Performance | Maintain Conditions & Improve Performance | Improve Conditions & Performance |
|---|---|---|---|---|
| Replacement and Rehabilitation | $10.3 | $11.7 | $10.3 | $11.7 |
| Asset Expansion | $5.3 | $5.4 | $5.5 | $5.7 |
| Performance Improvements | | | $6.6 | $6.6 |
| **Total** | **$15.6** | **$17.1** | **$22.5** | **$24.0** |

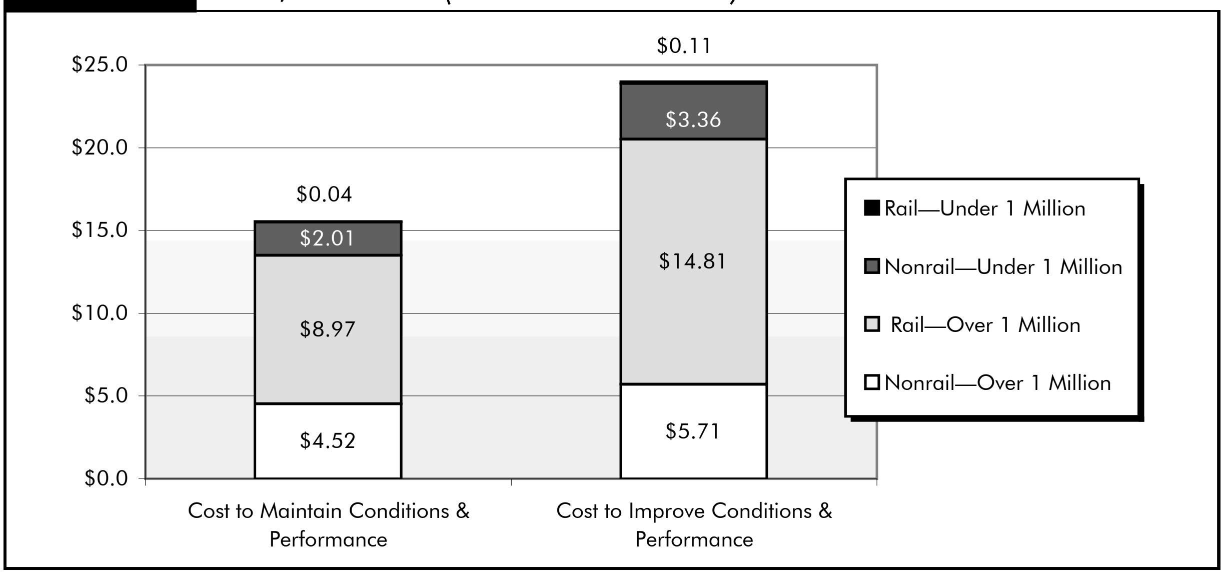
*Source: Transit Economic Requirements Model and FTA staff estimates.*

# Average Annual Costs to Maintain and Improve Conditions and Performance

## *Requirements by Population Area Size*

*Exhibit 7-10* provides a summary of transit investment requirements 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 investment in transit will be required in urban areas with populations of over 1 million, reflecting the fact that, in 2002, 91.6 percent of the Nation's passenger miles were in these areas.

**Exhibit 7-10** *Transit Average Annual Investment Requirements by Area Population Size and Mode, 2003–2022 (Billions of 2002 Dollars)*




*Source: Transit Economic Requirements Model and FTA staff estimates.*

It is estimated that an average of $13.5 billion annually would be needed to maintain conditions and performance of the transit assets in these large urban areas, and $20.5 billion annually would be needed to improve the conditions and performance of the assets in these areas. The needs of less-populated areas (i.e., those with populations under 1 million) are estimated to be considerably lower than those of more populous areas because they have fewer transit assets. It is estimated that an average of $2.1 billion annually would be needed to maintain the conditions and performance of the transit infrastructure in these less-populated areas, and $3.5 billion would be needed annually to improve them.

**Exhibit 7-11** *Annual Average Cost to Maintain and Improve Transit Conditions and Performance, 2003–2022*

| Mode, Purpose & Asset Type (Millions of 2002 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 (*)** | | | | | |
| Replacement & Rehabilitation | (Vehicles) | $2,275 | $434 | | $2,709 |
| | (Nonvehicles) (**) | 1,049 | 12 | | 1,061 |
| Asset Expansion | (Vehicles) | 639 | 14 | | 653 |
| | (Nonvehicles) | 525 | 0 | | 525 |
| Improve Performance | (Vehicles) | | | 331 | 331 |
| | (Nonvehicles) (**) | | | 373 | 373 |
| Special Service(***) | (Vehicles) | 38 | 21 | | 59 |
| **Subtotal Nonrail** | | **4,526** | **481** | **705** | **5,711** |
| **Rail** | | | | | |
| Replacement & Rehabilitation | (Vehicles) | 1,468 | 253 | | 1,721 |
| | (Nonvehicles) (**) | 3,787 | 358 | | 4,145 |
| Asset Expansion | (Vehicles) | 914 | 0 | | 914 |
| | (Nonvehicles) (**) | 2,803 | 99 | | 2,901 |
| Improve Performance | (Vehicles) | | | 652 | 652 |
| | (Nonvehicles) (**) | | | 4,480 | 4,480 |
| **Subtotal Rail** | | **8,972** | **710** | **5,131** | **14,813** |
| **Total Areas Over 1 Million** | | **13,498** | **1,191** | **5,836** | **20,524** |
| **Areas Under 1 Million in Population** | | | | | |
| **Nonrail (*)** | | | | | |
| Replacement & Rehabilitation | (Vehicles) | 748 | 94 | | 842 |
| | (Nonvehicles) (**) | 409 | 0 | | 409 |
| Fleet Expansion | (Vehicles) | 238 | 5 | | 243 |
| | (Nonvehicles) (**) | 123 | 0 | | 122 |
| Improve Performance | (Vehicles) | | | 178 | 178 |
| | (Nonvehicles) (**) | | | 538 | 538 |
| Special Service (***) | (Vehicles) | 215 | 116 | | 331 |
| Rural | (Vehicles) | 277 | 121 | 283 | 681 |
| | (Nonvehicles) (**) | 5 | 10 | | 15 |
| **Subtotal Nonrail** | | **2,014** | **346** | **1,000** | **3,360** |
| **Rail** | | | | | |
| Replacement & Rehabilitation | (Vehicles) | 1 | 0 | | 1 |
| | (Nonvehicles) (**) | 14 | 0 | | 14 |
| Fleet Expansion | (Vehicles) | 6 | 0 | | 6 |
| | (Nonvehicles) (**) | 19 | 1 | | 20 |
| Improve Performance | (Vehicles) | | | 10 | 10 |
| | (Nonvehicles) (**) | | | 57 | 57 |
| **Subtotal Rail** | | **40** | **1** | **67** | **108** |
| **Total Areas Under 1 Million** | | **2,054** | **347** | **1,067** | **3,467** |
| **Total** | | **15,552** | **1,537** | **6,903** | **23,992** |

(*) Buses, vans and other (including ferryboats.)

(**) Nonvehicles comprise guideway elements, facilities, systems, and stations.

(***) Vehicles to serve the elderly and disabled.

*Source: Transit Economic Requirements Model and FTA staff estimates.*

**Q.** **Why has the amount required to rehabilitate and replace the nonrail infrastructure in both densely and less densely populated urbanized areas increased by more than 35 percent since the 2002 edition of this report?**

**A.** Estimated capital investment requirements for nonrail vehicles in these areas increased due to upward revisions in estimated replacement costs of these vehicles as reported to FTA. Estimated nonrail vehicle rehabilitation and replacement costs are on average 30 percent higher than they were in 2000 as presented in the 2002 report. The amount needed to rehabilitate and replace nonrail, nonvehicle assets also increased because data collected by the Asset Conditions Reporting Module (ACM) and from the New York Metropolitan Transportation Authority (MTA) revealed that the size as indicated by the value of this infrastructure, principally facilities, was considerably larger than previously estimated and, although in very marginally better condition, would require higher rehabilitation and replacement expenditures to support a more extensive infrastructure. Enhancements to the benefit-cost module and lower projected growth in passenger travel on transit exerted downward pressure on projected nonrail needs; however, these impacts were outweighed by the revisions to costs and the increase in estimated infrastructure size.

**Q.** **Why has the amount required under the "Maintain Conditions" scenario to rehabilitate and replace rail vehicles in urbanized areas with populations greater than 1 million to maintain conditions declined by 28 percent since the 2002 edition of this report?**

**A.** The estimated amount needed to rehabilitate and replace rail vehicles in large urbanized areas has decreased since the last edition of this report, in part, due to the revision in the deterioration schedule for commuter rail vehicles. The conditions of commuter rail vehicles were found to decline more gradually after the age of 22 years, the average age of commuter rail vehicles in 2002, than previously estimated. (See *Exhibit 3-45* in Chapter 3.) The amount estimated to be needed to rehabilitate and replace rail vehicles also declined due to the revisions in the benefit-cost analysis, which set a more rigorous benefit standard. These revisions more than offset the 6 percent increase in rail vehicle rehabilitation and replacement costs that occurred between 2000 and 2002.

**Nonrail Needs in Urban Areas with Populations over 1 Million**—The cost of maintaining the conditions of the nonrail infrastructure (buses, vans, and ferryboats) in urban areas with populations over 1 million is considerably less than the cost of maintaining the rail infrastructure in these areas. Thirty-four percent of the total investment requirement in these larger urban areas, or about $4.5 billion annually, would be needed to maintain the conditions and performance of this nonrail infrastructure. Seventy-four percent of the $4.5 billion, or $3.3 billion annually, would be used to rehabilitate and replace assets to maintain conditions, and 26 percent, or $1.2 billion, would be needed to purchase new assets to maintain performance. It is estimated that 68 percent of rehabilitation and replacement expenditures and 55 percent of asset expansion expenditures would be for vehicles. The incremental costs to improve nonrail conditions are estimated to be $481 million annually, of which $455 million would be needed for vehicle rehabilitation and replacement. The incremental costs to improve performance are estimated to be $705 million annually, of which 47 percent ($331 million) would be spent on new vehicles (principally buses) and 53 percent ($373 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). A total of $5.7 billion annually is estimated to be needed to improve both conditions and performance of the nonrail assets in these more heavily populated areas.

**Rail Needs in Urban Areas with Populations over 1 Million**—Sixty-six percent of the total transit investment requirements of large urban areas, or about $9.0 billion annually, is estimated to be needed to maintain conditions and performance of the transit rail infrastructure, 27 percent less than the $9.6 billion reported in the 2002 report. [See Q & A on bottom left of page.] Fifty-eight percent, or $5.2 billion annually, would be required to rehabilitate and replace rail assets to maintain conditions, and 42 percent, or $3.7 billion, would be required for rail asset expansion to maintain performance as ridership increases. The incremental cost to improve rail asset conditions so that they achieve an average condition rating of "good" by 2022 is estimated to be $710 million annually, $253 million for vehicle and $457 million for nonvehicle asset rehabilitation and replacement. The incremental costs to improve performance of these rail systems are estimated to be $5.1 billion annually, including the cost of purchasing rights-of-way. Eighty-seven percent of this amount, or $4.5 billion, would be needed for the expansion of the nonvehicle rail infrastructure. This 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 $14.8 billion annually is estimated to be needed to improve both conditions and performance of rail in these more heavily populated, urbanized areas.

**Nonrail Needs in Areas with Populations of Under 1 Million**—Ninety-eight percent of the transit investment requirements in areas with populations under 1 million is projected to be for nonrail transit. The annual cost to maintain conditions and performance of the nonrail transit infrastructure in these less-populated areas is estimated to be $2.0 billion annually. The total amount needed to improve both conditions and performance of nonrail transit in these areas is estimated to be $3.4 billion annually. The incremental investment required to improve nonrail conditions in these areas is estimated to be $346 million annually and the investment needed to improve performance is estimated to be $1 billion. Of the $1 billion incremental annual investment to improve performance, 46 percent, or $461 million, would be needed to acquire new vehicles and 54 percent, or $538 million, would need to be invested in the new nonvehicle infrastructure. The estimated investment needed for nonrail performance enhancements has increased considerably since the last report for methodological reasons. The current report assumes that investment required to improve speed will be in the form of BRT rather than light rail, except in systems where light rail already exists. The last edition of this report assumed that all investment to increase speeds in these less populous areas would be in light rail. Twenty-eight percent of the expansion in investment needed to improve performance, or $283 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**—Rail needs in areas with populations of less than 1 million are minimal. Currently, only three light rail systems operate in these less-populated areas. Maintaining conditions and performance of the rail assets in these areas would require an estimated $40 million annually, of which $33 million, or 83 percent, would be needed for investment in nonvehicle rail infrastructure. The amount needed to improve performance is estimated to be $67 million annually. This amount declined from $112 million in 2000 because of the revision in TERM to increase speed with investment in BRT instead of light rail. The 2002 $67 million amount is for improvements in the three existing light rail systems only.

**Q.** What would the investment requirements be if performance improvements in areas with populations of less than 1 million were made by shifting bus investment to light rail instead of to BRT as was done in earlier reports?

**A.** This change would increase the annual amount to improve performance by $49 million annually. The amount of rail investment in these areas would increase by $518 million and the amount of bus investment in these areas would decrease by $469 million.

## *Requirements by Asset Type*

*Exhibit 7-12* provides disaggregated annual investment requirements to maintain conditions and performance and to improve conditions and performance 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—facilities, guideway elements, stations, systems, and vehicles. The annual funding requirements 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. In the 2002 report, some costs for vehicles, stations, facilities and other "hard assets" were improperly reported as system design or right-of-way acquisition. These costs are now correctly allocated to the asset category to which they correspond. Under the "Improve" scenario, this revision has contributed to the larger investment requirements for each asset than reported in the last edition of the report.

### Rail Infrastructure

Fifty-eight percent of the total amount needed to maintain conditions and performance ($9.0 billion dollars annually) and 62 percent of the total amount needed to improve conditions and performance ($14.9 billion annually) are estimated to be for rail infrastructure. As shown in *Exhibit 7-13*, vehicles and guideway elements are estimated to require the largest amount of the total capital investment of all rail assets between 2003 and 2022, followed in descending order of investment requirements by stations, power systems, and facilities.

G*uideways* are estimated to account for 49 percent of the total value of the Nation's rail infrastructure. (The estimated value of transit infrastructure in 2002 by type of asset is provided in Exhibit 3-51.) Slightly more than one-quarter of the total amount estimated to be required to maintain and to improve the conditions and performance of the Nation's transit rail assets will be needed for investment in guideway elements. Guideway elements are composed of elevated structures, systems structures, and track. The annual amount needed to maintain the conditions and performance of rail guideway is estimated to be $2.5 billion, and the annual amount needed to improve the conditions and performance of rail guideways is estimated to be $3.8 billion. Annual rehabilitation and replacement costs are estimated to be $1.4 billion to maintain conditions; annual asset expansions are estimated to cost $1.1 billion to maintain performance and $1.4 billion to improve performance. The estimated average condition of guideway improved slightly, from 3.21 in 2000 to 3.56 in 2002, principally based on data from the ACM and the New York MTA. The estimated value of the Nation's rail guideway asset base increased by 14 percent in current dollar values between 2000 and 2002, largely as a result of the substantial increases in the estimated unit costs of at-grade ballast and elevated structures, with upward revisions ranging from 100 to 300 percent. However, the estimated amount needed for investment in guideway elements has declined since the 2002 report due to the a higher estimated guideway condition and the increased rigor of the benefit-cost test, coupled with higher replacement costs and lower projected passenger miles traveled (PMT) growth. (The 2002 report estimated that $3.7 billion annually was needed to maintain guideway conditions and performance and $4.8 billion annually to improve guideway conditions and performance.)

**Exhibit 7-12** *Transit Infrastructure Average Annual Investment Requirements by Asset Type, 2003–2022*

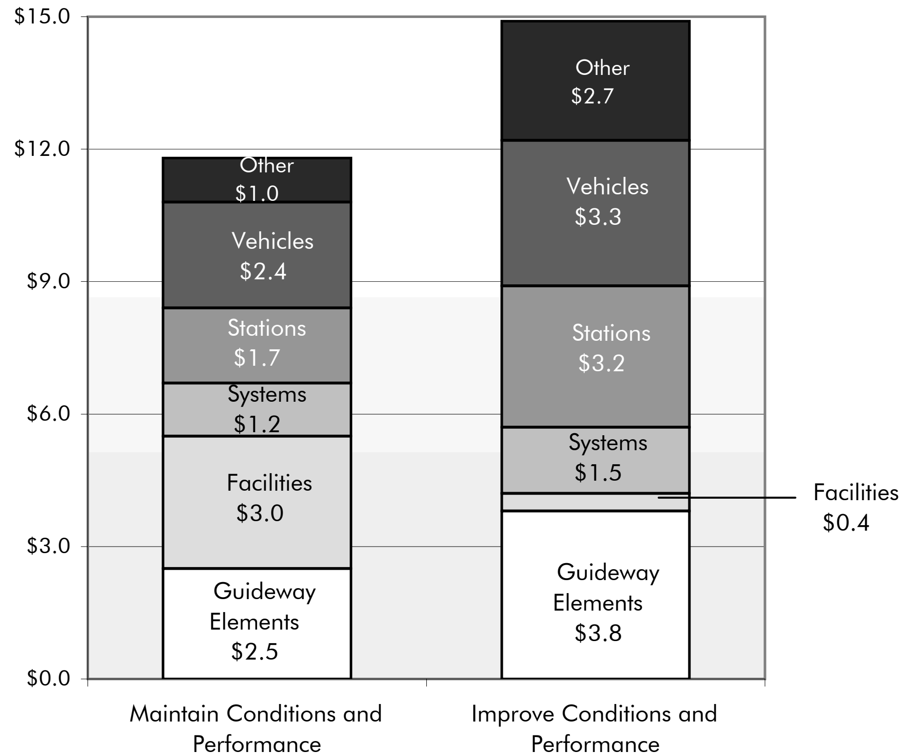
| Maintain Conditions and Performance | | | | |
|---|---|---|---|---|
| (Millions of 2002 Dollars)<br>**Asset Type** | **Rehabilitation and Replacement** | **Asset Expansion** | **Improve Performance** | **Total** |
| **Rail** | | | | |
| Guideway Elements | $1,395 | $1,069 | | $2,464 |
| Facilities | 206 | 102 | | 307 |
| Systems | 922 | 237 | | 1,159 |
| Stations | 1,278 | 461 | | 1,738 |
| Vehicles | 1,469 | 920 | | 2,389 |
| Other Project Costs | | 954 | | 954 |
| **Subtotal Rail** | **5,270** | **3,742** | **0** | **9,012** |
| **Nonrail** | | | | |
| Guideway Elements | 29 | 182 | | 212 |
| Facilities | 1,255 | 330 | | 1,584 |
| Systems | 132 | 48 | | 180 |
| Stations | 46 | 54 | | 100 |
| Vehicles | 3,553 | 876 | | 4,429 |
| Other Project Costs | | 35 | | 35 |
| **Subtotal Nonrail** | **5,016** | **1,524** | **0** | **6,540** |
| **Total Maintain Conditions** | **10,285** | **5,266** | **0** | **15,551** |

| Improve Conditions and Performance | | | | |
|---|---|---|---|---|
| **Asset Type** | **Rehabilitation and Replacement** | **Asset Expansion** | **Improve Performance** | **Total** |
| **Rail** | | | | |
| Guideway Elements | 1,395 | 1,069 | 1,382 | 3,845 |
| Facilities | 205 | 102 | 117 | 424 |
| Systems | 924 | 237 | 330 | 1,491 |
| Stations | 1,635 | 560 | 968 | 3,163 |
| Vehicles | 1,722 | 920 | 662 | 3,304 |
| Other Project Costs | | 954 | 1,740 | 2,693 |
| System Design and Right-of-Way Acquisition | | | | 0 |
| **Subtotal Rail** | **5,881** | **3,842** | **5,198** | **14,921** |
| **Nonrail** | | | | |
| Guideway Elements | 29 | 182 | 244 | 456 |
| Facilities | 1,246 | 329 | 305 | 1,880 |
| Systems | 128 | 48 | 9 | 185 |
| Stations | 66 | 54 | 230 | 350 |
| Vehicles | 4,354 | 1,178 | 510 | 6,042 |
| Other Project Costs | | 35 | 124 | 158 |
| **Subtotal Nonrail** | **5,824** | **1,826** | **1,421** | **9,071** |
| **Total Improve Conditions** | **11,705** | **5,667** | **6,620** | **23,992** |

*Source: Transit Economic Requirements Model and FTA staff estimates.*

*Vehicles* are estimated to account for 19 percent of the total value of the Nation' rail infrastructure. Twenty-seven percent of the amount needed to maintain rail assets conditions and performance, or $2.4 billion annually, and 22 percent of the amount needed to improve rail assets conditions and performance, or $3.3 billion annually, are estimated to be for vehicles. Annual vehicle rehabilitation and replacement costs are estimated to be $1.5 billion to maintain conditions and $1.7 billion to improve conditions. Annual asset expansion costs are estimated to be $920 million to maintain performance and $662 million to improve

**Exhibit 7-13** *Annual Rail Investment Requirements, 2003–2022 (Billions of 2002 Dollars)*




*Source: Transit Economic Requirements Model and FTA staff estimates.*

performance. Actual conditions of rail vehicles are estimated to have declined very minimally from 3.55 in 2000 to 3.48 in 2002. However, the estimated amount of capital investment required for rail vehicles has decreased substantially since the 2002 report. Although the estimated total value of the rail vehicle fleet increased by 24 percent in current dollar terms between 2000 and 2002, this was largely a result of revisions in unit costs. Any increases in investment needs from this increased valuation were more than offset by the increased rigor of the benefit-cost analysis, revisions to the commuter rail decay curves, and reduction in projected passenger growth. (The 2002 report estimated that $3.1 billion annually was needed to maintain rail vehicle conditions and performance and $3.3 billion annually to improve rail vehicle conditions and performance.)

*Stations* are estimated to account for 16 percent of the total value of the Nation's rail infrastructure. Nineteen percent of the amount required to maintain the conditions and performance of rail assets, or $1.7 billion annually, and 21 percent of the annual amount required to improve the conditions and performance of rail assets, or $3.2 billion annually, are estimated to be for stations. The amount needed for rehabilitation and replacement to maintain conditions is estimated to be $1.3 billion annually, and the amount needed to improve conditions is estimated to be $1.6 billion annually. The annual amount needed for asset expansion to maintain performance is estimated to be $461 million, and the annual amount needed to improve performance is estimated to be $1.5 billion. The amount of estimated capital investment for stations has increased substantially since the 2002 edition of this report. The data collected by the ACM and from the New York MTA indicated that the value or size of rail station assets was larger than previously estimated and their conditions worse. Estimated conditions of rail stations fell from 3.52 in 2000 to 2.87 in 2002, principally as a result of new information. However, the estimated value of the Nation's rail station infrastructure for 2002 is 81 percent higher than for 2000. This higher asset valuation of stations, combined with a decrease in their estimated condition level and lower replacement costs, has led to considerably higher estimates of future capital investment requirements, and outweighed any decreases in investment requirements resulting from the strengthened benefit-cost test and lower projected growth in passenger travel. (The 2002 report estimated that $692 million annually was needed to maintain station conditions and performance and $981 million annually to improve station conditions and performance.)

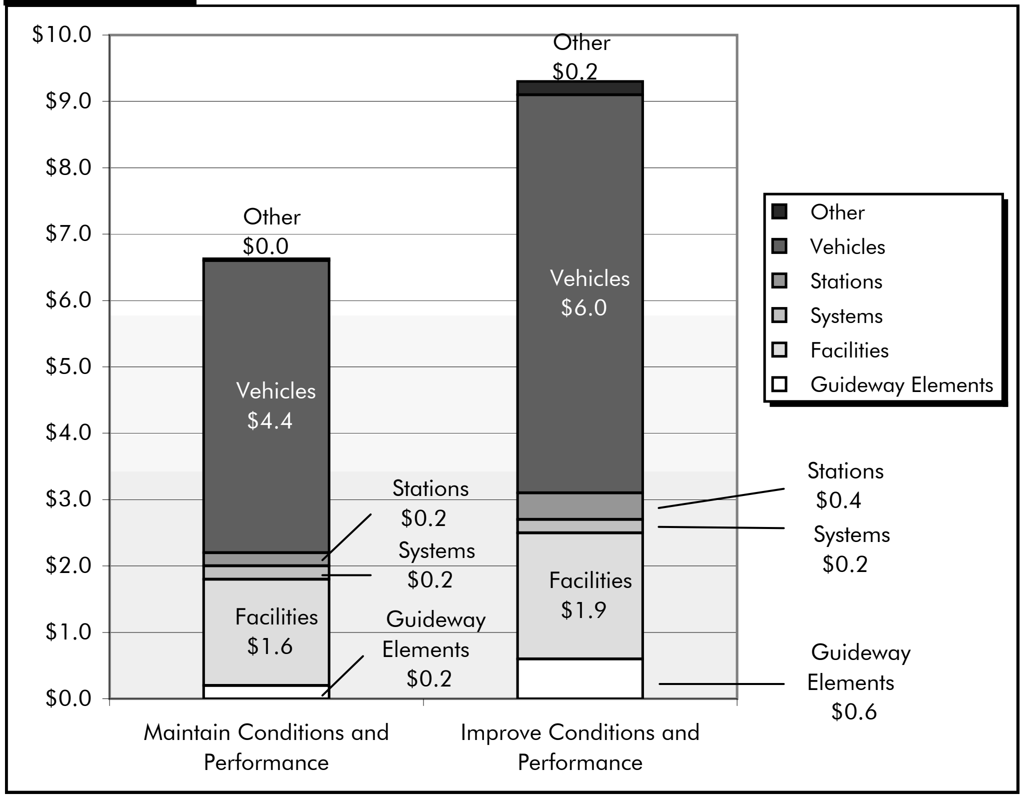
*Rail power systems*, comprising substations, overhead wire, and third rail, are estimated to account for 13 percent of the total value of the Nation's rail asset base. Thirteen percent of the amount needed to maintain the conditions and performance of rail assets or $1.2 billion annually, and 10 percent of the amount needed to improve the conditions and performance of rail assets, or $1.5 billion annually, are estimated to be for rail power systems. Annual rehabilitation and replacement costs are estimated to be $922 million to maintain conditions and $924 million to improve conditions. Annual asset expansion costs are estimated to be $237 million to maintain rail power system performance and an additional $330 million to improve performance. The estimated condition of rail power systems increased slightly from 3.96 in 2000 to 4.08 in 2002. Although the value of the rail power systems infrastructure is estimated to be 27 percent higher in 2002 than in 2000, estimated investment requirements for rail power systems have not changed significantly. This is because any increase in investment requirements stemming from a higher asset valuation was more than offset by decreases in investment requirements resulting from the strengthened benefit-cost test, lower projected growth in passenger travel, and lower estimated replacement costs. (The 2002 report 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.)

*Facilities* for rail vehicles (maintenance facilities and yards) are estimated to account for 2 percent of the total value of the Nation's rail transit asset base. Three percent of the amount needed to maintain conditions ($307 million annually) and 3 percent of the amount needed to improve conditions and performance ($424 million annually) are estimated to be for facilities. Annual rehabilitation and replacement costs are estimated to be $206 million to maintain conditions and $205 million to improve conditions. Asset expansion costs are estimated to be $102 million annually to maintain performance and $117 million annually to improve performance. The estimated value of facilities in current dollars is 155 percent higher in 2002 than in 2000, as a result of new data collected by the ACM and from the New York MTA as well as updated information from the NTD. Estimated replacement costs for commuter rail and heavy facilities increased and those for light rail decreased. Data collected by the ACM revealed the average age of rail maintenance facilities was lower, and the average condition higher, than previously estimated. The estimated average condition of facilities increased from 3.21 in 2000 to 3.56 in 2002. In summary, the substantially higher asset valuation of maintenance facilities has led to higher estimates of future capital investment requirements, which have outweighed any decreases in investment requirements resulting from the strengthened benefit-cost test, increase in estimated condition, and slight decrease in the growth of projected use. (The 2002 report estimated that $235 million annually was needed to maintain rail facilities conditions and performance and $294 million annually to improve rail facilities conditions and performance.)

## Nonrail Assets

Forty-two percent of the total amount needed to maintain conditions and performance, or $6.5 billion dollars annually, and 39 percent of the total amount needed to improve conditions and performance, or $9.1 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 2003 and 2022, as shown in *Exhibit 7-14,* followed in descending order of investment requirements by facilities, guideway elements (dedicated lanes for buses), power systems, and stations.

**Exhibit 7-14** *Nonrail Annual Investment Requirements, 2003–2022 (Millions of 2002 Dollars)*




*Source: Transit Economic Requirements Model and FTA staff estimates.*

*Vehicles* are estimated to account for 36 percent of the total value of the Nation's nonrail assets in 2002, excluding vehicles in rural areas. However, they account for substantially more of projected nonrail investment requirements because they depreciate much more quickly than nonvehicle assets. The estimated investment in nonrail vehicles required to maintain conditions and performance is $4.4 billion annually, and the estimated investment required to improve conditions and performance is $6.0 billion annually. The bulk (70 to 75 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 to maintain performance and 36 percent of the amount required to improve performance. The investment requirements for nonrail vehicles increased since the 2002 report as a result of the expansion in the number of nonrail vehicles, slightly lower condition levels, and an increase in unit costs. (The 2002 report estimated that $3.1 billion annually was needed to maintain the conditions and performance of nonrail vehicles and $4.8 billion annually to improve the conditions and performance of nonrail vehicles.)

*Facilities* are estimated to account for 57 percent of the total value of the Nation's nonrail assets, excluding facilities in rural areas. [Note that asset value is estimated by TERM, which does not include rural operators.] In total, the most recent data collected revealed that the valuation of nonrail facilities was underestimated in the 2000 report and has, therefore, increased by about 100 percent between 2000 and 2002. Although facilities account for more than half of the nonrail assets, they represent only about a quarter of future nonrail investment requirements because external structures and many of the facility components depreciate slowly. Facilities are estimated to need $1.6 billion annually to maintain the conditions and performance and $1.9 billion annually to improve nonrail conditions and performance. While the conditions of bus maintenance facilities increased from 3.29 in 2000 to 3.34 in 2002, the substantially higher asset valuation of maintenance facilities has led to higher estimates of future capital investment requirements and has outweighed any decreases in investment requirements resulting from the strengthening of the benefit-cost test and reduction in passenger growth. (The 2002 report estimated that $1.1 billion annually was needed to maintain the conditions and performance of nonrail facilities and $1.4 billion annually was needed to improve the conditions and performance of nonrail facilities.)

*Guideway elements* account for 4 percent of the Nation's nonrail assets, *stations* account for 2 percent, and *power systems* account for 1 percent. Limited revisions were made to the valuation of these nonrail assets. Nonrail guideway elements are estimated to require an annual investment of $212 million to maintain conditions and performance and $456 million annually to improve conditions and performance (compared with $353 million annually and $460 million annually in the 2002 report). Nonrail stations are estimated to require an annual investment of $100 million to maintain conditions and performance and $350 million annually to improve conditions and performance (compared with $162 million annually and $199 million annually in the 2002 report). Nonrail power systems are estimated to require $180 million annually to maintain conditions and performance and $185 million annually to improve conditions and performance (compared with $207 million annually and $209 million annually in the 2002 report).

## Rural Transit Vehicles and Facilities

Investment requirements in rural areas have been estimated using the same information and methodology as in the 2002 edition of the 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 project investment requirements for the 2002 edition of this report. The changes in estimated requirements since the last report result from revisions in estimated vehicle and facility replacement costs. The amount needed to maintain conditions and performance increased by 19.1 percent in current dollars, from $237 million in 2000 to $277 in 2002. The amount needed to improve conditions and performance decreased by 5.2 percent, from $758 million in 2000 to $681 million in 2002. The amount needed to maintain conditions and performance increased as a result of increases in the estimated replacement costs ranging between 13 and 26 percent for buses and nonaccessible vans. Combined, these vehicles are estimated to account for 84 percent of the rural fleet. The replacement cost of maintenance facilities was also estimated to be 18 percent higher than in the 2002 report. The amount needed to improve conditions and performance decreased because the costs of accessible small vehicles and vans used to calculate investment requirements in the last edition of the report were too high. The "Improve Conditions and Performance" scenario assumes that all small vehicles and vans are replaced with models that are ADA accessible. As in the last edition of the 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

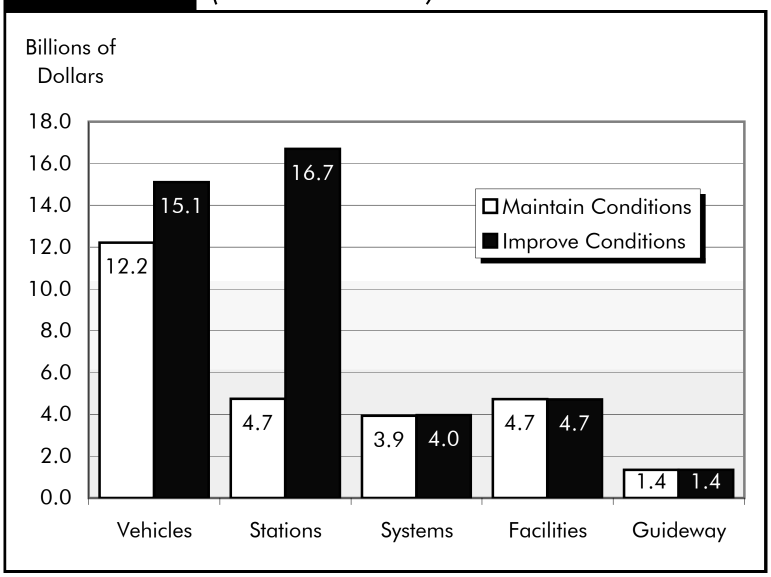
Estimated investment requirements for special service vehicles are 48 percent higher than they were in the 2002 edition of this report as a result of the increase in fleet size and higher vehicle replacement costs. The number of special service vehicles, as reported in the FTA Trends Report FY2002 on the use of Section 5310 Elderly and Persons with Disabilities Program funds, increased from 28,664 in 2000 to 37,720 in 2002, an increase of 30 percent. Based on information reported to FTA by grantees, the average replacement price of a special service vehicle was assumed to have increased from $43,498 in 2000 to $46,985 in 2002. Note that the investment needed to maintain and improve the conditions of vehicles funded by FTA accounts for 43 percent of the amount needed to maintain and improve the conditions of the entire 37,720 special service vehicle fleet.

# Existing Needs in the Transit Infrastructure

TERM estimates the amount of investment that would be required to correct existing needs in the Nation's transit infrastructure. The "backlog" is the level of investment needed to replace all assets with conditions below the condition replacement thresholds specified by TERM 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 requirements 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 $27.0 billion if assets are replaced at the threshold levels specified by TERM to maintain conditions (compared with $16.4 billion in the 2002 report) and a $41.8 billion backlog if assets are replaced at the threshold level specified by TERM to improve conditions (compared with $30.7 billion in the 2002 report). The increase in backlog to maintain conditions comes principally from an $8.2 billion increase in the replacement backlog for vehicles. Because the conditions of vehicles have increased since the last report, a higher level of investment is needed to maintain these conditions. The increase in the backlog to improve conditions principally resulted from a $12.3 billion increase in the backlog for stations. Between 2000 and 2002, the estimate for station conditions dropped from 3.44 to 2.99, primarily as a result of new information. These numbers do not include the costs of upgrading assets or eliminating the backlog for deficiencies in rural or special service transit services.

*Exhibit 7-15* shows the backlog according to asset type. Forty-five percent of the backlog under the replacement thresholds set by the "Maintain" scenario, or $12.2 billion, is estimated to be needed to replace vehicles; 18 percent, or $4.7 billion each, is estimated to be needed to replace stations and facilities; 15 percent, or $3.9 billion, is estimated to be needed to replace systems; and 5 percent, or $1.4 billion, is estimated to be needed to replace guideway. Under the thresholds set by the "Improve" scenario, 40 percent of the backlog, or $16.7 billion, is for stations and 36 percent, or $15.1 billion, is for vehicles.

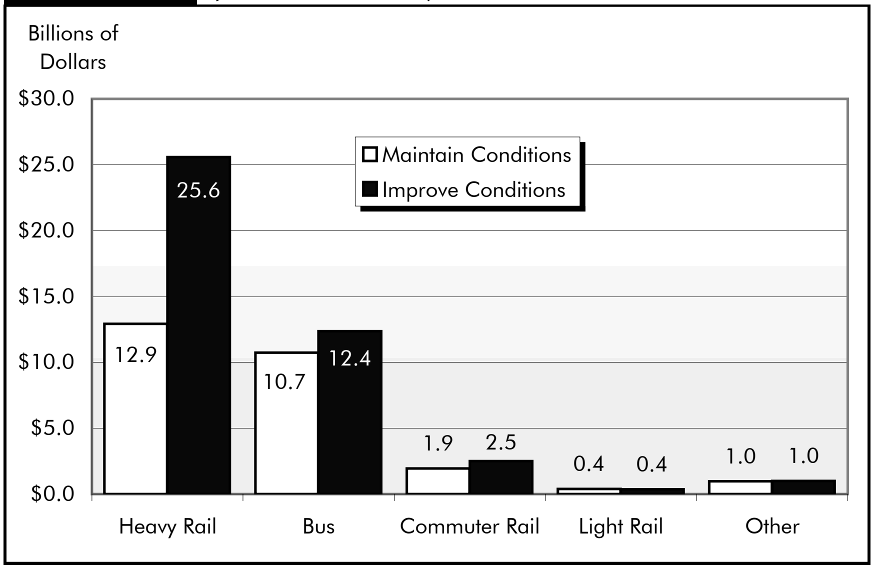
**Exhibit 7-15** *Estimated Backlog Transit Asset Type (Billions of Dollars)*




*Source: Transit Economic Requirements Model.*

The backlog by mode is provided in *Exhibit 7-16*. Eighty-five 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 $12.9 billion using replacement thresholds set by the "Maintain" scenario, and $25.6 billion using replacement thresholds set by the "Improve" scenario. The backlog for buses is estimated to be $10.7 billion using maintain thresholds and $12.4 billion using improve thresholds.

**Exhibit 7-16** *Estimated Backlog in 2002 by Transit Mode (Billions of Dollars)*




*Source: Transit Economic Requirements Model.*

# Summary of Revisions Since the Last Edition (2002) of this Report

In some cases, the amounts of capital investment requirements by asset type provided in Exhibits 7-10 and 7-11 have been considerably revised from the amounts presented in the 2002 edition of this report. As discussed earlier, these revisions are based on new data collected since the last edition of this report, including new asset inventory data provided by the NTD ACM and New York MTA. They also reflect updated information on rail asset costs, revisions to the benefit-cost analysis component of TERM, and revisions to projected PMT growth.

**Data**—As previously discussed, data collected by the ACM and from the New York MTA have led to more comprehensive transit asset coverage and improved asset condition estimates. Substantial revisions were also made to replacement cost estimates for rail assets based on information collected by two recent FTA studies, *Light Rail Transit Capital Cost Survey, October 2003,* and *Heavy Rail Transit Capital Cost Survey, June 2004,* which updated earlier studies undertaken in 1991 and 1994, respectively. Capital investment requirements are now based on asset replacement costs that are unique to each rail mode. Projected capital investment requirements in earlier editions of this report used the same asset replacement costs for commuter rail, light rail, and heavy rail assets because insufficient information was available on the costs for each mode.

The new FTA capital cost studies also found that rail construction costs have increased more rapidly than general construction costs since the 1991 and 1994 surveys, as a result of the increasing sophistication of rail systems. Prior editions of the C&P report relied heavily on the cost estimates for rail infrastructure gathered in the 1991 and 1994 studies, inflated to current dollars based on the Means Construction Index, a price index for general construction.

**Bus Decay Curve**—Engineering surveys of bus physical conditions, performed in 2001 and 2002, found that bus conditions decline slightly more rapidly during the first three years of life than previously estimated, and slightly less after age 15. This finding had virtually no impact on bus condition estimates.

**Q.** Could U.S. Federal Lands benefit from additional investment in transit?

**A.** 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 requirements on Federal Lands been estimated outside the scope of the TERM framework and are discussed in more detail in Chapter 20. In 2004, a joint FTA and FHWA study was completed, which estimated ATS on U.S. Forest Service (USFS) lands. The USFS is 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 ($687 million or $34.4 million in 2002 dollars 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 ($1.82 billion in 2002 dollars). Ninety-one percent of these needs were estimated to be required by the NPS, 7 percent by the USFWS, and 2 percent by BLM.

**Commuter Rail Decay Curve**—Engineering surveys of commuter rail vehicle physical conditions were performed in 2002. These surveys found that the conditions of commuter rail vehicles deteriorate considerably more rapidly in the first 5 years of their life, plateau between the ages of 5 and 22 years, and then decline again although very gradually. The fact that commuter rail vehicles are estimated to deteriorate more gradually in later years than previously estimated contributed to a decrease in rail vehicle investment requirements.

**Projected PMT**—Projected annual PMT growth has been reduced from an average annual rate of 1.6 percent to 1.5 percent, based on a survey of 76 agencies, compared with 33 agencies surveyed for the 2002 edition of this report. Projected PMT growth rates have decreased for most FTA regions since the last survey of PMT forecasts was made for the 2002 edition of this report, including those with the largest share of national PMT. This slight decrease in the projected demand for transit services exerted downward pressure on the amounts needed for asset expansion to maintain and improve performance. Projected PMT growth rates varied according to region, ranging from 0.95 to 3.15 percent.

**Speed Improvements**—The performance enhancement module of TERM was revised to shift investment in areas with populations of less than 1 million from regular bus modes to BRT in order to improve the speed of passenger travel. TERM previously increased speed in these areas by shifting investment from bus to light rail.

**Benefit-Cost Analysis**—The benefit-cost analysis component of TERM was revised by removing the imputation of fare box revenues as a benefit. Fare box revenues represent a transfer to transit agencies from another part of the economy and not a benefit. This revision exerted downward pressure on capital investment requirements for all rail and nonrail modes.

**Reclassification of System Design and Right-of-Way Acquisition Costs**—In the 2002 report, some costs for vehicles, stations, facilities and other "hard assets" were improperly reported as system design or right-of-way acquisition. These costs are now correctly allocated to the asset category to which they correspond. This revision has contributed to the larger investment requirements for each asset under the "Improve Performance" scenario than what was reported in the 2002 edition.

# CHAPTER 8

## Comparison of Spending and Investment Requirements

# Summary

This chapter compares the current spending for capital improvements described in Chapter 6 with the future investment requirement 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 investment requirements 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 requirement scenario and current spending is dependent on the investment requirement analysis and the underlying assumptions used to develop that analysis. Chapter 10 explores the impacts that varying some assumptions would have on the investment requirements.

*Exhibit 8-1* compares the difference between investment requirements and spending in this report with the corresponding difference based on the data shown in the 2002 C&P report. The first column of figures contains values shown in the 2002 C&P report, which compared 2000 spending with the average annual investment requirements for 2001 to 2020.

**Exhibit 8-1** *Highway, Bridge, and Transit Spending Versus Investment Requirements Compared with Data from the 2002 C&P Report*

| Percent by which Investment Requirements Exceed Current Spending | Based on 2000 Data | Based on 2002 Data |
|---|---|---|
| **Cost to Maintain** | | |
| Highways and Bridges | 17.5% | 8.3% |
| Transit | 63.8% | 26.8% |
| **Cost to Improve** | | |
| Highways and Bridges (Maximum Economic Investment Level) | 65.3% | 74.3% |
| Transit | 127.5% | 95.1% |

## Highways and Bridges

The average investment requirements estimated for the "Cost to Maintain Highways and Bridges" scenario in the 2002 C&P report were 17.5 percent ($11.2 billion) higher than highway capital expenditures in 2000. The estimated gap decreased to 8.3 percent ($5.7 billion) in 2002. The difference between the "Maximum Economic Investment level (Cost to Improve Highways and Bridges)" and 2002 spending is 74.3 percent ($50.7 billion). This represents an increase over the 65.3 percent gap estimated in the 2002 C&P report ($42.2 billion), based on the spending figures for 2000 presented in that report.

The changes in the size of the estimated gap between spending and investment requirements are largely the result of improvements in the modeling of highway performance (most notably the consideration of the impacts of highway operations strategies) and the cost of capital improvements. These changes have the effect of reducing the estimated level of investment required to reach a given level of performance, while increasing the cost of more expensive improvements that are nevertheless cost beneficial.

As discussed in Chapter 6, the preliminary figures for highway capital expenditures in 2000 reported in Highway Statistics 2000 and used in the 2002 C&P report were subsequently revised downward in Highway Statistics 2001. If the revised 2000 figures had been available at the time that the 2002 report was prepared, the gap between spending and investment requirements in that report would have been larger.

# Transit

The estimated gaps between current spending on transit capital investment and the investment required to Maintain" and "Improve" conditions and performance have declined since the 2002 report. These gaps declined principally because of a 35.8 percent increase in transit capital investment from 2000 to 2002, compared with an increase of 4.8 percent in the amount needed to maintain conditions and performance and an increase of 16.4 percent in the amount needed to improve conditions and performance (all in nominal terms). They also reflect lower projected ridership growth of 1.5 percent, compared with a projected 1.6 percent in 2002.

The Federal Transit Administration (FTA) estimates that an average of $15.6 billion annually is needed between 2003 and 2022 to maintain transit asset conditions and performance, or $3.3 billion (27 percent) more than actual spending in 2002; $24.0 billion annually is estimated to be needed to improve transit asset conditions and performance, or $11.7 billion (95.1 percent) more than actual spending in 2002. The FTA estimates for 2000 to 2020 provided in the 2002 report were 64 percent above actual capital spending in 2000 for the "Maintain Conditions and Performance" scenario and 127 percent above actual capital investment in 2000 for the "Improve Conditions and Performance" scenario.

Required capital investment in vehicles to maintain conditions and performance is estimated to be $6.9 billion annually, 68 percent more than actual expenditures in 2002; required capital investment in vehicles to improve conditions and performance is estimated to be $9.3 billion annually, or 127 percent more than actual expenditures of $4.1 billion in 2002. Required capital investment in nonvehicle transit infrastructure to maintain conditions and performance is estimated to be $8.7 billion annually, or 6 percent more than actual expenditures of $8.2 billion in 2002; required capital investment in nonvehicle transit infrastructure to improve conditions and performance is estimated to be $14.7 annually, or 79 percent more than actual expenditures in 2002.

# Highway and Bridge Spending Versus Investment Requirements

This section compares the average annual investment requirements estimated in Chapter 7 with the 2002 highway and bridge capital spending outlined in Chapter 6. As noted in Chapter 7, it is important to consider the relationship between the future funding gaps identified in this chapter and the parameters used in the Highway Economic Requirements System (HERS) and National Bridge Investment Analysis System (NBIAS) models. In particular, if the sample section travel growth projections reported in the Highway Performance Monitoring System (HPMS) do not accurately reflect travel that would occur at a constant level of system performance as was assumed in this analysis, and instead implicitly reflect a deteriorating level of performance, then the funding gap would be larger. If an unexpected demographic or economic shift occurs that reduces the level of travel that would occur at a constant level of service, then the reverse would be true. The specific impacts that changes in the vehicle miles traveled (VMT) growth projections and other key parameters would have on the investment requirement estimates are discussed in Chapter 10.

**Q.** **Does this report recommend any specific level of investment?**

**A.** No. The analysis of investment requirements in this report is intended to estimate what the consequences may be of various levels of spending on highway system performance. The comparisons in this chapter between current spending and the highway and bridge investment requirement scenarios are intended to be illustrative only. They are not intended to endorse any of the investment requirement scenarios as the "correct" level of transportation investment.

## Average Annual Investment Requirements Versus 2002 Spending

*Exhibit 8-2* compares the average annual investment requirements under the "Cost to Maintain" and "Maximum Economic Investment" scenarios [*see Chapter 7*] with 2002 highway and bridge capital expenditures. The average annual "Cost to Maintain Highways and Bridges" projected for the 2003 to 2022 period is $5.7 billion (8.3 percent) higher than 2002 capital expenditures, while the estimated "Maximum Economic Investment for Highways and Bridges" exceeds current spending by $50.7 billion (74.3 percent). Expenditures for bridge preservation in 2002 exceeded the corresponding component of the "Cost to Maintain" scenario, which is drawn from the "Maintain Economic Backlog" scenario in NBIAS [*see Chapter 7*].

While the "gap" between 2002 highway preservation spending and the "Cost to Maintain" scenario is the largest shown, this does **not** indicate that current investment is inadequate to maintain pavement conditions. As noted in Chapter 7, the 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 highway 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.

**Exhibit 8-2** *Average Annual Investment Requirements Versus 2002 Capital Outlay*

| | 2002 Capital Outlay ($Billions) | Investment Requirements (Billions of 2002 Dollars) | | | |
|---|---|---|---|---|---|
| | | Cost to Maintain | Percent Difference | Maximum Economic Investment | Percent Difference |
| Highway Preservation | $24.5 | $31.1 | 26.5% | $43.2 | 76.0% |
| Bridge Preservation | $11.3 | $8.9 | -21.0% | $12.5 | 10.8% |
| System Expansion | $26.5 | $27.5 | 3.9% | $52.9 | 99.9% |
| System Enhancements | $5.9 | $6.4 | 8.3% | $10.2 | 74.3% |
| **Total** | **$68.2** | **$73.8** | **8.3%** | **$118.9** | **74.3%** |

# Types of Improvements

*Exhibit 8-3* compares the distribution of highway and bridge capital outlay by improvement type for the "Maximum Economic Investment for Highways and Bridges" and the "Cost to Maintain Highways and Bridges" with the actual pattern of capital expenditures in 2002. In that year, 38.8 percent of highway and bridge capital outlay went for system expansion. The distribution of funding by investment type suggested by the investment requirement scenarios developed using the HERS and NBIAS models depends on the level of available funding. For the "Cost to Maintain Highways and Bridges," 37.2 percent of the projected 20-year investment requirements is for system expansion, slightly lower than its share of current capital spending. However, 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, 44.5 percent of the total investment requirements is for system expansion.

**Q.** How does the improvement mix for the investment scenarios in this report compare with those in the 2002 C&P?

**A.** The investment scenarios in this report are more heavily weighted toward preservation relative to capacity improvements than in the previous report. This is due largely to the key model revisions discussed in Chapter 7 and Appendix A, including the consideration of highway operations improvements and their impact on performance, updated modeling of pavement deterioration and estimated unit costs of the different types of capital improvements, and the introduction of work zone delay into the evaluation of alternative improvements. These changes all have the effect of making traditional highway capacity improvements relatively less attractive on benefit-cost grounds.

**Exhibit 8-3** *Highways and Bridges Investment Requirements and 2002 Capital Outlay, Percentage by Improvement Type*

| | System Preservation | | | System Expansion | System Enhance-ments | Total |
|---|---|---|---|---|---|---|
| | Highway | Bridge | Total | | | |
| Maximum Economic Investment for Highways and Bridges | 36.4% | 10.5% | 46.9% | 44.5% | 8.6% | 100.0% |
| Cost to Maintain Highways and Bridges | 42.1% | 12.1% | 54.1% | 37.2% | 8.6% | 100.0% |
| 2002 Capital Outlay | 36.0% | 16.5% | 52.6% | 38.8% | 8.6% | 100.0% |

As discussed in Chapter 7, investment requirements for nonmodeled 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 enhancements, the percentages for the "Maximum Economic Investment for Highways and Bridges" and for the "Cost to Maintain Highways and Bridges" were set at 8.6 percent to match the percentage of expenditures in 2002.

## Comparison with Previous Reports

*Exhibit 8-4* compares the estimated differences between current spending and average annual investment requirements for this and the 1997, 1999, and 2002 C&P reports.

The percentage difference between current spending and the "Cost to Maintain Highways and Bridges" is approximately half that in the 2002 report. As shown in Exhibit 8-4, the 2002 C&P report estimated that average annual investment requirements were 17.5 percent above current spending. Estimates of the gap based on the 1999 and 1997 reports were in a similar range.

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 fell to 92.9 percent in the 1999 C&P report and 65.3 percent in 2002 report, but has rebounded slightly in this report.

**Q.** How do changes in the "funding gap" since the 1997 report relate to changes in highway capital expenditures over that time?

**A.** The "Cost to Maintain" gap has decreased from 21.0 percent (based on 1995 data) to 8.3 percent (based on 2002 data), while the "Cost to Improve" gap has decreased from 108.9 percent to 74.3 percent. From 1995 to 2002, constant dollar highway capital outlays increased by 27.0 percent.

**Q.** What options are available to reduce the "funding gaps" cited in this chapter?

**A.** As previously noted, this report does not endorse any of the investment requirement 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 and certain innovative finance programs 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.

While 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 future investment requirements, it is important to note that this 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), rather than replacing them. Ongoing research described in the "Pricing" section of Part V of this report suggests that, if congestion pricing were adopted on a universal basis, the revenue generated would be sufficient to easily eliminate the gap between current spending and the "Cost to Maintain" scenario and to begin to address the "Maximum Economic Investment" scenario, assuming the proceeds from these tolls were used to increase highway capital expenditures.

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.

**Exhibit 8-4** *Average Annual Investment Requirements Versus Current Spending—1997, 1999, 2002, and 2004 C&P Reports*

| Report Year | Relevant Comparison | Percent Above Current Spending: Cost to Maintain Highways & Bridges (Low Scenario*) | Percent Above Current Spending: Cost to Improve Highways & Bridges (High Scenario*) |
|---|---|---|---|
| 1997 | Average annual investment requirements for 1996–2015 compared with 1995 spending | 21.0% | 108.9% |
| 1999 | Average annual investment requirements for 1998–2017 compared with 1997 spending | 16.3% | 92.9% |
| 2002 | Average annual investment requirements for 2001–2020 compared with 2000 spending | 17.5% | 65.3% |
| 2004 | Average annual investment requirements for 2003–2022 compared with 2002 spending | 8.3% | 74.3% |

* The investment requirement scenarios are not fully consistent between reports. See Chapter 7 and Appendix A.

As noted in Chapter 6, preliminary figures for 2000 highway capital shown in the 2002 C&P report were subsequently revised downward by approximately 5 percent. As a result, the gap between estimated investment requirements and funding for that year under either investment scenario would have been higher than what was reported.

# Transit Capital Spending Compared with Investment Requirements

## 2002 Capital Spending and Estimated Average Annual Investment Requirements

**Total Capital Spending**—In 2002, total capital investment in transit by Federal, State, and local governments was $12.3 billion, about 25 percent less than the amount estimated by the Federal Transit Administration (FTA) to be needed to maintain condition and performance annually between 2003 and 2022. FTA estimates that an additional investment of $3.3 billion annually (26.8 percent more than actual capital investment in 2002) would be required to maintain conditions and performance, and an additional annual investment of $11.7 billion annually (95.1 percent more than actual capital investment in 2002) would be required to improve conditions and performance *[Exhibit 8-5].* These estimates are based on TERM (Transit Economic Requirements Model).

**Exhibit 8-5** *2002 Transit Capital Expenditures Versus Estimated Average Annual Investment Requirements*

| (Billions of 2002 Dollars) | | Average Annual Requirements Minus Actual Expenditures in 2002 | Average Annual Requirements Percent Above Actual Expenditures in 2002 |
|---|---|---|---|
| **Actual 2002 Capital Expenditures** | $12.3 | | |
| **Estimated Annual Average Requirements 2003–2022** | | | |
| **Costs to:** | | | |
| Maintain Conditions & Performance | $15.6 | $3.3 | 26.8% |
| Improve Conditions & Maintain Performance | $17.1 | $4.8 | 39.0% |
| Maintain Conditions & Improve Performance | $22.5 | $10.2 | 82.9% |
| Improve Conditions & Performance | $24.0 | $11.7 | 95.1% |

*Sources: National Transit Database (NTD), Transit Economic Requirements Model (TERM) and FTA staff estimates.*

**Capital Spending by Asset Type**—In 2002, $4.1 billion was invested in transit vehicles and $8.2 billion in nonvehicle transit infrastructure, i.e., facilities, guideway elements, stations, and systems *[Exhibits 8-6* and *8-7].*

**Capital Spending on Vehicles**—The average annual amount estimated by TERM to be required to maintain the conditions and performance of the Nation's transit vehicle assets between 2003 and 2022 is $6.9 billion annually, 68 percent above the actual spending of $4.1 billion in 2002. The average annual amount estimated to be required to improve the conditions and performance of the Nation's transit vehicle assets is $9.3 billion annually, 127 percent above the 2002 amount.

The entire bus fleet will need to be replaced at least once during the period 2003 to 2022, in spite of a reduction in the number of overage bus vehicles since 2000. In 2002, approximately 16,500 buses were overage compared with 16,200 in 2000. The decline in the number of overage buses has resulted largely from a decline in the number of overage and full-size and articulated buses. Large and medium-sized buses have an expected life of 15 to 16 years (and a minimum of age of 12 years before they can be replaced with

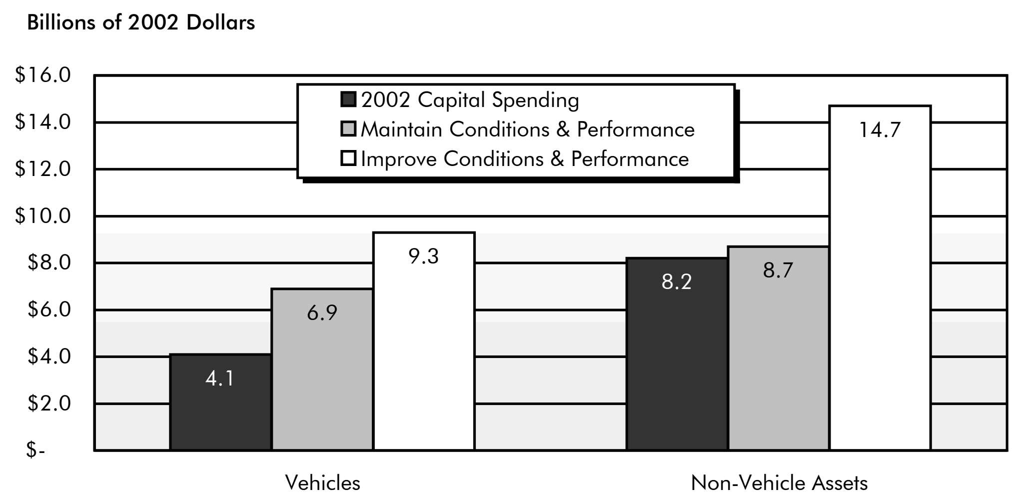
**Exhibit 8-6** *Average Annual Transit Investment Requirements Versus 2002 Capital Spending by Asset Type*

| | Vehicles | | | Nonvehicle Assets | | |
|---|---|---|---|---|---|---|
| | Billions of 2002 Dollars | Percent Above Actual Spending | Percent of Total Capital Spending Requirements [1] | Billions of 2002 Dollars | Percent Above Actual Spending | Percent of Total Capital Spending Requirements [1] |
| **2002 Capital Spending** | **$4.1** | | **31%** | **$8.2** | | **69%** |
| Costs to | | | | | | |
| Maintain Conditions & Performance | $6.9 | 68% | 42% | $8.7 | 6% | 58% |
| Improve Conditions & Performance | $9.3 | 127% | 39% | $14.7 | 79% | 61% |

[1] Percent of total 2002 capital spending/ percent of total investment requirements to Maintain and Improve Conditions and Performance.

*Source: Transit Economic Requirements Model and FTA staff estimates.*

**Exhibit 8-7** *Comparison of 2002 Transit Capital Spending with Average Annual Investment Requirements*




*Source: Transit Economic Requirements Model and FTA staff estimates.*

FTA funds), and small buses and vans have an expected life of 7 to 10 years (and a minimum age of 7 years before they can be replaced with FTA funds). The current average ages of these vehicles range from 7 to 8 years for larger buses and 3 to 4 1/2 years for smaller buses and vans.

With an average life expectancy of 25 to 30 years, a large proportion of the existing rail fleet will also need to be replaced between 2003 and 2022. The current average age for the nation's rail vehicles is 16 years for light rail vehicles, 20 years for heavy rail vehicles, and between 17 and 27 years for commuter rail vehicles, depending on the type. The number of overage rail vehicles increased from approximately 6,780 in 2000 to 6,980 in 2002. In 2002, 68 percent of commuter rail self-propelled passenger coaches, 36 percent of heavy rail vehicles, and 34 percent of commuter rail passenger coaches were overage, compared with 61 percent of commuter rail vehicles, 40 percent of heavy rail vehicles, and 29 percent of commuter rail passenger coaches in 2000.

In addition to rehabilitating and replacing existing bus and rail vehicles, the annual investment requirement for vehicles also 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 almost 42,000 vehicles from 2002 to 2022, approximately 45 percent. The investment required to improve service performance would expand the 2002 bus fleet by an additional 24,000 vehicles, or 24 percent. Similarly, expansion to serve projected growth in rail passengers would require close to 5,000 additional vehicles for the period 2002 to 2022, an increase of roughly 26 percent. To improve rail service would require about 4,500 additional vehicles, an increase of 25 percent. Given the life cycle needs of each vehicle type, 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 2022. Each of these capital investment needs is included in the overall vehicle needs estimates.

**Capital Spending on Nonvehicle Infrastructure**—The annual amount estimated by TERM to be needed to maintain the conditions and performance of the Nation's nonvehicle transit infrastructure is $8.7 billion annually, 6 percent more than actual expenditures of $8.2 billion in 2002. The annual amount estimated to be needed to improve the conditions and performance of nonvehicle assets is $14.7 billion, 79 percent above actual expenditures in 2002. As discussed in Chapter 3, 20 percent of all rail maintenance facilities, 20 percent of all yards, 6 percent of all substations, 19 percent of all overhead wire, 14 percent of third rail, 15 percent of track, 9 percent of elevated structures, 17 percent of underground tunnels, and 56 percent of stations are estimated to be in poor or substandard condition. As discussed in Chapter 7, 31 percent of the nonvehicle investment estimated to be needed to maintain conditions and performance is for guideway elements (elevated structures [bridges, tunnels, and track]), approximately 22 percent is for maintenance facilities, 21 percent is for stations, and 15 percent is for systems. The remaining 11 percent is estimated to be for other project costs. The distribution of these amounts changes under the improve conditions and performance scenario. Thirty percent of the nonvehicle investment required to improve conditions and performance is estimated to be for guideway elements, 15 percent for maintenance facilities, 22 percent for stations, and 10 percent for systems. The remaining 21 percent is estimated to be for other project costs. As with the vehicle investment, the investment in nonvehicle transit infrastructure includes rehabilitation and replacement of existing assets; expansion investment to meet growth in the demand for transit services; and, for the performance improvement scenario, investment to improve operating speeds and capacity.

# Comparison with Previous Reports

*Exhibit 8-8* compares the percentage difference between current spending levels and investment requirements in 2002 with the percentage differences provided in the 1995, 1997, 1999, and 2002 C&P reports. As a result of methodological improvements, estimated investment requirements are not directly comparable from year to year. The estimated annual amount of investment required to maintain conditions and performance between 2003 and 2022 is 26 percent higher than actual capital expenditures in 2002. This compares with an estimated annual investment requirement ranging from 38 to 64 percent more than actual spending in earlier editions of the report. The decrease in the difference between estimated requirements and actual expenditures reflects a 16.5 percent average annual growth in transit capital expenditures between 2000 and 2002 from $9.1 to $12.3 billion, a lower ridership growth forecast of 1.5 percent compared with 1.6 percent in the 2002 report, and the application of a more rigorous benefit-cost test to identify future investments. A detailed account of the changes in investment requirements is provided in Chapter 7.

**Exhibit 8-8** *Average Annual Transit Investment Requirements Versus Current Spending—1995, 1997, 1999, 2002, and 2004 C&P Reports*

| Report Year | Spending Year | Investment Requirement Forecast Years | Percent Above Current Spending: Cost to Maintain Conditions and Performance | Percent Above Current Spending: 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% |

*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 preservation backlog. The impacts on condition 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 2000 and 2002 have been sufficient to maintain conditions and performance, although increases in funding will be needed to maintain an expanded transit infrastructure and meet projected ridership demand. The chapter examines the impact of limiting rehabilitation and replacement expenditures to less than the amounts estimated to be required 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 preservation 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 preservation investments from NBIAS were interpolated from the two NBIAS investment scenarios and current bridge preservation spending levels.

## 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 2002 by 41.0 percent, from $48.4 billion to $68.2 billion. This equates to a 24.5 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 preservation rose from 47.6 percent in 1997 to 52.6 percent in 2002. The combined result of this increase in total capital investment and the shift in the types of investments being made was a 56 percent increase in spending on system preservation, from $23.0 billion to $35.8 billion. As indicated in Chapter 6, the term "system preservation" is used in this report to describe capital improvement on existing roads and bridges intended to preserve the existing pavement and bridge infrastructure.

The percentage of capital outlay used for system expansion fell from 44.4 percent in 1997 to 38.8 percent in 2002. Spending for system expansion grew more slowly than that for system preservation over this period, rising 23 percent from $21.5 billion dollars in 1997 to $26.5 billion in 2002.

### *Physical Conditions*

The improved highway and bridge conditions reported in Chapter 3 reflect the effects of the increased investment in system preservation noted above. The share of vehicle miles traveled (VMT) on the National Highway System routes with "acceptable" ride quality increased from 89.1 percent to 90.6 percent from 1997 to 2002. Acceptable miles on Interstate highways in urbanized areas rose from 90.0 percent to 91.7 percent over this period. The percent of urbanized Interstates meeting the stricter criteria for "good" ride quality increased from 39.3 percent to 48.7 percent over this same period. While pavement conditions

**Q.** Are the recent trends in condition and performance consistent with the gap identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges?

**A.** 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 required 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.

While there has been an increase in the number of miles of acceptable pavement on the National Highway System and the Interstate System, the positive impacts on highway users of improved ride quality on these systems are outweighed by the negative impacts on drivers of increasing congestion.

As indicated in Chapter 8, spending on bridge preservation has exceeded the investment requirements 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.

declined on some of the lower-ordered functional systems, the overall percentage of road miles with good ride quality rose from 42.8 percent to 46.6 percent between 1997 and 2002. The percent of deficient bridges decreased from 1998 to 2002, falling from 29.6 percent to 27.5 percent.

### *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 2002. The Percent of Travel Under Congested Conditions increased from 27.4 percent to 30.4 percent from 1997 to 2002, while the Percent Additional Travel Time increased from 30 percent to 37 percent. The Average Annual Hours of Traveler Delay in urbanized areas increased from 19.4 hours to 23.8 hours between 1997 and 2002. 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 five years before 1999.

## 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. The third column, 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 ($118.9 billion annually), the average pavement quality would improve by 16.5 percent, while the percentage of VMT on pavement rated as adequate or better would rise from 84.9 percent to 92.6 percent. At the Cost to Maintain level, average IRI would decrease by 7.0 percent, and the VMT percentage on good pavement would increase from 44.8 percent to 54.3 percent.

Exhibit 9-1 also shows projections of pavement quality at other funding levels, including the actual 2002 capital outlay level. If highway spending would be held at 2002 levels (in constant dollars), increasing only with inflation, average IRI would be projected to decrease by 2.7 percent if improvements were implemented in the manner recommended by HERS. The percentage of VMT on roads with good pavement would

**Exhibit 9-1** *Projected Changes in 2022 Highway Physical Conditions Compared with 2002 Levels for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 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 [1] | | IRI<95 | IRI<170 | Funding Level Description |
| | | | 44.8% | 84.9% | 2002 Values |
| **$118.9** | $81.2 | -16.5% | 60.9% | 92.6% | Maximum Economic Investment scenario |
| $110.2 | $75.1 | -16.4% | 61.7% | 92.1% | |
| $103.2 | $70.1 | -15.3% | 61.0% | 91.4% | |
| $96.1 | $65.1 | -13.9% | 59.9% | 90.6% | |
| $89.1 | $60.1 | -12.0% | 58.4% | 89.6% | |
| $79.8 | $53.5 | -9.1% | 56.2% | 88.1% | |
| **$73.8** | $49.3 | -6.8% | 54.3% | 86.8% | Cost to Maintain scenario |
| $70.3 | $45.1 | -4.5% | 52.6% | 85.5% | |
| **$68.2** | $42.4 | -2.7% | 51.2% | 84.5% | Actual 2002 Capital Outlay |

*Source: Highway Economic Requirements System.*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

increase to 51.2 percent, while the percentage on adequate pavement would be virtually unchanged. Such results are consistent with the recent improvements in pavement quality brought on by increased spending noted above. Note, however, that these values from HERS assume a slightly higher share of capital spending being devoted to preservation improvement than is currently the case.

# 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) [*see Chapter 7*]. Exhibit 9-2 indicates that an average annual investment of $79.8 billion would be sufficient to maintain average highway speeds at their 2002 level of 42.2 miles per hour. This dollar amount is higher than the amount identified as the Cost to Maintain Highways and Bridges, at which investment level average speed would drop by 0.7 miles per hour. At the Maximum Economic Investment level of spending, average speeds would increase to 43.1 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 2002 highway spending levels were maintained through 2022, the percentage of VMT on congested roads would be projected to increase from 23.8 percent to 36.8 percent, while the percentage on severely congested roads would increase from 13.7 percent to 19.7 percent. The percentage of VMT on congested roads would be projected to increase (to 31.4 percent) even at the Maximum Economic Investment level of investment, while the percentage of VMT on severely congested roads would decline slightly.

**Exhibit 9-2** *Projected Changes in 2022 Highway Performance Compared with 2002 Levels for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 Dollars) | | Average Speed (mph) | Impact of HERS-Derived Investment on Roads Modeled in HERS | | |
|---|---|---|---|---|---|
| | | | Percent of VMT on Roads with | | |
| Total | HERS-Derived Component [1] | | V/SF>.80 | V/SF>.95 | Funding Level Description |
| | | 42.2 | 23.8% | 13.7% | 2002 Values |
| **$118.9** | $81.2 | 43.1 | 31.4% | 13.3% | Maximum Economic Investment scenario |
| $110.2 | $75.1 | 43.0 | 32.1% | 14.0% | |
| $103.2 | $70.1 | 42.8 | 32.6% | 14.5% | |
| $96.1 | $65.1 | 42.6 | 33.2% | 15.2% | |
| $89.1 | $60.1 | 42.4 | 34.1% | 16.2% | |
| **$79.8** | $53.5 | **42.2** | 35.1% | 17.4% | **Average Speed Maintained** |
| **$73.8** | $49.3 | 41.9 | 35.8% | 18.3% | Cost to Maintain scenario |
| $70.3 | $45.1 | 41.7 | 36.3% | 19.2% | |
| **$68.2** | $42.4 | 41.5 | 36.8% | 19.7% | Actual 2002 Capital Outlay |

*Source: Highway Economic Requirements System.*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

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 9-3 shows how the HERS projections of average delay per VMT would change at different funding levels, as well as separate projections for congestion delay and incident delay. The HERS calculates these values as part of its determination of average speed and travel time costs (see the 2002 edition of the C&P report for a more complete description). At current spending levels, average total delay per VMT would be projected to increase by 9.2 percent, while spending at the Maintain Highways and Bridges level would result in an increase of 6.6 percent. If all cost-beneficial improvements were implemented, then average total delay would be projected to decline slightly, by 1.0 percent.

The impacts on congestion delay and incident delay at various funding levels differ significantly. Congestion delay would be projected to increase by 7.4 percent even at the Maximum Economic Investment level, with larger decreases at lower investment levels, reaching 23.4 percent at the Maintain Current Spending level. Incident delay, however, would be projected to decrease significantly at this higher investment level, by 15.7 percent, and would increase slightly only at the lower levels. At the Cost to Maintain level, congestion delay would be projected to increase 19.2 percent, while incident delay would decrease by 2.3 percent.

**Exhibit 9-3** *Projected Changes in 2022 Highway Performance Compared with 2002 Levels for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 Dollars) | | Impact of HERS-Derived Investment on Roads Modeled in HERS | | | |
|---|---|---|---|---|---|
| | | Percent Change in | | | |
| Total | HERS-Derived Component [1] | Total Delay per VMT | Congestion Delay per VMT | Incident Delay per VMT | Funding Level Description |
| **$118.9** | $81.2 | -1.0% | 7.4% | -15.7% | Maximum Economic Investment scenario |
| $110.2 | $75.1 | 0.2% | 9.3% | -13.5% | |
| $103.2 | $70.1 | 1.5% | 11.0% | -11.1% | |
| $96.1 | $65.1 | 2.5% | 12.8% | -9.3% | |
| $89.1 | $60.1 | 3.7% | 14.8% | -7.5% | |
| $79.8 | $53.5 | 5.4% | 17.3% | -4.2% | |
| **$73.8** | $49.3 | 6.6% | 19.2% | -2.3% | Cost to Maintain scenario |
| $70.3 | $45.1 | 8.2% | 21.8% | 0.1% | |
| **$68.2** | $42.4 | 9.2% | 23.4% | 1.8% | Actual 2002 Capital Outlay |

*Source: Highway Economic Requirements System.*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

The divergent results for projected congestion and incident delay reflect differences in the impact that highway investment has on these two types of delay in the procedures used by the HERS model. The additional travel projected to occur over the next 20 years is likely to increase recurring congestion delay, even with significant investments in new capacity. However, 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 owing to incidents, making it possible to reduce average incident delay per VMT.

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.

# Impact of Investment on Different Types of 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 2002 levels. The analysis presented there estimates that an average annual investment of $73.8 billion would be required to maintain highway user costs at their baseline 2002 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 $73.8 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would rise by 0.6 percent, whereas average vehicle operating costs would fall by 0.7 percent. The 2002 capital investment level of $68.2 billion would be sufficient to maintain vehicle operating costs. Travel time costs would be maintained or decreased only if average annual investment exceeded $79.8 billion for highways and bridges.

**Exhibit 9-4** *Projected Changes in 2022 Highway User Costs Compared with 2002 Levels for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 Dollars) | | Impact of HERS-Derived Investment on Roads Modeled in HERS | | | |
|---|---|---|---|---|---|
| | | Percent Change in | | | |
| Total | HERS-Derived Component [1] | Total User Costs | Travel Time Costs | Vehicle Operating Costs | Funding Level Description |
| **$118.9** | $81.2 | -2.1% | -2.6% | -2.2% | Maximum Economic Investment scenario |
| $110.2 | $75.1 | -1.9% | -2.1% | -2.1% | |
| $103.2 | $70.1 | -1.5% | -1.6% | -1.9% | |
| $96.1 | $65.1 | -1.2% | -1.2% | -1.7% | |
| $89.1 | $60.1 | -0.9% | -0.7% | -1.4% | |
| $79.8 | $53.5 | -0.4% | 0.0% | -1.0% | |
| **$73.8** | $49.3 | **0.0%** | 0.6% | -0.7% | **Cost to Maintain scenario** |
| $70.3 | $45.1 | 0.5% | 1.3% | -0.3% | |
| **$68.2** | $42.4 | 0.8% | 1.7% | 0.0% | Actual 2002 Capital Outlay |

*Source: Highway Economic Requirements System.*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

**Q.** What is the significance of the relatively small changes in user costs presented here?

**A.** 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. A 1 percent change would thus correspond to roughly $20 billion in estimated total user costs at current traffic levels.

Estimates of total user costs vary at different levels of future investment, rising by nearly 1 percent at the current spending level and falling 2.1 percent at the maximum economic level of investment. Travel time costs show slightly greater variation, ranging from a 1.7 percent increase at current funding levels to a 2.6 percent decrease at the Maximum Economic Investment level.

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.

# Impact of Investment Levels on Future Travel Growth

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 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.

**Q. Do the travel demand elasticity features in HERS differentiate between the components of user costs based on how accurately highway users perceive them?**

**A.** No. The model assumes that comparable reductions or increases in travel time costs, vehicle operating costs, or crash costs would have the same effect on future VMT. The elasticity values in HERS were developed from studies relating actual costs to observed behavior; these studies did not explicitly consider perceived 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.

Future pavement and widening improvements would tend to reduce highway user costs and induce additional travel. 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.

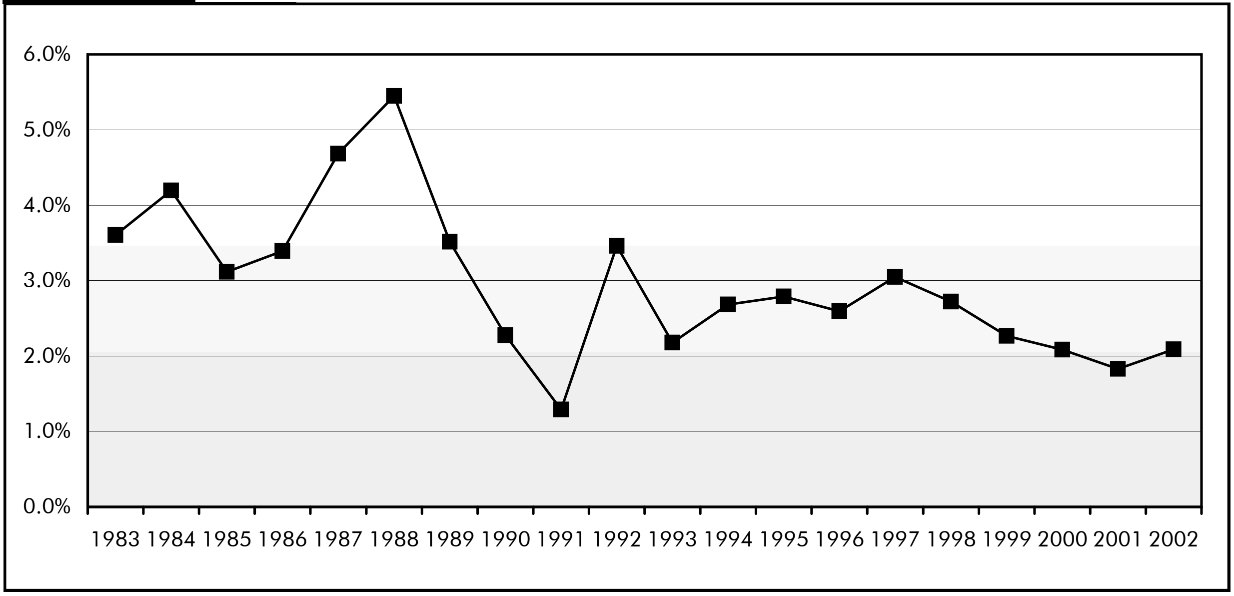
One implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. The higher the overall investment level, the higher the projected travel will be. Another implication is that any external projection of future VMT growth will be valid only for a single level of investment in HERS. Thus, the State-supplied 20-year growth forecasts in the Highway Performance Monitoring System (HPMS) 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 very similar to the baseline growth rate implicit in the HPMS data.

## *Historic Travel Growth*

*Exhibit 9-5* shows annual VMT growth rates for the 20-year period from 1982 to 2002. The average annual VMT growth rate over this period was 2.96 percent. Travel growth has varied somewhat from year to year, ranging from a high of 5.45 percent in 1988 to a low of 1.29 percent in 1991. Highway travel growth is typically 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 1990–1991 and 2000–2002, while annual VMT growth was higher than 3 percent in every year from 1983 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, 1982–2002*




*Source: Highway Performance Monitoring System.*

## *Projected Travel Growth*

*Exhibit 9-6* 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.

Based on the baseline future travel forecasts in HPMS, the weighted average annual growth rate for all sample sections is 2.07 percent. Projected growth in rural areas (2.29 percent average annual) is somewhat larger than in urban areas (1.93 percent).

If average annual highway and bridge capital outlay rose to $73.8 billion in constant 2002 dollars, HERS predicts that overall highway user costs in 2022 would remain at 2002 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. In this particular analysis, the resulting average annual VMT growth rates in urban areas and in the Nation as a whole at this level of investment are slightly higher than those derived from the baseline HPMS data, while rural VMT growth rates would be just slightly lower than the baseline.

Implementing all of the cost-beneficial highway investments in the $118.9 billion Maximum Economic Investment scenario would reduce user costs, resulting in higher travel growth rates than currently projected in HPMS, because of the travel demand elasticity features in HERS. Total VMT would grow at an average annual rate of 2.21 percent, while rural and urban VMT would grow at 2.34 and 2.12 percent, respectively. Note, however, that even these elevated levels are well below the average annual growth rates experienced over the last 20 years.

In 2002, all levels of government spent $68.2 billion for highway capital outlay, corresponding to the "Maintain Current Spending" row in Exhibit 9-6. 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 urban VMT growth to 2.05 percent, below the baseline forecasts in HPMS.

**Exhibit 9-6** *Projected Average Annual VMT Growth Rates, 2003–2022, for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 Dollars) | | Impact of HERS-Derived Investment on Roads Modeled in HERS | | | |
|---|---|---|---|---|---|
| | | Average Annual VMT Growth | | | |
| Total | HERS-Derived Component [1] | Total | Rural | Urban | Funding Level Description |
| | | **2.07%** | **2.29%** | **1.93%** | **HPMS Baseline VMT Projection** |
| **$118.9** | $81.2 | 2.21% | 2.34% | 2.12% | Maximum Economic Investment scenario |
| $110.2 | $75.1 | 2.19% | 2.33% | 2.09% | |
| $103.2 | $70.1 | 2.17% | 2.33% | 2.07% | |
| $96.1 | $65.1 | 2.15% | 2.32% | 2.05% | |
| $89.1 | $60.1 | 2.14% | 2.31% | 2.03% | |
| $79.8 | $53.5 | 2.11% | 2.30% | 1.99% | |
| **$73.8** | $49.3 | 2.09% | 2.28% | 1.97% | Cost to Maintain scenario |
| $70.3 | $45.1 | 2.07% | 2.27% | 1.94% | |
| **$68.2** | $42.4 | 2.05% | 2.26% | 1.92% | Actual 2002 Capital Outlay |

*Source: Highway Economic Requirements System.*

[1] The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

The future travel growth projections in HPMS indicate future levels of VMT, but provide no information as to how travel will grow year by year within the 20-year forecast period. As discussed in Chapter 7, the HERS model assumes that VMT growth will be linear (growing by a constant amount annually rather than at a constant rate), implying that rates will gradually decline over the forecast period. *Exhibit 9-7* shows projected year-by-year VMT derived from HERS under this assumption for three different funding levels. If average annual investment were to reach the Maximum Economic Investment level, VMT would be expected to grow to 4.44 trillion in 2022. If average annual investment remains at 2002 levels in constant dollar terms, VMT would grow to only 4.31 trillion, while VMT growth at the Cost to Maintain level of investment would reach 4.35 trillion. Note that projected travel growth for each of these funding levels is well below the historic growth rate over the last 20 years.

# Impact of Investment on the Bridge Preservation Backlog

Chapter 7 projects that funding bridge investments at approximately $12.5 billion annually over a 20-year period would eliminate the existing backlog and correct other deficiencies that are expected to develop by 2022, 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 $8.9 billion annually would ensure that the cost of addressing all bridge deficiencies in 2022 would remain the same as in 2002. 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 $62.6 billion. If investment over the 20-year period were limited to $5.9 billion per year, the backlog would rise to $120.1 billion. If bridge investment were maintained at the 2002 funding level in constant dollars ($11.3 billion), the bridge backlog would be projected to decrease by 69.9 percent, to approximately $18.9 billion. However, it should be noted that 2002 appears to have been an unusually high year for bridge preservation spending; preliminary information available for 2003 suggests that bridge preservation spending is likely to decline relative to 2002.

**Exhibit 9-7** *Annual Projected Highway VMT at Different Funding Levels (VMT in Billions; Funding in Billions of 2002 Dollars)*

| Funding Level Description | Maximum Economic Investment | Cost to Maintain Highways and Bridges | Actual 2002 Capital Outlay |
|---|---|---|---|
| **Funding Level** | **$118.9** | **$73.8** | **$68.2** |
| **2002 (actual)** | **2,874** | **2,874** | **2,874** |
| 2003 | 2,953 | 2,947 | 2,946 |
| 2004 | 3,031 | 3,021 | 3,018 |
| 2005 | 3,110 | 3,095 | 3,090 |
| 2006 | 3,189 | 3,168 | 3,162 |
| 2007 | 3,267 | 3,242 | 3,234 |
| 2008 | 3,346 | 3,316 | 3,306 |
| 2009 | 3,425 | 3,389 | 3,378 |
| 2010 | 3,503 | 3,463 | 3,450 |
| 2011 | 3,582 | 3,537 | 3,522 |
| 2012 | 3,661 | 3,610 | 3,594 |
| 2013 | 3,739 | 3,684 | 3,665 |
| 2014 | 3,818 | 3,757 | 3,737 |
| 2015 | 3,897 | 3,831 | 3,809 |
| 2016 | 3,975 | 3,905 | 3,881 |
| 2017 | 4,054 | 3,978 | 3,953 |
| 2018 | 4,133 | 4,052 | 4,025 |
| 2019 | 4,211 | 4,126 | 4,097 |
| 2020 | 4,290 | 4,199 | 4,169 |
| 2021 | 4,369 | 4,273 | 4,241 |
| **2022** | **4,447** | **4,346** | **4,313** |

*Source: Highway Economic Requirements System.*

**Exhibit 9-8** *Projected Changes in 2022 Bridge Preservation Backlog Compared with 2002 Levels for Different Possible Funding Levels*

| Average Annual Investment (Billions of 2002 Dollars) | Backlog | Percent Change from 2002 | Funding Level Description |
|---|---|---|---|
| 12.5 | 0.0 | -100.0% | Maximum Economic Investment scenario |
| 11.3 | 18.9 | -69.9% | 2002 Bridge Preservation Spending |
| 10.5 | 32.0 | -48.9% | |
| 9.4 | 52.5 | -16.1% | |
| 8.9 | 62.6 | 0.0% | Maintain Economic Backlog |
| 8.2 | 74.4 | 18.9% | |
| 7.0 | 96.3 | 53.9% | |
| 5.9 | 120.1 | 92.0% | |

*Source: National Bridge Investment Analysis System.*

# Transit Investment Impacts

## Impacts of Transit Investment

Transit investment leads to improved transit access, an increase in ridership, improved air quality, and improved accessibility to jobs and other local resources.

For example, total transit investment from Federal, State, and local sources of $21.6 billion in 20 existing and proposed new starts projects under Full Funding Grant Agreements, with a proposed Federal share of $8.5 billion (39 percent), is expected to:

**Q.** How are the effects of New Starts projects on ridership, automobile use, travel time savings, and transit accessibility measured?

**A.** The methodology used to calculate these impacts is described in *Reporting Instructions for the Section 5309 New Starts Criteria,* FTA, April 2004. http://www.fta.dot.gov/documents/pt_I_FY07_NS_Reporting.pdf.

- Carry over 641,000 riders each day.
- Carry 194 million riders annually, of which approximately 74.2 million riders will have formerly used an automobile for their trip.
- Improve air quality by reducing 40 billion tons of $CO_2$ emissions annually;
- Save over 95 million hours of travel-time annually; and
- Provide fixed guideway access to an additional 721,300 households, of which 87,000 are low income. (Households with accessibility are assumed to be ½ mile or less from a transit station.)

If operating today, these projects would provide households with access to 9.3 million jobs located within ½ mile of the proposed transit stations.

## Impact of Investment on Conditions

### *Historical Investment and Rehabilitation and Replacement Needs*

As shown in *Exhibit 9-9,* current capital spending in urban areas reached its highest level relative to estimated rehabilitation and replacement needs in 2002 ($12.3 billion in spending compared with $10.3 billion estimated for rehabilitation and replacement), 19 percent higher than required. Since 1993, capital investment in transit assets has been equal to or slightly higher than the pure replacement and rehabilitation levels necessary to maintain conditions. Rehabilitation and replacement expenditures are always lower than total capital investment because a portion of the amount allocated to capital investment in each year is invested in new system capacity. Based on FTA's budgetary history, about half of FTA's capital assistance has been allocated to rehabilitation and replacement expenditures and about half has gone to asset expansion, which also contributes to higher average condition levels through the purchase of new assets.

**Maintain Conditions**—Funding levels between 2000 and 2002 have been adequate to maintain conditions. Total capital investment increased from $9.1 billion in 2000, to $10.8 billion in 2001, and $12.3 billion in 2002. Bus vehicle conditions improved, increasing from an average of 3.05 in 2000 to an average of 3.21 in 2002 (based on comparable vehicle categories as explained in the section on Bus Conditions on page 3-17). Over the same time period, the average age of a bus vehicle declined from 6.8 to 6.2 years. Average rail vehicle conditions improved from 3.38 in 2000 to 3.47 in 2002 and the average vehicle age declined from 21.8 to 20.4 years. The amount required to maintain transit asset conditions will continue to increase as the size of the transit infrastructure base increases.

**Exhibit 9-9** *Current Transit Capital Spending Levels Versus Rehabilitation and Replacement Needs, 1993–2002*

(Billions of Current Dollars)

| Analysis Year | Capital Spending | Estimated Replacement and Rehabilitation Needs |
|---|---|---|
| 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 |

**Maintain Performance**—Funding levels between 2000 and 2002 have been sufficient to maintain and slightly improve performance. (Performance improved because ridership did not grow as rapidly over this period as in earlier years.) There was a slight increase in the average speed of passengers traveling on transit between 2000 and 2002 from 19.9 to 20.1 miles per hour. The average speed of passenger travel on rail modes increased from 24.9 miles per hour in 2000 to 25.8 miles per hour in 2002; the average speed as experienced by passengers on bus modes was unchanged at 13.7 miles per hour. TERM estimates that for urban areas $5.3 billion annually will be needed to maintain current performance if PMT increases annually at the projected rate of 1.5 percent, or about 158 million new passengers per year.

## *Future Impacts of Constrained Rehabilitation and Replacement Expenditures*

*Exhibit 9-10* shows the effect on transit asset conditions of constraining rehabilitation and replacement expenditures below the level estimated by TERM (Transit Economic Requirements Model) to be required to maintain conditions. 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 TERM estimates the amount of investment required to make the average asset condition in 2022 the same as the average asset condition that existed on in 2002 for all assets combined. However, the condition of each asset category is slightly different in 2022 than in 2002. [TERM assumes investment will be made so that assets with relatively lower conditions in 2002 (e.g., stations) will have more improvement in conditions between 2002 and 2022, and that assets with relatively higher conditions in 2002 (e.g., guideway elements) will have a slight deterioration in conditions between 2002 and 2022.]

If the amount estimated to be needed to maintain conditions (rehabilitation and replacement expenses) in urban areas is reduced by 10 percent from $9.69 billion annually to $8.72 annually, TERM estimates that the average condition of transit assets would fall from 3.7 in 2002 to 3.6 in 2022. If the amount estimated to be need for rehabilitation and replacement expenses in urban areas is reduced by 30 percent to $6.78 billion, TERM estimates that average asset conditions would fall to 3.4 in 2022.

**Exhibit 9-10** *Effect of Capital Spending Constraints on Transit Condition Estimates*

| | 2002 Condition | Percent of Recommended Rehabilitation and Replacement Expenditures to Maintain Conditions | | | |
|---|---|---|---|---|---|
| **Asset Type** | | **100%** | **90%** | **80%** | **70%** |
| Guideway Elements | 4.3 | 4.0 | 3.9 | 3.9 | 3.9 |
| Facilities | 3.4 | 3.3 | 3.1 | 3.1 | 3.1 |
| Systems | 4.1 | 4.0 | 3.8 | 3.7 | 3.6 |
| Stations | 3.0 | 3.6 | 3.6 | 3.6 | 2.9 |
| Vehicles | 3.4 | 3.4 | 3.3 | 3.1 | 3.0 |
| **All Assets** | **3.7** | **3.7** | **3.6** | **3.5** | **3.4** |
| **Rehabiliation and Replacement Expenditure Scenarios** * | | $9.69 | $8.72 | $7.75 | $6.78 |

* *Excludes rural vehicles and facilities.*

## *Impact of Investment Levels on Future Transit Use (PMT Growth)*

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 comprised of out-of-pocket costs and travel-time costs. Travel time-savings are realized in two ways, 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.

**Q.** How responsive is transit ridership to changes in user costs?

**A.** Transit riders are not highly sensitive to changes in user costs. Research has shown that transit riders demand for transit services is "inelastic" and that the relationship between user costs and riders is an inverse one. This means that a one percent increase or decrease in transit user costs will lead to less than one percent decrease or increase, respectively, in the number of transit riders. The percentage change in ridership resulting by one percent change is user costs is know 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 for details.)

TERM estimates that $6.52 billion annually will be needed to improve performance in urban areas. Of this amount, $1.65 billion annually will be required for asset expansion in new rail or BRT service to increase speed and $4.87 billion annually for asset expansion in new vehicles to reduce occupancy levels. The average ridership estimated to result from speed improvements achieved by expanding or building new rail or BRT system capacity is 22.2 million passengers annually; the average annual ridership estimated to result from decreasing occupancy levels by adding new vehicles is 36.7 million passengers annually. (Note that total "Improve Performance" requirements are $6.6 billion annually. The additional investment required represents the cost of increasing the rural transit fleet by 3.5 percent per year.)

# CHAPTER 10

## Sensitivity Analysis

# Summary

This chapter explores the effects of varying some of the assumptions that were used to develop the investment requirement 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.

One of the most significant enhancements to the HERS modeling process in this report is the consideration of the effects of operations strategies and improvements. The analyses in Chapter 7 incorporated a baseline scenario for future operations deployments based on existing trends. The impact of this scenario is illustrated by reporting results from HERS that do not take such deployments into account. An alternative scenario assuming a more aggressive deployment of operations improvements is also analyzed.

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 investment requirement projections. Alternative estimates of highway investment requirements are shown for a scenario in which baseline constant-price future highway travel growth rates match those observed over the last 20 years. The sensitivity of the estimated transit investment requirements 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).

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 HERS and TERM by 25 percent and 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 statistical life and truck volume shares.

# Highway Sensitivity Analysis

The accuracy of the investment requirements 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 requirement analytical 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 requirements would also affect the gaps identified in Chapter 8 between projected spending and the investment requirement scenarios.

## Alternative Operations/ ITS Deployment Scenarios

As described in Chapter 7, one of the key additions to the HERS analysis for this edition of the C&P report is the ability to consider the impact of current and future intelligent transportation system (ITS) deployments and operations strategies on highway conditions and performance, with resulting implications for the projected investment requirements. The analyses of Chapters 7, 8, and 9 used a baseline scenario for future deployments based on existing trends. *Exhibit 10-1* shows the impact on the results of two alternative deployment scenarios: one with more aggressive assumptions about future deployments and one that excludes operations from the analysis entirely. Chapter 7 and Appendix A include more information on the types of strategies and investments reflected in both the existing trends and aggressive operations deployment scenarios, 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).

**Exhibit 10-1** *Impact of Alternate Operations/ITS Deployment Assumptions on Investment Requirements*

| | Cost to Maintain Highways & Bridges | | Maximum Economic Investment for Highways & Bridges | |
|---|---|---|---|---|
| | ($Billions) | Percent Change | ($Billions) | Percent Change |
| Chapter 7 Baseline | $73.8 | | $118.9 | |
| No Operations Impacts | $76.0 | 3.0% | $120.7 | 1.5% |
| Aggressive Deployment | $71.4 | -3.3% | $118.7 | -0.2% |

*Source: Highway Economic Requirements System (HERS).*

As shown in Exhibit 10-1, ignoring the impact of operations and ITS deployments in the analysis would result in higher estimates of the cost of the two investment scenarios. The impact is greater, proportionally, for the Cost to Maintain scenario than for the Maximum Economic Investment scenario. Without operations, additional infrastructure improvements would be needed to accommodate future travel growth in order to maintain the conditions and performance of the system, and more such improvements would be perceived as cost-beneficial in the absence of ITS deployments.

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 further decrease the estimated infrastructure investment necessary to maintain conditions and performance at current levels by approximately $2.4 billion per year under this particular scenario.

The aggressive scenario does not have as significant an impact on the Maximum Economic Investment relative to that based on existing trends. While in some cases, ITS deployments would reduce the benefit-cost ratio 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 greater under the aggressive scenario than under the baseline trends scenario. For example, average highway user costs would be 0.2 percent lower than under the existing trends scenario, and incident delay would be further reduced by nearly 3 percent, even though the overall level of investment is slightly lower.

**Q. What are the costs associated with the aggressive deployment strategy analyzed here, relative to those for the baseline existing trends deployment strategy?**

**A.** 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 capital cost of new deployments** under the aggressive deployment strategy used for these analyses is $7.5 billion over 20 years (in 2002 dollars). These costs are included in the capital investment requirements 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 $1.5 billion over 20 years.

**Estimated operating and maintenance costs** for the aggressive deployment strategy over the same 2003 to 2022 time period are $25.1 billion (in 2002 dollars), including $17.1 billion for new deployments and $8.0 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 $10.9 billion, including $2.9 billion for new deployments and $8.0 billion for the existing infrastructure.

# Historic Versus Projected Travel Growth

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 only occur at this level if pavement and capacity improvements made on the segment over the 20-year analysis period are sufficient to maintain highway-user costs at 2002 levels. If HERS predicts that highway-user costs will deviate from baseline 2002 levels on a given highway segment, the model's travel demand elasticity features will modify the baseline VMT growth projections from HPMS.

**Q. Does the accuracy of the investment requirements projected by HERS depend on how accurately the travel forecasts in HPMS predict what future VMT growth will be?**

**A.** Not exactly. The HERS model assumes the travel forecasts in HPMS accurately predict what future VMT growth *would* be if highway-user costs remained constant, rather than what future growth *will* be. This is a critical distinction.

The accuracy of the investment requirements depends on the accuracy of the travel forecasts in HPMS as *modified by the travel demand elasticity features* in HERS. At current funding levels, HERS predicts that highway-user costs will increase over time, so VMT will grow more slowly than the HPMS baseline forecasts. This concept is discussed in more detail in Appendix A.

The HERS model utilizes VMT growth projections to predict future conditions and performance of individual highway segments and to calculate future investment requirements. If the HPMS VMT forecasts *as modified by the HERS travel demand elasticity features* are overstated, the investment requirement projections may be too high. If travel growth is underestimated, the investment requirement projections 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 2002 to 2022 average 2.07 percent per year, well below the 2.96 percent average annual VMT growth rate observed from 1982 to 2002. The HERS model assumes that the 2.07 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 9-6 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 10-2* shows the impact on investment requirements 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 (this was done by adjusting the travel forecasts entered into HERS for each section accordingly). Modifying the travel growth projections in this fashion would increase the Cost to Maintain Highway and Bridges by 65.0 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 over 50 percent of total spending. Both of these factors would tend to increase the investment required to maintain user costs at 2002 levels. The Maximum Economic Investment for Highways and Bridges would increase by 30.8 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.

**Exhibit 10-2** *Impact of Alternate Constant-Price Travel Growth Assumptions on Investment Requirements*

| | Cost to Maintain Highways & Bridges | | Maximum Economic Investment for Highways & Bridges | |
|---|---|---|---|---|
| | ($Billions) | Percent Change | ($Billions) | Percent Change |
| Chapter 7 Baseline | $73.8 | | $118.9 | |
| Historic VMT Growth Rates | $121.8 | 65.0% | $155.4 | 30.8% |

*Source: Highway Economic Requirements System (HERS).*

**Q.** Can Exhibit 10-2 be used to analyze the impact that travel demand management policies (such as pricing) on the investment requirements estimates?

**A.** No. Travel demand management policies such as road pricing 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 is 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 10-2 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 explicitly induced by pricing policies.

More generally, Exhibit 10-2 should not be used to infer a direct linear relationship between a certain level of future VMT and future highway investment requirements. 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 future investment requirements as much as smaller increases in VMT on severely congested highway sections.

# 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 estimates of future investment requirements were recomputed using different values for some of these parameters, including improvement costs, the value of a statistical life, the value of reductions in incident delay, the value of ordinary travel time, short-run and long-run elasticity, and truck volume growth. *Exhibit 10-3* shows the impacts of the alternative parameter values on the Maximum Economic Investment for Highways and Bridges.

## *Improvement Costs*

The unit improvement costs used in HERS 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 in order to ensure that non-cost-beneficial projects are not mistakenly included in the investment requirements estimated by HERS.

Exhibit 10-3 shows the impact of inflating all the improvement costs used by HERS by 25 percent on the Maximum Economic Investment level. The increase in investment requirements due to higher unit values for the improvement costs is largely offset by the elimination of some projects that would no longer be considered cost-beneficial by HERS. The net result is an increase of 6.6 percent in the estimated investment requirements.

**Exhibit 10-3** *Impact of Alternate Model Features and Parameters on Investment Requirements*

| Maximum Economic Investment for Highways & Bridges | ($Billions) | Percent Change |
|---|---|---|
| **Chapter 7 Baseline** | **$118.9** | |
| Improvement Costs | | |
| Increase 25 percent | $126.7 | 6.6% |
| Value of a Statistical Life | | |
| Reduce 50 percent | $118.2 | -0.6% |
| Increase 100 percent | $119.9 | 0.8% |
| Value of Incident Delay Reduction | | |
| Equal to value of ordinary travel time | $111.8 | -5.9% |
| 3 times value of ordinary travel time | $124.0 | 4.4% |
| Value of Ordinary Travel Time | | |
| Increase 25 percent | $127.8 | 7.6% |
| Reduce 25 percent | $108.8 | -8.4% |
| Elasticity Values | | |
| Reduced 50 percent | $128.8 | 8.4% |
| Truck Volumes | | |
| Based on Freight Analysis Framework | $83.0 | 1.9% |

*Source: Highway Economic Requirements System (HERS).*

## 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 0.8 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 0.6 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 estimates of annual investment requirements. 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 V of this report includes a discussion of future research options for improving the HERS model's capabilities in this area.

## 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 is 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 estimates of investment requirements 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 10-3 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, though slightly smaller in magnitude. Increasing the reliability premium to 3.0 makes incident delay-reducing improvements relatively more valuable, thereby raising investment requirements by 4.4 percent at the Maximum Economic Investment level. Eliminating the premium results in a corresponding reduction of 5.9 percent in the investment estimate.

**Q. Are any sensitivity analysis results available from the National Bridge Investment Analysis System (NBIAS) model?**

**A.** Yes. NBIAS supports the ability to apply a swell factor to maintenance, repair, and rehabilitation (MR&R) needs to recognize that in some cases when bridge repair and rehabilitation projects are conducted to address deficiencies for some bridge components, other nondeficient components may be upgraded as well. This feature was utilized in the baseline scenarios for the 2002 edition of the C&P report, as the version of NBIAS used to develop that analysis analyzed bridges at an aggregate level, making it much more likely that its recommended improvements to bridge elements would not capture everything that would ordinarily occur as part of a real-world bridge project. As NBIAS now analyzes individual bridges, its recommended improvements are now much more inclusive, so that any ancillary bridge work that is not reflected should not be nearly as significant.

Had a swell factor of 1.25 been used, as was the case in the 2002 C&P report, then the bridge preservation component of the Cost to Maintain Highways and Bridges would have been approximately 15 percent higher. The bridge preservation component of the Maximum Economic Investment for Highways and Bridges would have been approximately 8 percent higher. The Maximum Economic Investment level is not affected to the same degree, because this adjustment would cause some potential bridge projects to fail the benefit-cost test imposed under this scenario, partially offsetting the increase in costs for the remaining projects.

## *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 by 7.6 percent. Increasing the value of time causes HERS to consider more widening projects (which reduce travel time costs) to be cost-beneficial. The proportion of capacity projects implemented as a percentage of total investment would increase to nearly 47 percent of total improvement costs. Reducing the value of time by 25 percent would have the opposite effect, resulting in an 8.4 percent reduction in the Maximum Economic Investment level.

## *Elasticity Values*

As described in Appendix A, HERS applies both short-run and long-run travel demand elasticity procedures in its analysis, using assumed input values for these elasticities. 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 (-0.6 for short-run elasticity and -1.2 for long-run elasticity) are considered by some to be on the high end for the type of highway user responses modeled by the travel demand procedures in HERS. Therefore, a sensitivity analysis was performed using elasticity values half the magnitude of those in the baseline.

The impact of such a change in these parameters is to increase the Maximum Economic Investment level for Highways and Bridges by 8.4 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.

## *Truck Volumes*

The HPMS sample data used in HERS include values for the percentage of single-unit and combination trucks in the current vehicle mix on each segment. Forecasts of future traffic, however, are not broken down by vehicle class, meaning that the data effectively assume no changes in truck shares. Many national forecasts of future VMT, however, indicate that truck travel is expected to grow faster than passenger auto travel.

**Q. What impacts do alternate parameter assumptions have on the Cost to Maintain Highways and Bridges?**

**A.** The impacts of alternative model parameters and procedures on the estimated investment requirements 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 was based on the Maintain User Cost scenario, in which investment is sufficient to allow average highway user costs for 2022 as calculated by HERS to match the initial levels in 2002. The initial calculation of user costs, however, is directly affected by many of the parameters shown in Exhibit 10-3, including the values of time, incident delay, statistical life, and truck volume. 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 all 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 will then generally be required to maintain user costs at this higher, less "ambitious" level in the future. Increasing the share of trucks over time has the opposite effect: since trucks have higher travel time and vehicle operating costs than do passenger vehicles, an increasing truck share will cause average user costs to rise as well, thus requiring more investment to maintain user costs at the initial level. 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.

Increasing the unit improvement costs in HERS by a given percentage has a straightforward impact on the investment needed to maintain user costs, but the impact is also less interesting analytically. Since the investments included in the Maintain User Cost scenario all have benefit-cost ratios well above 1.0, raising the improvement cost estimates does not cause HERS to forego any improvements on benefit-cost grounds. The increase in the portion of the Cost to Maintain Highways and Bridges will thus be directly proportional to the change in improvement costs. On the whole, the increase will be a less-than-proportional increase in the estimated Cost to Maintain Highways and Bridges simply due to the fact that bridge preservation investments modeled in the NBIAS, which are not affected by changes in HERS parameters, are also part of the cost of that investment scenario.

For this report, HERS has been adapted to accept alternate truck volume data and forecasts for sections in the HPMS data set. The source of this alternate data was FHWA's Freight Analysis Framework (FAF). The FAF forecasts generally show truck volumes increasing at a faster rate than general traffic levels. Exhibit 10-3 indicates that using the FAF forecasts for truck volume growth within the HERS estimation procedures would increase the Maximum Economic Investment by 1.9 percent. HERS finds a slightly larger number of additional projects to be cost-beneficial when the larger truck shares in FAF are accounted for.

Chapter 13 and Appendix A contain more information on the FAF and how its forecasts were used in HERS.

# Transit Sensitivity Analysis

This section examines the sensitivity of projected transit investment requirements by the Transit Economic Requirements Model (TERM) to variations in the values of the following exogenously determined model inputs:

- Passenger miles traveled (PMT) on transit
- Capital costs
- Value of time
- User travel cost elasticities.

These alternative projections illustrate how investment requirements for transit vary according to different assumptions of these input values.

## Sensitivity to 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 (VMT) as a part of the regional transportation planning process. These projections incorporate assumptions about the relative growth of travel on transit and in private vehicles in a metropolitan area. The average annual growth rate in PMT of 1.5 percent used in this report is a weighted average of the most recent, primarily 2000 to 2003, MPO forecasts available from 76 of the Nation's largest metropolitan areas. Investment requirements in the 2002 report were based on a projected PMT growth rate of 1.6 percent, based on a weighted average of the forecasts available from 33 of the Nation's largest metropolitan areas.

Future transit investment requirements have been estimated by TERM based on three alternative projected PMT scenarios to examine the sensitivity of transit investment needs to variations in PMT *[Exhibit 10-4].* These scenarios are as follows:

(1) PMT growth is 50 percent greater than the forecast levels.

(2) PMT growth is 50 percent less than the forecast levels.

(3) PMT remains unchanged (zero growth).

Varying the assumed rate of growth in PMT significantly affects estimated transit investment requirements. This effect is more pronounced under the Maintain Conditions and Performance scenario than under the Improve Conditions and Performance scenario, as PMT growth rates affect primarily asset expansion costs, which comprise a larger portion of total estimated Maintain Conditions and Performance needs than

**Exhibit 10-4** *Impact of Alternative PMT Growth Rates on Transit Investment Requirements*

| Annual PMT Growth Rate | Annual Cost to Maintain Conditions & Performance | | Annual Cost to Improve Conditions & Performance | |
|---|---|---|---|---|
| | (Billions of 2002 Dollars) | Percent Change | (Billions of 2002 Dollars) | Percent Change |
| Baseline (1.5%) | $15.55 | – | $23.99 | – |
| Increased 50% (to 2.25%) | $18.38 | 18.1% | $26.74 | 11.5% |
| Decreased 50% (to 0.75%) | $12.62 | -18.7% | $20.95 | -11.8% |
| Decreased 100% (to 0%) | $10.15 | -33.6% | $18.49 | -21.5% |

*Investment requirements 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.*

estimated Improve Conditions and Performance needs. A 50 percent increase/decrease in PMT growth will increase/decrease the cost to maintain conditions by 18 to 19 percent and the cost to improve conditions and performance by about 12 percent. Investment requirements to maintain conditions and performance decrease by 34 percent if PMT remains constant, although this is not a likely scenario.

# Sensitivity to a 25 Percent Increase 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 2002 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 projected transit investment requirements.

As shown in *Exhibit 10-5,* a 25 percent increase in capital costs increases the costs to maintain conditions and performance by 14 percent and the costs to improve conditions and performance by 9 percent. With this increase in costs, fewer investments pass the benefit-cost hurtle under the Improve Conditions and Performance scenario than under the Maintain Conditions and Performance scenario.

**Exhibit 10-5** *Impact of a 25 Percent Increase in Capital Costs on Transit Investment Requirements**

| | Annual Cost to Maintain Conditions & Performance | | Annual Cost to Improve Conditions & Performance | |
|---|---|---|---|---|
| | (Billions of 2002 Dollars) | Percent Change | (Billions of 2002 Dollars) | Percent Change |
| Baseline | $15.55 | – | $23.99 | – |
| Increase Costs 25% | $17.72 | 13.9% | $26.24 | 9.4% |

*Investment requirements 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.*

# Sensitivity to 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 under both the Maintain Performance and 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 10-6* 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.

Overall, variations in the value of time have a very limited effect on investment needs. 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 requirements 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 10-6** *Impact of Change in the Value of Time on Transit Investment Requirements**

| Annual PMT Growth Rate | Annual Cost to Maintain Conditions & Performance | | Annual Cost to Improve Conditions & Performance | |
|---|---|---|---|---|
| | (Billions of 2002 Dollars) | Percent Change | (Billions of 2002 Dollars) | Percent Change |
| Baseline | $15.55 | – | $23.99 | – |
| Increase 100% | $15.21 | -2.2% | $23.58 | -1.7% |
| Decrease by 50% | $15.57 | 0.1% | $23.91 | -0.4% |

* Investment requirements 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.*

# Sensitivity to Changes in User Cost Elasticities

"User cost" elasticity is the percentage change in ridership resulting from a 1 percent change is 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 10-7*, a doubling or halving of these elasticities has almost no effect on projected investment requirements.

**Exhibit 10-7** *Impact of Change in the Value of User Cost Elasticities on Transit Investment Requirements**

| User Cost Elasticities | Annual Cost to Maintain Conditions & Performance | | Annual Cost to Improve Conditions & Performance | |
|---|---|---|---|---|
| | (Billions of 2002 Dollars) | Percent Change | (Billions of 2002 Dollars) | Percent Change |
| Baseline | $15.55 | - | $23.99 | - |
| Increase 100% | $15.61 | 0.4% | $23.89 | -0.4% |
| Decrease by 100% | $15.65 | 0.7% | $24.00 | 0.0% |

* Investment requirements 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.*

# Special Topics

# Part III

# Introduction

Chapters 11 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 analyses are intended to provide additional insights into these issues and to highlight some related activities currently underway within the Department of Transportation.

Chapter 11, **Federal Safety Initiatives,** identifies current Departmental safety initiatives designed to address the safety performance issues identified in Chapter 5. The discussion is organized by agency, highlighting the safety-related activities of the Federal Highway Administration Safety Office (FHWA), the National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), and the Federal Transit Administration (FTA).

Chapter 12, **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 13, **Freight,** 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 14, **The Importance of Transit,** describes the role transit plays in the life of the American people and provides details of the demographics of transit use.

Chapter 15, **Bridges,** presents additional information on the status and condition of the Nation's bridges to supplement the information presented in Chapters 2 and 3.

# CHAPTER 11

# Federal Safety Initiatives

# Introduction

Chapter 5 of this report presents a variety of safety statistics for both the Nation's highways and public transportation systems. This chapter describes various initiatives that have been undertaken by the U.S. Department of Transportation (DOT) to address safety performance issues. This chapter is broken down into separate sections describing programs of the Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), and the Federal Transit Administration (FTA). While these distinctions are useful from a chapter-organizational perspective, it is important to recognize that these individual agencies actively cooperate with each other (as well as with other agencies such as the Federal Railroad Administration [FRA]) on many of the highway and transit initiatives described in the chapter.

# Highway Safety Programs: Federal Highway Administration

Safety remains the U.S. Department of Transportation's highest priority. The Department has established a goal to reduce the national highway fatality rate from the 2002 level of 1.5 deaths per 100 million vehicle miles traveled to 1.0 per million vehicle miles traveled by the year 2008. The 1.0 goal was exceeded by 13,734 fatalities in 2002.

In announcing this goal to reduce fatalities, it must be made clear that there is no one silver bullet that will drive down the fatality rate. Major improvements in highway safety require a comprehensive and coordinated approach that addresses driver behavior, vehicle design, and the roadway. A successful comprehensive approach to safety also requires a wide variety of partnerships with State departments of transportation; other Federal, State, and local agencies; and the private sector.

Many of the safety-related activities currently being carried out by DOT are a result of a national Strategic Highway Safety Plan that was developed by the American Association of State Highway and Transportation Officials (AASHTO) with the assistance of FHWA; NHTSA; the Transportation Research Board (TRB), and experts from private sector safety and transportation organizations, industry, and academia. This comprehensive plan includes 22 emphasis areas and 90 strategies to improve driver behavior, vehicle design, roadway safety, emergency medical services, and pedestrian and bicycle safety. To implement the plan, 30 "lead States" are testing new tools and guides developed by the National Cooperative Highway Research Program (NCHRP) to help States improve their highway safety planning and programs.

## Roadway Safety

The FHWA has the overall lead in improving the safety of the Nation's roadway infrastructure. The agency has identified safety as its highest priority among the "vital few" focus areas targeted for greater attention and resources. As part of a comprehensive approach to safety, the FHWA partners with a variety of organizations that are interested in improving roadway safety, including AASHTO, individual State departments of transportation, the Governors' Highway Safety Association (GHSA), the National Association of County Engineers (NACE), the International Association of Chiefs of Police (IACP), the American Traffic Safety Service Association (ATSSA), the Institute of Transportation Engineers (ITE), the American Road and Transportation Builders Association (ARTBA), the American Public Works Association (APWA), the Transportation Research Board (TRB), the National Association of Regional Councils (NARC), the Association of Metropolitan Planning Organizations (AMPO), and the National Utility Contractors Association (NUCA).

The FHWA Office of Safety has recently launched an approach to safety that better focuses resources and more effectively supports activities that will achieve the aggressive goal of FHWA and DOT to reduce the fatality rate from 1.5 to 1.0 fatalities per 100 million vehicle miles traveled by 2008. As part of the "focused" approach to safety, 16 States have been identified as having the greatest opportunity to contribute to reducing the national fatality toll. These States, known as "opportunity" States, are in the top half of States in terms of overall fatality numbers, and have either a fatality rate above the national average or a fatality rate improvement trend below the national average. In addition, FHWA identified "focus" States that have fatality rates above the national average and fatalities above a number threshold value for each of the emphasis areas related to the highest number of fatalities nationwide—intersection, roadway departure, and pedestrian crashes.

Attention to "opportunity" and "focus" States does not mean that other States will be "left out in the cold." The FHWA will continue to support safety activities in every State across the country, particularly those developing and implementing a comprehensive highway safety plan. All States need to take a data-driven approach to identifying their specific safety problems and goals, identifying and implementing appropriate countermeasures, and aggressively advancing safety. The FHWA will continue to be an important partner with the States, as well as other agencies and organizations, in these activities.

The FHWA takes a comprehensive approach to Safety by including the 4 E's (Engineering, Enforcement, Education and Emergency Services) in its program activities. FHWA Office of Safety, in supporting the national AASHTO Strategic Highway Safety Plan, has also concentrated on providing direct assistance to states in helping them develop state comprehensive highway safety plans. Over 30 states are participating in the development of safety plans with the target for all states to have plans by FY06.

The FHWA's safety programs focus on engineering-related improvements to the roadway that have proven effective in reducing the potential for crashes and the severity of crashes when they occur. They target three types of crashes linked to high numbers of fatalities: roadway departure crashes (24,412 or 59 percent of all traffic fatalities in 2002), intersection crashes (9,273 or 21 percent of fatalities), and pedestrian-related crashes (4,851 or 11 percent of fatalities). Many crashes involve multiple factors related to the roadway, the driver, and the vehicle. For example, an intersection crash may involve other vehicles, a young driver, and a pedestrian. A number of strategies are needed and currently available to reduce these types of crashes, including low-cost improvements such as illumination, signing, pavement marking and delineation, traffic signal upgrading, and the installation of rumble strips.

To assist States and localities in implementing roadway safety improvements, FHWA administers the Hazard Elimination Program, which makes funds available to States and localities for safety projects to reduce the number and severity of crashes at hazardous highway locations, sections and elements on any public road, at public railway-highway crossings, any public surface transportation facility, or any publicly owned bicycle or pedestrian pathway or trail. In addition to the low-cost improvements noted above, projects implemented with Hazard Elimination Program funds include intersection improvements (e.g., channelization, new traffic signals, and sight distance improvements), pavement and shoulder widening, the installation and upgrading of guardrail and median barriers and breakaway utility poles and sign supports, pavement grooving and skid-resistant overlays, modification of roadway alignment, and pedestrian-related improvements. The FHWA also administers the Highway-Rail Grade Crossings Program that is intended to reduce the number and severity of train collisions with vehicles and pedestrians. All public crossing safety improvements

**Q. How effective are roadway safety improvements in reducing crashes?**

**A.** Roadway safety improvement projects continue to show benefits. To illustrate, South Carolina installed nearly 400 miles of median barrier on its Interstate system in an effort to reduce the potential for median crossover crashes. Using multiple sources of funds, including Federal-aid, State and local, and private sector funds, these improvements were implemented over a 2-year period. The cable median barrier that was installed reduced the number of fatal Interstate median crossover crashes by 67 percent. Overall, South Carolina's Interstate Safety Improvement Program resulted in a savings of approximately $375 million over 2 years and a benefit-cost ratio of nearly 20 to 1.

are eligible for Federal funding. Typical projects include the installation and upgrading of active warning devices (e.g., lights and gates), the installation of signs and markings, sight distance improvements, grade separations, and the elimination of crossings.

Funding for safety improvements is not restricted to the Hazard Elimination and Highway-Rail Grade Crossings Programs. They can also be funded from the larger Federal-aid programs such as the Surface Transportation Program, the National Highway System, and Interstate Maintenance at the State's option.

To ensure that these improvements are carried out in an organized, systematic manner where the greatest benefits can be achieved, States are required to develop and implement, on a continuous basis, a highway safety improvement program (HSIP) that has the overall objective of reducing the number and severity of crashes and decreasing the potential for crashes on all highways. Under the HSIP, the States utilize data to identify hazardous locations and elements, conduct engineering studies, and establish project priorities. The States have considerable flexibility to carry out HSIPs that will best meet their needs.

The FHWA's program of nationally coordinated research and technology safety innovations is dedicated to reducing highway crashes and related fatalities and injuries. The FHWA's Safety R&D Program focuses on priority highway safety improvement objectives related to roadway departure prevention and mitigation, safety management, intersection improvement, and pedestrian protection. This includes providing transportation officials and practitioners with improved understanding, information, and state-of-the-art tools so that they can make informed decisions about highway safety improvements. The FHWA's Safety R&D Program also conducts advanced research to determine new ways to solve highway safety problems and challenges.

The FHWA's Safety R&D Program includes:

- Conducting research to evaluate and improve the safety designs of highway geometry, roadway elements, and traffic control devices;
- Improving understanding of the dynamics of run-off-the-road (ROR) crashes and identifying means to reduce the number of fatalities and serious injuries resulting from these types of crashes through crash tests and simulations to improve crash barriers and other roadside hardware, and to reduce the incidence and severity of rollover crashes;
- Using data to identify the nature and magnitude of safety problems, develop analytical tools, and evaluate the effectiveness of various safety treatments; and
- Conducting studies and research to assess human performance and behavior under various roadway conditions.

Other agency research efforts include speed management to encourage wider adoption of safe travel speeds appropriate for road and travel conditions, safety management to ensure that resources are allocated to achieve the maximum returns in reducing the number and severity of crashes, work zone safety improvements, and human-centered systems to incorporate human factors into highway design. The FHWA offers human factors workshops for highway design engineers and traffic safety specialists. The workshops emphasize the relationship between highway standards and human needs and provide an opportunity to apply human factors principles to resolve highway design, operations, and safety issues. Seventy human factors workshops have been offered throughout the country in the last 4 years.

The following program descriptions provide examples of the types of strategies and tools used by FHWA to reduce roadway departure, intersection, and pedestrian fatalities.

# Reducing Roadway Departure Crashes

Roadway departure crashes, which include ROR, head-on, and opposite direction sideswipe crashes, are a very serious problem. Of the 43,005 total fatalities in 2002, 25,241 fatalities, or almost 59 percent, were from roadway departure crashes. ROR crashes resulted in 17,046 fatalities or 40 percent of all fatalities. This represents a 10.3 percent increase in ROR fatalities since 1995 when there were 15,456 fatalities (comprising 33 percent of all fatalities). Fatalities from head-on and opposite direction sideswipe crashes totaled 8,195 or 19 percent of all fatalities in 2002. Seventy percent of ROR fatalities occur in rural areas, with about 90 percent of these occurring on two-lane roads. The FHWA's 5-year goal is to reduce overall roadway departure fatalities by 10 percent by the year 2007. This goal includes ROR, head-on, and opposite direction sideswipe crashes. Excessive or inappropriate speed for highway conditions is a factor in approximately 30 percent of all fatalities each year. The FHWA's role in assisting States to develop effective speed management programs will be described later in the chapter.

The FHWA is actively pursuing improved roadway departure safety through a multifaceted approach in the fields of engineering, education, and enforcement. As part of its comprehensive safety program, FHWA engineers work closely with state highway engineers and law enforcement officials to identify appropriate engineering safety countermeasures for high-risk locations and new roads. The FHWA promotes effective engineering solutions such as removing and relocating objects in hazardous locations, flattening severe horizontal curves, eliminating pavement edge/shoulder drop-offs, and paving and widening shoulders. The FHWA, a partner with the Georgia Department of Transportation in developing methods of constructing pavement edges on new paving projects called "Safety Edge," is promoting improving shoulders with such treatments to reduce the effect of pavement drop-offs. When a vehicle tire drops off the edge of the road, many drivers over-react by braking hard and trying to turn sharply back onto the roadway. This action frequently leads to loss of vehicle control and subsequent rollover.

## *Designing Safer Roadways*

The FHWA researches, develops, and promotes a variety of design features that create safer roadways to prevent roadway departures. The focus is on two approaches: (1) "Keeping the vehicle on the road" and (2) "Minimizing the consequences if the driver leaves the road." The FHWA and representatives from seven State departments of transportation are working in partnership to develop the Interactive Highway Safety Design Model (IHSDM), an interactive and innovative road safety evaluation software that is being developed for use by roadway designers. A training course was developed to teach engineers and planners to use IHSDM to evaluate the safety of highway geometry when they design and redesign roadways.

## *Protecting Drowsy Drivers*

Drowsiness and inattention contribute to roadway departure crashes. Rumble strips, particularly the milled type, that provide an audible warning to inattentive drivers and create a physical vibration, are an extremely effective way to prevent roadway departures on freeways and other selected roadways. They are also used along the highway centerline on two-lane facilities in several States to reduce head-on collisions. The FHWA is spearheading a movement to increase nationwide use of milled rumble strips and has issued a technical advisory on rumble strips to encourage uniform application of this safety countermeasure on a national basis.

## More Visible Signs and Pavement Markings

Greater visibility of roadway markings and signs are also an important method of preventing roadway departure crashes. While only 25 percent of travel occurs at night, about half of traffic fatalities occur during hours of darkness. During the daylight hours, drivers have a number of visual cues, such as shoulders, roadside vegetation, guardrails, and fences to make navigation easier. At night, many of these cues cannot be seen unless they are illuminated or retroreflective. Adequately maintained retroreflective signs and pavement markings have better nighttime visibility and help motorists stay safely on the road. The FHWA is using innovative retroreflectivity technology to efficiently measure the nighttime visibility of signs and pavement markings and has developed proposed national guidelines for minimum sign retroreflectivity levels for use by State and local highway agencies.

## The "Forgiving Roadside"

The FHWA's "forgiving roadside" approach encourages development and use of roadway design features that help to reduce the severity of a crash when a motorist leaves the roadway. Crashworthy roadside hardware, including modern traffic barriers and terminals, crash cushions, bridge railings, and work zone devices, are all designed and tested to minimize the impact of a crash. In addition, a cadre of FHWA engineers provides roadside design training to highway agencies on request. This training is also provided in a formal National Highway Institute course covering the information contained in the *Roadside Design Guide,* an AASHTO publication (www.transportation.org) recognized as the best source of information on roadside design.

## Context-Sensitive Safety Design

There are many factors that must be considered when planning and designing streets and highways. While the principal goal is to provide a safe and efficient facility for moving people and goods, the character of the highway often must meet aesthetic and historical needs of the community as well. To safely accommodate landscaping, community signage, and other context-sensitive features, the Office of Safety works with the Office of Environment & Planning and the Office of Infrastructure to present a consistent design policy to the field and the State departments of transportation. The Office of Safety develops crashworthy aesthetic treatments such as traffic barriers and raised islands for trees, develops educational material such as training courses and videos, and is actively involved in the AASHTO Strategic Highway Plan efforts to reduce the deaths and injuries caused by trees in hazardous locations. The FHWA also participates in National Cooperative Highway Research Program (NCHRP) Project 16-04, *Design Guidelines for Safe and Aesthetic Roadside Treatments in Urban Areas,* that is intended to produce designs for aesthetic treatments for streets and highways in urban areas that will not degrade safety.

## Safety Partnerships with Law Enforcement for Better Crash Data

Safety partnerships with State and local law enforcement and accurate crash data are very important to preventing roadway departures and other fatal crashes. Both are important features of *Safety Starts With Crash Data.* The FHWA co-produced this video to help train law enforcement personnel to thoroughly investigate crashes and submit accurate, complete, and timely crash reports. Distributed to law enforcement agencies throughout the country, this video is the product of an FHWA partnership with the IACP; the National Sheriffs Association; and two federal sister agencies, NHTSA and FMCSA.

# Improving Intersection Safety

Intersection safety is a serious, national public health issue. In 2002, there were almost 3 million intersection crashes, comprising over 40 percent of all reported crashes for that year. In 2002, 9,273 fatalities were intersection-related – accounting for 22 percent of the 43,005 traffic fatalities. The FHWA's Office of Safety is engaged in several initiatives to work toward lowering the national fatality rate to 1.0 per 100 million vehicle miles traveled by improving the public's safety at intersections. The Office of Safety's pedestrian safety programs are closely linked to improvements in intersection safety. The contributions of these programs to intersection and pedestrian safety will be described later in the chapter.

## *National Agenda for Intersection Safety*

The FHWA is actively pursuing improved intersection safety through a multidisciplinary approach in the fields of engineering, education, and enforcement in coordination with State and local police and fire agencies. The FHWA has worked with industry partners to develop a National Agenda for Intersection Safety—a multi-pronged approach toward improving intersection safety. There are 11 categories of solutions and strategies in this national plan, including engineering and technology improvements, intersection safety audits, red light running, training for local safety professionals, and increasing public awareness.

## *Stop Red Light Running*

The FHWA continues its participation in the "Stop Red Light Running" Campaign—a national safety partnership dedicated to improving intersection safety through the reduction of red light running. The American Trauma Society has been a partner with FHWA since 1998. Currently, over 200 communities, including local law enforcement, are part of this nationwide effort to reduce red light running at intersections. The FHWA developed guidance for the use of red light running cameras and a practitioner's guide, *Engineering Safe Intersections to Prevent Red Light Running.*

## *Resources on Intersections and Roundabouts*

The FHWA has recently developed a training course on intersection safety. This course provides local practitioners with training on conventional and nonconventional engineering treatments to improve safety at their intersections. The FHWA recently published an informational guide on the design and application of roundabouts (circular intersections). Roundabouts have fewer conflict points than traditional intersections so their potential to improve safety is great, if well designed. The FHWA is in the process of publishing a guidebook on signalized intersections.

Its Office of Safety Web site (http://safety.fhwa.dot.gov) and Intersection Safety Resource CD-ROMs are being used to put many guidebooks and resources into the hands of practitioners.

## *Intelligent Technology for Intersections*

The FHWA is also looking to intelligent technology to improve intersection safety. The Intersection Collision Avoidance System is being developed to help drivers avoid crashes at intersections. In partnership with automotive manufacturers and State and local departments of transportation, this initiative will pursue optimized vehicle-roadway communication systems designed to address the full set of intersection crash problems. Some examples include crashes related to violations of traffic signals and stop signs. The goal is to develop commercially deployable intersection collision avoidance systems.

**Q. Are there other ways intelligent transportation system (ITS) technology can be used to improve intersection safety?**

**A.** Yes, the Kentucky Transportation Cabinet is testing another ITS application. The Cabinet teamed with the Louisville Metro Public Works to deploy TRIMARC Intelligent Transportation System, an innovative use of ITS technology to help traffic safety engineers. TRIMARC is the regional transportation management system for the Louisville-Southern Indiana area. It is managed jointly by the Kentucky Transportation Cabinet, the Indiana Department of Transportation, and the FHWA. TRIMARC includes two cameras with directional microphones, a VCR, and a central controller installed on opposite corners of an intersection. The equipment provides frame-by-frame analysis that enables the engineer to determine the speed and angles of impact vital to accident reconstruction. It also provides the actual sights and sounds just before a crash or near miss in a video of the incident and the results. Engineers use this information to develop quantitative data as a basis for effective intersection safety improvements.

### *Highway-Rail Grade Crossing Safety Activities*

A special type of intersection is one where a highway crosses a railroad track, known as a highway-rail grade crossing. The number of incidents at public highway-rail grade crossings has been reduced by approximately 75 percent since 1975. The FHWA's Office of Safety is designated to manage the Railway-Highway Crossings Program (as directed by 23 U.S.C. 130). The FHWA, in close coordination with the Federal Railroad Administration (FRA) and the Federal Transit Administration (FTA), is involved with activities to further reduce the number of incidents at public grade crossings. Some activities related to highway-rail grade crossings include the installation of lights and gates, roadway grade separations, pavement markings, signing, crossing closures, and roadway geometric improvements. Additionally, a comprehensive database of crossings, including geometric challenges, has been developed to provide valuable information to road users (particularly low-clearance commercial vehicles). The FHWA recently developed *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* for roadway authorities and railroads to use as a toolbox for grade crossing safety. The FHWA is working on two key documents to include in its grade crossing toolbox: a document on pre-signals and warrants for traffic signals near highway-rail grade crossings and a revision to the *Highway-Rail Grade Crossing Handbook.* Operation Lifesaver, a national, nonprofit education and awareness program, provides additional support to improve safety at highway-rail grade crossings.

## Reducing Pedestrian Fatalities

In 2002, 4,808 pedestrians were killed in traffic-related crashes. The FHWA's 5-year goal is to reduce pedestrian fatalities by 465 by the year 2007 by actively pursuing improved pedestrian safety through a comprehensive approach in the fields of engineering, education, and enforcement.

### *Pedestrian Safety Partnerships*

The FHWA has developed pedestrian safety partnerships with State and local officials, concerned citizens, local business leaders, schools, and youth organizations. Partnering with State and local law enforcement is another way that FHWA works to keep pedestrian safety high on the list of priorities. State and local police agencies played an important role in the development of FHWA's successful "Pedestrian Safety Outreach" Campaign.

## *Engineering Countermeasures*

As part of its comprehensive pedestrian safety program, FHWA engineers work closely with State highway engineers and law enforcement officials to identify appropriate engineering safety countermeasures for high-risk locations and new roads. The FHWA supports research into a variety of design features that create safer crossings at intersections for all pedestrians, including those with disabilities. These design features include adequate timing and location of pedestrian signals, improved signage and lighting to enhance visibility, tactile warnings for visually impaired pedestrians, median refuge islands, crosswalk improvements, pedestrian warning signs that alert oncoming traffic to pedestrians in the crosswalk, and highly visible retroreflective signs.

**Q.** How can community design standards protect pedestrians?

**A.** Montgomery County, Maryland, developed and implemented new design standards for including sidewalks and bike paths on residential and collector roads. The new standards balance the goals of developers, utility companies, public agencies, and motorists with the safety of bicyclists and pedestrians. The standards support safe passage for pedestrians, bicyclists, and motorists. On higher speed roads, the standards call for wider clear zones with sidewalks and bike paths farther from the roadway. On low-volume roads, bike paths and sidewalks may be closer to the roadway. The standards for pedestrian facilities also comply with the requirements of the Americans with Disabilities Act.

## *Pedestrian Safety Resources*

The FHWA is dedicated to improving public awareness and providing technical training about pedestrian safety. To accomplish this, FHWA has funded and sponsored the Pedestrian Safety Roadshow (http://safety.fhwa.dot.gov/roadshow/walk), the "Pedestrian Safety" Campaign, the Pedestrian and Bicyclist Resource Set on CD, the *Safer Journey* CD (seen by more than 5 million school children), the Pedestrian and Bicyclist University Course, the *WALK!* Video, multilingual brochures, and the resource catalogue. The "Pedestrian Safety" Campaign is one of the most popular products developed by FHWA.

It includes a how-to guide for organizing a pedestrian safety campaign at the local level. The guide addresses gaining community "buy-in," funding, and ways to measure effectiveness and includes sample public service announcements for print, cinema, and television and posters in Spanish and English. Campaign kits have been sent out to 160 communities that have agreed to use the materials in their own pedestrian safety campaigns. An evaluation of effectiveness is ongoing.

## *Pedestrian Safety Roadshow*

One of FHWA's top educational initiatives for pedestrian safety in recent years is the Pedestrian Safety Roadshow. This education workshop is designed to assist communities in raising public awareness and developing their own approach to improving pedestrian safety. In just 3 years, over 300 people were trained to facilitate this workshop. This successful national program is now considered a model of a successful, community-based, safety campaign. Other groups that promote roadway safety have adopted the aspects of the program.

**Q.** How have communities developed successful pedestrian programs?

**A.** The Phoenix, Arizona, School Safety Program is the product of a Safety Task Force that examined the safety conditions at more than 1,700 school-related crosswalks. Its comprehensive approach to safety includes improved training and monitoring of school crossing guards, strengthening traffic enforcement at schools and crosswalks, and encouraging more responsible driver behavior near schools and more parent and community involvement in school traffic safety. Real-time speed indicators have been posted beneath speed limit signs near schools. The School Safety Program has produced English and Spanish versions of the Crossing Guard Training Program and a School Crossing Guard Safety Audit that are used throughout Phoenix.

# Additional Program Areas

## *Improving Safety on Local Roads*

Sixty percent of highway fatalities occurred on rural roads in 2002 and 41 percent of these fatalities occurred on rural two-lane roads. Seventy-seven percent of U.S. roads are located in or near areas below 5,000 in population. The sheer number of these roads, their low traffic volumes, and the high cost of major construction make it impractical to rebuild most rural roads with safer designs. Many of these roads are ineligible for most Federal-aid funding and must compete with State priorities for limited safety set-aside funds. Lack of prompt emergency medical response after crashes also contributes to the high number of fatalities on rural roads. Efforts to improve rural road safety are further complicated because they are often the responsibility of local governments without the resources to undertake significant improvements. Despite these challenges, low-cost safety improvements can have a significant impact on the safety of local roads. The FHWA is encouraging State use of innovative strategies to expand these low-cost strategies to roads under local jurisdiction. Technical assistance to local governments on effective safety improvements is critical to reducing fatalities. State departments of transportation and the Local Technical Assistance Program (LTAP) are important conduits of information on low-cost countermeasures to local governments. The FHWA is also initiating a pilot Roadway Safety Circuit Rider Program, based in LTAP centers, to provide local governments engineering and technical support and training in best practices and low-cost safety countermeasures to help them reduce fatalities on local roads.

## *Speed Management*

Managing speed is a complex problem involving many factors including public attitudes, driver behavior, vehicle performance, roadway characteristics, enforcement strategies, court sanctions, and speed zoning. The problem is being addressed through a multi-disciplinary Speed Management Team that includes participation from the FHWA, NHTSA and the FMCSA. The team has drafted a strategic initiative that outlines actions needed to more effectively manage speed and reduce speeding related fatalities and injuries. Variable speed limits that change with road, weather, and traffic conditions have been identified as a key engineering strategy to more effectively manage speed and crash risk on freeways. Field operational tests in work zones have been carried out with promising results. A web-based expert system known as USLIMITS has been developed to assist practitioners in setting reasonable, safe, and consistent speed limits in speed zones. The expert speed zone advisor will be of particular use to small communities and agencies that lack experienced traffic engineers. NHTSA and FHWA are jointly supporting efforts in seven states to demonstrate and evaluate a holistic approach to the setting and enforcement of rational speed limits. A series of pilot workshops have been carried out that brought together critical engineering, enforcement, and judiciary personnel to discuss the multi-disciplinary aspects of managing speed and identified actions needed to restore the credibility of speed limits. A train-the-trainer workshop and planning guide for others who want to sponsor similar speed management workshops are under development.

## *Older Drivers*

Older drivers (age 70 and over) have a high rate of crashes and fatalities per mile driven, second only to that of drivers aged 16 to 24. The FHWA recognizes the need to address the concerns of the growing number of older drivers. To help engineers incorporate these needs in highway design, FHWA has published the results of an older driver research program in *The Older Driver Highway Design Handbook.* The FHWA also offers a 1-day Older Driver workshop to educate traffic engineers on highway design elements that address older drivers' needs.

## *Road Safety Audits*

A road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent team that then reports on potential safety issues. The FHWA has been promoting road safety audits as a tool to improve safety. A brochure has been developed for marketing this tool to local decision makers, and a Web site (www.roadwaysafetyaudits.org) has been updated to provide practitioners with resources and information to begin a program. The Cities of Grand Rapids and Detroit, Michigan, have conducted numerous intersection safety audits in partnership with AAA Michigan. A similar program is beginning in Milwaukee, Wisconsin. A model road safety audit program can be found at the South Carolina Department of Transportation. The department conducts 10 road safety audits each year on projects at various stages of development including design, construction, and existing roads.

## *Integrating Safety into Transportation Planning*

The potential to improve highway safety would be greatly enhanced if safety were fully integrated into the transportation planning process. Success in this area can provide access to additional Federal funds for safety and the opportunity to influence State and metropolitan plans and policies to improve safety. It also provides the opportunity to educate decision makers within the planning process on the importance of safety.

The Transportation Equity Act for the 21st Century (TEA-21) modifies the metropolitan and statewide transportation planning processes to "provide for consideration of projects and strategies that will increase the safety and security of the transportation system for motorized and nonmotorized users." While safety is often listed as a goal, specific strategies to increase safety are not yet a part of many transportation plans. Safety conscious planning is an initiative led by FHWA in cooperation with the Transportation Research Board, the Governors' Highway Safety Association, NHTSA, FMCSA, AASHTO, the National Association of Regional Councils, and the Association of Metropolitan Planning Organizations to integrate safety as an explicit priority within the transportation planning process, in both short-range metropolitan and statewide transportation improvement programs and long-range transportation plans. Initiative goals include the consideration of safety throughout the entire planning process on a par with environmental compliance, congestion relief, and economic development. The current Federal effort on safety conscious planning is based on partnerships between Federal agencies and leaders within the State and local safety and planning communities. Its purpose is to provide planners with the tools and training needed to accomplish safety conscious planning. Research is underway to develop a guide for planners and tools for forecasting safety needs. Eighteen safety conscious planning forums have brought together State and local safety and planning professionals throughout the country to establish partnerships and action plans for implementing safety conscious planning. State requests for forums are continuing. A training course is now available to assist safety, planning, and transit professionals to integrate safety into the planning process.

# Highway Safety Programs: National Highway Traffic Safety Administration

Over the past four decades, the U.S. Department of Transportation (DOT) has used a variety of strategies to reduce highway fatalities and injuries. For example, DOT/NHTSA has worked to improve safety through regulatory action, such as implementing Federal laws that cover safety belt performance requirements, child safety seat construction requirements, air bags, and intoxicated driving standards.

Rather than adopting a single policy to improve safety, NHTSA uses a variety of strategies and approaches, as well as interacting with both the public and private sectors.

## Safety Restraint Systems

The public's acceptance of safety restraint systems represents one of the greatest public policy success stories of the past several decades. This success has been the result of the "Buckle Up America" Campaign, which is a four-pronged approach consisting of (1) public-private partnerships, (2) strong legislation, (3) active high-visibility law enforcement, and (4) effective public education. Additionally, the "Click It or Ticket" Mobilizations have proven effective in getting drivers and passengers in motor vehicles to buckle up on every trip, every time. Prompted by these campaigns, public acceptance of safety devices steadily increased during the 1980s, 1990s, and into the current century. By 2004, about 80 percent of American motorists used shoulder belts, compared with 58 percent in 1994.

Several types of restraints help reduce traffic injuries and deaths. One such device, the safety belt, was the earliest type of automobile restraint system. Safety belt systems were introduced in cars in 1965 with lap belts and later included lap/shoulder belts in all outboard seating positions. Lap/shoulder belts will be required in rear center seating positions starting in model year 2006. Beginning with the 1991 model year, car manufacturers were required to install automatic crash protection—either air bags or automatic safety belts for driver and front outboard seating positions. All model year 1998 passenger cars and model year 1999 light trucks were required to have driver and front passenger air bags. According to the National Center for Statistics and Analysis, it is estimated that, as of 2002, more than 133 million air bag–equipped passenger vehicles were on the road, including 111 million with driver and front passenger air bags. A third safety mechanism, child restraint systems, is also increasingly used by parents and caregivers to reduce the likelihood of harm to young passengers.

*Exhibit 11-1* shows the number of lives estimated to have been saved by restraint systems between 1993 and 2002. Safety belts saved an estimated 14,164 lives in 2002; air bags saved 2,248 lives; and child restraints saved 376 lives that year. Safety belts alone are estimated to have prevented 112,805 deaths between 1993 and 2002.

For the last several years, NHTSA has engaged in several initiatives to increase occupant safety. Section 1403 of TEA-21, for example, contained a safety incentive grant program (Section 157) to encourage States to increase safety belt use. Under this program, funds were allocated each fiscal year (FY) from 1991 until 2005 to States that exceeded the national average for safety belt use or that improved their State's safety belt use rate. The authorized level for this program increased from $82 million in FY 1999 to $112 million in FY 2005.

**Exhibit 11-1** *Estimated Number of Lives Saved by Restraint Systems, 1993–2002*

| Restraint Type | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Safety Belts | 7,773 | 9,219 | 9,882 | 10,710 | 11,259 | 11,680 | 11,941 | 12,882 | 13,295 | 14,164 |
| Air Bags | 190 | 309 | 536 | 783 | 973 | 1,208 | 1,491 | 1,716 | 1,978 | 2,248 |
| Child Restraints | 313 | 420 | 408 | 480 | 444 | 438 | 447 | 479 | 388 | 376 |

*Source: Fatality Analysis Reporting System (FARS).*

Section 2001 of TEA-21 reauthorized the State and Community Highway Safety formula grant program to broadly reduce traffic crashes and resulting fatalities, injuries, and property damage. The authorized level increased from $149.7 million in FY 1998 to $165 million in FY 2003.

Section 2003(b) of TEA-21 established a new program of incentive grants to encourage States to implement child passenger protection programs. This program authorized $7.5 million in FY 2000 and FY 2001, and was extended through 2003. Also under Section 2003 of TEA-21, Section 405(a) established a new program of incentive grants to encourage States to adopt and implement effective programs to reduce highway deaths and injuries resulting from individuals riding unrestrained or improperly restrained in motor vehicles. The authorized level for this program increased from $10 million in FY 1999 to $20 million in FY 2003.

# Responsible Driving Initiatives

The NHTSA works with industry partners, States, and local governments to improve driver behavior. The 1980s and early 1990s saw a great deal of activity, such as the formation of a Presidential Commission on Drunk Driving and grassroots organizations such as Mothers Against Drunk Driving. States also enacted tougher impaired driving laws, and jurisdictions across the country increased their enforcement efforts. All of these efforts increased the public's awareness and concern over traffic safety issues, resulting in a sharp decline in highway fatalities and injuries, particularly those involving alcohol. Additionally, with the establishment of a national drinking age of 21, teens were no longer driving to neighboring States to purchase and consume alcohol.

Following the mid 1990s, however, there was a period when little progress was made in reducing these numbers. Since the late 1990s, DOT/NHTSA has dedicated new focus, energies, and strategies to highway safety efforts; 2003 data indicate that injuries and fatalities have started to decline.

Currently, there are numerous DOT/NHTSA initiatives to promote responsible driving, most notably the prevention of impaired driving. Section 1404 of TEA-21, for example, established a new program of incentive grants (Section 163) to encourage States to establish a 0.08 percent blood alcohol concentration (BAC) as the legal limit for drunk driving offenses. The authorized level for this program increased from $55 million in FY 1998 to $110 million in FY 2003. In October 2000, Congress passed legislation that made 0.08 BAC the national standard for impaired driving. States were required to adopt 0.08 BAC laws by FY 2004 or face the withholding of certain highway construction funds.

Before the incentive grant program was signed into law in June 1998, only 16 States had enacted 0.08 BAC per se laws. Between June 1998 and October 2000, two additional States and the District of Columbia enacted and began enforcing these laws. Now, in 2004, following the implementation of the combined incentive and sanction program, all 50 States and the District of Columbia have enacted 0.08 BAC per se laws.

The TEA-21 also established other programs to reduce impaired driving, including the Section 410 impaired driving incentive grant program. With the implementation of Section 410, alcohol-related fatalities dropped significantly in 2003, the first such decline since 1999.

# High-Visibility Enforcement

Enforcement alone has its limitations; however, enforcement combined with extensive media support (such as seen with the "Click It or Ticket" Campaign) greatly improves highway safety, particularly in the area of safety belt use. The perceived risk of receiving a citation is increased, even if the actual risk is only slightly higher. Research shows that the public will buckle up if they believe the police are enforcing the law. High-visibility enforcement campaigns, combined with coordinated publicity, have also helped to reduce the number of alcohol-related crashes and increase the use of child restraint systems. Recently, there has been interest in increasing public awareness campaigns to spotlight critical issues such as the dangers of fatigued and distracted driving and the importance of rural emergency management services. Speeding is also a continuing program; in 2003, speeding was a contributing factor in 31 percent of all fatal crashes.

# Public Awareness

Public awareness campaigns can shape public opinion if the advertising is effective, the message is strong, and the media supports the campaign by donating airtime and space. The NHTSA has two examples of how public service messages influence attitudes and behavior. With the help of the "Drunk Driving Prevention" Campaign, begun in 1983, the proportion of traffic fatalities caused by alcohol-related crashes dropped from 60 percent in 1982 to 40 percent in 2004. Sixty-two percent of Americans say they have tried to stop someone from driving drunk, and 90 percent of adults are aware of the tagline "Friends Don't Let Friends Drive Drunk."

Safety belt education is another example of how public awareness can stimulate a behavior change. In 1985, only 21 percent of Americans buckled up. The NHTSA's ad campaign, featuring the crash test dummies "Vince and Larry" helped persuade the country to "don't be a dummy, buckle your safety belt." Using safety belts is now considered the norm, and it's the law in 49 states. Vince and Larry retired a few years ago, as NHTSA found that a strong enforcement message, coupled with vigorous ticketing campaigns, raised safety awareness and raised safety belt usage rates to the highest in America's history—80 percent in 2004.

While donated airtime can have enough of an educational impact to positively affect behavior, it also can be "hit or miss" since there is no way to control when television and radio stations actually play the PSA or when a target audience actually sees the message. Paid advertising, on the other hand, allows an Agency like NHTSA to have more control over when a target audience sees and/or hears a message that is designed to positively affect behavior change.

In 2003, with Congressional funding support for national paid advertising, NHTSA promoted the buckle up message in a campaign called "Click It or Ticket" (the "Click It or Ticket" Mobilization combines high-visibility law enforcement, advertising, and earned media to increase safety belt and child safety seat use). Forty-three States, the District of Columbia, and Puerto Rico used paid advertising to support the mobilization. The campaign continued at the same rate of support in 2004. More than $50 million was spent over 2003 and 2004 in paid advertising with earned media value over both years averaging $13 million. The paid advertising of a strong enforcement message, "wear your safety belt or you *will* get a ticket," along with a strong law enforcement component, helped raise the safety belt use rate by 7 percent.

For the May 2004 "Click It or Ticket" Mobilization, NHTSA made a media buy of $10 million on network and cable television and network radio. The agency also spent $8.6 million on media buys for 17 States—Arkansas, Arizona, California, Florida, Illinois, Maine, Maryland, Mississippi, Nevada, Nebraska, New Mexico, North Carolina, Oregon, Pennsylvania, Utah, Vermont, and Wisconsin. NHTSA also made a separate media buy to support pickup truck campaigns for Arkansas and New Mexico. The States received over $4.2 million in value-added (bonus) media and exposure (including network billboards, liners, live reads, sports tickers, bonus spots, program upgrades, etc.) in support of "Click It or Ticket," and the national safety belt use rate rose to its present level of 80 percent.

## Intelligent Vehicle Initiative

The Intelligent Vehicle Initiative (IVI) of the DOT Intelligent Transportation Systems (ITS) program is a research program that has explored how state-of-the-art advanced technologies can help drivers avoid crashes that would otherwise occur. However, providing drivers with additional in-vehicle information is a complex endeavor that, unless technologies are carefully designed, may even compromise driver safety and efficiency. For this reason, DOT has carefully selected certain IVI services that it considers "prime candidates" for improving driver performance because they (1) improve safety or (2) may impact safety. The program has addressed four major types of crashes: rear-end crashes, road departure crashes, crashes associated with lane changes, and crashes that occur at intersections. The program also addresses how driver inattention and distraction contribute to crashes and how advanced technologies can be used to ameliorate this problem. Work in each of these problem areas consists of basic work in sensors, driver interfaces, and warning/control strategies and culminates in a field operational test of state-of-the-art driver assistance systems. The IVI program has been a landmark effort to develop a solid understanding of how advanced technologies can help improve safety on our public roads. The program will soon conclude as the last four field operational tests are completed during 2005 and 2006. The information gained from the IVI program provides the NHTSA, other DOT agencies, and the motor vehicle industry with a wealth of factual data that will serve as a foundation for future efforts to implement effective driver assistance systems.

## Data Collection

Section 2005 of TEA-21 established a new program of incentive grants to encourage States to adopt and implement effective programs to improve data collection and to link State systems with other State and National data systems. This incentive program calls for evaluating the effectiveness of efforts to improve the system, linking data systems and traffic records with other data systems within a State, and improving the compatibility of the State data system with National data systems. The improvements to data collection will enhance a State's ability to observe and analyze national trends in such areas as crash occurrences, rates, outcomes, and circumstances.

# Highway Safety Programs: Federal Motor Carrier Safety Administration

The trucking industry is large, complex, and dynamic. The FMCSA estimates that there are almost 675,000 motor carriers operating commercial motor vehicles (CMVs) in interstate commerce. Motor carriers vary widely in size, from hundreds of thousands of owner-operators to over 50,000 carriers with 10 or more power units. Nationwide, approximately 7.9 million trucks and nearly 800,000 buses are registered to State departments of motor vehicles. In 2002, there were more than 11.3 million truck and 470,000 bus crossings annually at U.S.-Canada and U.S.-Mexico borders. The agency also has jurisdiction over 6 million commercial drivers.

In 2002, large trucks represented only 3.5 percent of registered vehicles; however, they accounted for 7.5 percent of travel volume on the Nation's highways. Of all the people killed in motor vehicle crashes, 11.5 percent died in crashes involving a large truck (FMCSA defines a large truck as a motor vehicle with a gross vehicle weight greater than 10,000 pounds). Thus, large trucks are overrepresented in fatal crashes. In 2002 crashes involving large trucks, an estimated 4,939 people died and 130,000 were injured in the fourth year in a row of decreasing fatalities; this compared with 4,856 fatalities and 133,000 injuries in 1993. While progress is being made toward meeting the FMCSA's goal of saving lives and reducing injuries by preventing truck and bus crashes, too many people continue to be injured and die as a result of crashes involving large trucks.

According to the Bureau of Labor Statistics, 808 truck drivers died while working in 2002, representing the largest number of on-the-job deaths for any occupation in the United States. With a fatality rate for truck drivers of 25.0 deaths per 100,000 employed, truck driving is the fourth most dangerous occupation in the country. Fatal highway incidents were the most frequent type of all fatal workplace events, accounting for 1,421 of the 5,524 (25 percent) total occupational fatalities. Truck drivers account for nearly 40 percent of all workers losing their lives on the highways.

The FMCSA's strategic objective is to save lives and reduce injuries by preventing truck and bus crashes. This is aligned with and contributes to the DOT Safety strategic objective and Highway Safety performance goal. Progress toward this goal, though, is challenged by annual increases in motor carrier traffic that increase exposure to crashes. Truck vehicle miles traveled (TVMT) have doubled since 1978 and are forecast to increase on the order of 3.4 percent per year. The trend for miles traveled by passenger vehicles, with which CMVs share the highways, is also on the rise, increasing car-truck interaction on the highways and contributing additional exposure to crashes. Without effective safety interventions, fatalities and injuries from truck-involved crashes could be expected to increase commensurate with the increases in TVMT.

## Enforcement Programs

The FMCSA's enforcement authority extends to interstate motor carriers and motor coaches. The FMCSA enforcement operations help ensure compliance with the Federal Motor Carrier Safety Regulations (FMCSRs), and their proven effectiveness in reducing crashes and fatalities on the highways has been borne out in the findings of the Roadside Inspection and Traffic Enforcement Intervention Model and Compliance

Review (CR) Impact Assessment Model. The Congress and the DOT Office of Inspector General (OIG) both emphasize the importance of strong enforcement to ensure motor carrier safety. However, CRs, the agency's primary method for determining compliance, presently reach less than 2 percent of the carrier population.

**Q. What impact do Compliance Reviews have on safety?**

**A.** The FMCSA conducts on-site CRs in order that, through education, heightened awareness of safety regulations, and the enforcement effects of the CR, motor carriers will improve the safety of their commercial vehicle operations and, ultimately, reduce crash incidence. The most recent implementation of FMCSA's Compliance Review Impact Assessment Model indicates that, by having completed CRs on high-risk carriers in 2001, FMCSA contributed to avoiding 1,600 crashes in 2002, including 58 fatal crashes and 690 injury crashes. It is estimated that 67 lives were saved and 1,105 injuries were avoided as a result of these CRs. Additionally, FMCSA annually conducts approximately 2,500 reviews of carriers that have a less-than-satisfactory safety rating and have been identified as continuing to pose a safety risk on the Nation's highways.

The FMCSA undertakes a balanced, targeted enforcement regime comprised of CRs, conditional carrier reviews, new entrant safety audits, enforcement actions for violations to include available sanctions, and a range of border-specific compliance and enforcement activities. This enforcement regime will be focused to increase the FMCSA's reach to those segments of the industry that present the highest safety risk.

## New Entrant

In May of 2002, FMCSA published its New Entrant Safety Assurance Process Interim Final Rule. It became effective January 1, 2003. The agency began conducting audits in April 2003.

The new entrant program targets motor carriers that are "new entrants" into the truck and bus industries and was originally designed to be primarily an educational rather than an enforcement program. However, the agency found that many new entrants were operating without comprehensive knowledge of the requirements and without being in compliance with applicable regulations. The FMCSA has revised the program to give it a greater enforcement focus. The operating philosophy is to address carrier safety problems at the beginning of operations to prevent larger safety problems from developing later on. This approach is a more effective use of limited agency enforcement resources and works to more quickly get unsafe carriers either operating more safely or off the roads.

Studies demonstrate that new entrants have higher crash rates than more established carriers and are less likely to comply with Federal regulations. Given that approximately 40,000 to 50,000 new entrants apply for registration annually, it is clear that attention to this population is imperative. The FMCSA has established the New Entrant Safety Assurance Process whereby all new entrants, in order to register, must certify that they are knowledgeable about the FMCSRs and Federal Hazardous Materials Regulations (FHMRs), and must undergo a safety audit within the first 18 months of registration, prior to receiving permanent operating authority.

In FY 2003, FMCSA and the States performed nearly 7,200 new entrant safety audits. Of these, about 58 percent were performed by FMCSA and 42 percent by the States. In FY 2004, FMCSA and the States plan to perform about 25,000 new entrant safety audits. Through the first 6 months of FY 2004, FMCSA performed 43 percent of the safety audits and the States performed 57 percent.

# Substance Abuse Program

The Omnibus Transportation Employee Act of 1991 authorized DOT to mandate substance abuse management for safety-sensitive employees in the motor carrier industry. In February 2004, FHWA's Office of Motor Carriers published final drug and alcohol testing regulations for drivers operating in commerce with a commercial driver's license. FMCSA is responsible for implementing these regulations and auditing the compliance of motor carriers with these rules. Drug and alcohol checks are performed during every compliance review performed on motor carriers by FMCSA and State enforcement personnel.

# North American Free Trade Agreement

The FMCSA implements the cross-border truck and bus provisions of the North American Free Trade Agreement (NAFTA). Since trucking is the principal means of commercial transportation between Mexico, Canada, and the United States, NAFTA includes a number of provisions that will greatly affect commercial vehicle operations. In preparing to implement the NAFTA access provisions fully, FMCSA has been working aggressively with the States and Mexico to increase enforcement and compliance and to improve safety systems on both sides of the U.S.-Mexico border.

The FMCSA's border program is another important agency compliance and enforcement program. The border enforcement program has provisions as directed in Section 350 of the 2002 DOT Appropriations Act. To ensure that Mexican motor carriers operating in the United States comply with the FMCSRs and FHMRs as required for both U.S. and Canadian motor carriers, FMCSA has established a safety audit process to ensure that Mexican carriers comply prior to operating in the United States beyond the commercial zone. FMCSA and State partners will maintain a strong safety focus at the border crossings for Mexican trucks entering the country. The FMCSA's border enforcement program will support activities such as inspection of vehicles; electronic verification of driver licenses, proof of insurance, and operating authority; public education and outreach; safety audits; compliance reviews; and, enforcement actions (addresses OIG Audit MH-2003-041, "Implementing NAFTA-II").

## *Southern Border*

Border grant funds are used to support State inspectors involved in inspecting foreign carriers along the border. State truck and bus safety enforcement agencies along the southern border have enhanced their presence along the border by increasing their staff to over 300 inspectors, staffing 25 commercial cargo crossings. As a result of these increased resources, the number of State border inspections is targeted to increase from approximately 200,000 in FY 2004 to approximately 400,000 in FY 2005. The States also use FMCSA grant funding to deploy officers in mobile units to conduct roadside inspections and perform inspections of commercial passenger carriers at other crossings, nonfixed facilities, and destination points in the United States. In addition, grant funding is used to construct permanent inspection facilities to handle the flow of traffic and to provide safer locations to conduct inspections.

## *Northern Border*

In August 2002, the President signed the 2002 Supplemental Appropriations Act for Further Recovery From and Response to Terrorist Attacks on the United States (S. 2551). This legislation provided funding to FMCSA to conduct a northern border safety and security study. One objective of the study is to provide recommendations on the roles and responsibilities FMCSA and State commercial vehicle enforcement agencies should play at the northern border with respect to commercial vehicle security. The study will be completed and a final report issued in 2004. At the completion of the study, FMCSA will review the report and take action to plan and implement the findings and recommendations, as appropriate.

## Performance and Registration Information Systems Management Program

The FMCSA also implements the Performance and Registration Information Systems Management (PRISM) Program, a grant program to States with the goal of improving motor carrier safety through a comprehensive system of identification, education, awareness, safety monitoring and treatment. In 2004, there are 32 States in the PRISM Program. The PRISM initiative has two major elements. The Commercial Vehicle Registration Process establishes a system of accountability by ensuring that no vehicle is registered without identifying the carriers responsible for the safety of the vehicle during the registration year. The second element is the Motor Carrier Safety Improvement Process, designed to improve the safety performance of motor carriers that have repeated safety problems. Carriers that do not improve their safety performance face progressively more stringent penalties, including Federal "unfit" or "imminent hazard" designations and the possible suspension of vehicle registration by the State.

## Outreach

The FMCSA conducts outreach to promote safe operation and best highway safety practices for commercial motor vehicles and passenger vehicles with whom they interact on the highways. Studies indicate that a large share of fatal crashes involving a CMV have causal factors attributable to the passenger vehicle involved in the crash. Of course, the overwhelming majority of casualties are the occupants of passenger vehicles. The impact of present enforcement funded by the Motor Carrier Safety Assistance Program is significant, but is largely limited in its reach to noncommercial drivers. More needs to be done to heighten awareness of the hazards of driving around trucks, consistent with broader DOT highway safety objectives. To change behaviors and heighten appreciation of safe operating practices, the agency identifies inherent problems or areas for improvement and targets educational materials and outreach countermeasures at affected audiences. Appropriately, FMCSA targets specific outreach aimed at changing the knowledge, attitudes, and behaviors of commercial motor carriers, CMV drivers, and passenger vehicle drivers driving in the vicinity of large trucks. Progress is being made in communicating about safe driving practices around trucks. Encouragingly, fatal crashes involving single large trucks and passenger vehicles were reduced 7.3 percent between 2000 and 2002.

Educating carriers about the benefits of operating safely, and in compliance with safety regulations, is much more advantageous to both the carrier and the enforcement community than imposing enforcement sanctions on the carrier (National Transportation Safety Board H-99-007 and H-99-008 recommend minimum standards for motor coach safety briefing materials and a requirement for pre-trip passenger briefings). In 2004, FMCSA completed the *Unsafe Driving Acts of Motorists in the Vicinity of Large Trucks* video as well as developed a model-training curriculum regarding sharing the road with CMVs. The FMCSA also published a pamphlet entitled *Safety Management for Motor Carriers: Learning from the Leaders in Safety Management Practices,* a best-practices approach to motor carrier safety.

Driver error in both passenger and commercial vehicles is the leading cause of crashes. Driving in or around large trucks and buses is particularly hazardous, resulting in a substantial portion of the nearly 5,000 truck- and bus-related fatalities annually. Consistent with DOT's approach to broader highway safety management, FMCSA addresses this issue by developing strategies to educate all drivers to share the road with large trucks. "Share the Road Safely" develops and implements education and outreach safety strategies combined with traffic enforcement to improve the way all highway users operate in or around trucks (The Government Accountability Office [GAO] audit report, GAO-03-680, recommends better evaluation of outreach initiatives).

The FMCSA has worked very closely with NHTSA to determine the best avenues for educating both the motoring public and CMV drivers, including incorporating such information into driver education courses. An integral part of the program includes a demonstration project that combines education, communication, and a high-visibility enforcement effort. In addition, FMCSA has taken steps to address recommendations offered by GAO in May 2003 to improve the way it measures the effectiveness of the "Share the Road Safely" Program. The FMCSA has adopted a systematic strategy for evaluating "Share the Road Safely" initiatives using the Selective Traffic Enforcement Program model developed by NHTSA. These improvements to the program, plus over 10 years of experience in reaching the motoring public on the limitations of CMVs and safe driving practices in proximity to large CMVs, puts FMCSA in a position to take the lead for this important highway safety program.

### *Increasing Driver Safety Belt Use*

A recent study conducted by FMCSA showed that only 48 percent of all commercial drivers wear safety belts as compared with 79 percent of passenger car drivers. Increasing safety belt usage could eliminate many of the 171 truck driver ejection fatalities each year. The FMCSA's CMV Safety Belt Usage Improvement Program is designed to support DOT safety belt objectives by increasing the level of safety belt usage by the target audience to improve their chance of surviving a CMV crash. This education/outreach program promotes the use of safety belts by highlighting the risks of not wearing one, combined with promoting traffic enforcement. The goal is to increase CMV driver safety belt usage by at least 15 percent from 2006 to 2009. Performance will be assessed by a comparison of CMV driver safety belt usage and CMV driver safety belt usage improvement rates. On December 9, 2003, DOT established a Commercial Motor Vehicle Safety Belt Partnership. This is a government/private industry partnership dedicated to increasing safety belt usage among CMV drivers. The FMCSA is implementing a five-point plan that addresses partnership, research, education, and outreach materials, as well as enforcement activities.

### *Motorcoach Safety*

Also, there is increasingly a role for outreach in communicating information about traveling safely by motorcoach. Presently, most consumers seeking motorcoach passenger transportation service buy this service based largely on price. The FMCSA seeks to develop a commercial passenger vehicle education and outreach campaign, "Choosing a Safe Motorcoach Company," to help a consumer also consider safety issues in their transportation choices. This approach has the additional benefit of encouraging motorcoach companies to maintain good safety records.

## Data Collection

Data collection is a vital component of the Department's safety efforts. Data are used to identify problems, target enforcement actions, evaluate safety programs, monitor trends, and guide resource allocations to address highway safety problems. Several modal agencies within DOT are involved in collecting data. The NHTSA collects information on all fatal crashes and a sample of all police reportable crashes. The FMCSA collects crash and citation data on all medium and heavy trucks; vehicles carrying hazardous material; and buses with seats for more than nine occupants that are involved in a fatal, injury, or tow-away crash. The FHWA collects information through the Highway Performance Monitoring System. The FHWA, FMCSA, NHTSA, Bureau of Transportation Statistics (BTS), and FRA represent DOT at the International Traffic Records Forum, an annual meeting that addresses worldwide crash data collection efforts. The FHWA's Office of Safety has also supported the National Model. This model is a software package that helps the local law enforcement agencies collect accurate crash information.

The FMCSA and NHTSA are collaborating on a study to determine the causes of large truck crashes that result in a fatality or serious injury. The Large Truck Crash Causation Study involves data collection at 24 sites nationwide. Data collection ended December 31, 2003, and the final database will be ready for analysis in late 2004.

Data collection at the national level is sometimes problematic. Although all States collect crash data, all States do not follow the exact same definitions or attributes in collecting crash data. The FHWA, FMCSA, NHTSA, and BTS support the implementation of Model Minimum Uniform Crash Criteria (MMUCC). MMUCC were developed in response to States' requests to develop a minimum standardized set of data elements. This minimum set promotes comparability of data within the highway safety community and serves as a foundation for State crash data systems.

The FMCSA maintains the Motor Carrier Management Information System crash file that is designed to be a census of all medium and heavy truck and bus crashes. However, FMCSA only received information on approximately 70 percent of all reportable crashes. Congress has given FMCSA funds to share with the States to improve the collection and analysis of truck and bus crash data.

Reporting data timely, accurately, and completely is necessary to determine the extent of the highway safety problem and to target enforcement and education programs.

# Transit Safety Programs: Federal Transit Administration

The FTA has six programs designed to work continuously to improve the safety and security of the Nation's transit systems: (1) Modal Safety, (2) Information Sharing/Technical Assistance, (3) Training and Education, (4) Substance Abuse, (5) Security Initiative, and (6) Data Collection and Analysis. Additionally, FTA works to improve safety through the DOT's Intelligent Vehicle Initiative.

## Modal Safety Program

The Modal Safety Program has three key components:

- Rail Fixed Guideway
- Railroad
- Bus.

The Rail Fixed Guideway component of the Modal Safety Program was implemented in 1995 when FTA published a final rule requiring States with fixed guideway systems to designate an independent oversight agency to oversee the safety of rail systems not regulated by FRA. Currently, 23 States and 37 systems are included in this program, but this number will change as new systems are opened. FTA audits the affected States for compliance with the rule and provides technical assistance.

The Railroad component consists of an ongoing coordination program with FRA on issues that affect the transit industry. The FTA participates with FRA in the development of shared track and shared corridor safety standards as well as the granting of waivers for shared track operations. The FTA is a member of the Rail Safety Advisory Committee for matters relating to commuter railroads. Three subprograms under the railroad component are (1) Railroad Grade Crossing Safety, (2) Rail Vehicle Materials Safety, and (3) Train Control Centers Safety.

Under the Railroad Grade Crossing Safety subprogram, FTA demonstrates, evaluates, and deploys innovative grade crossing technologies. The strategic deployment of these technologies enhances transit's ability to alert motorists and pedestrians of oncoming trains, improve passive and active warning signs and signals for light rail and commuter rail transit, develop cost-effective off-track train presence detection systems, and assess safety data to determine target areas for technology enhancements.

Under the Rail Vehicle Materials Safety subprogram, FTA is working with FRA to develop fire safety standards (flammability and smoke emissions) for materials used in the interior of rail vehicles and to test these standards. The FTA is also working with the Interagency Fire and Materials Working Group of the Federal government to produce uniform fire performance guidelines for any materials that may be used by government agencies. This effort includes testing new composites that may be considered for use in new railcars and buses.

Under the Train Control Centers Safety subprogram, FTA is working with FRA to assess the adequacy of rail control centers for rail transit systems operating on rights-of-way with freight and intercity passenger services. The FTA is in the process of evaluating control centers' equipment and personnel, focusing on the effectiveness of these centers during peak times. Additional work burdens will fall on control centers with the expansion of commuter service on freight railroad rights-of-way. In support of this subprogram, FTA completed an assessment of rail multimodal management centers to understand information exchanges between rail agencies that operate with common passenger terminals, shared tracks, shared rights-of-way, and joint control centers. Information exchanges were classified into four categories: operations, traveler-related functions, safety, and security. In each area, information-sharing opportunities exist, and as joint-use and mixed rail corridor operations increase, the utility of these centers will continue to grow.

The Bus component of FTA's Modal Safety Program comprises two parts. The Bus Testing Program ensures that any deficiencies in new bus models are corrected before being put into revenue service. Since its implementation, this program has successfully identified more than 4,000 malfunctions ranging from minor problems to serious design deficiencies. A state-of-the-art facility in Altoona, Pennsylvania, has tested 150 new bus models since 1992. In 1998, FTA initiated the Modal Transit Bus Safety and Security Program. This program established the core safety and security program elements that all transit bus agencies should implement. The core program elements involve security, driver/employee selection, driver/employee training, vehicle maintenance, drug and alcohol abuse programs, and safety data acquisition and analysis.

## Information Sharing and Technical Assistance Program

The FTA's Information Sharing and Technical Assistance Program includes a clearinghouse that is the focal point for all requests for information, materials, and resources currently available on transit safety, security, and related technologies; a transit safety and security Web site describing ongoing programs and new initiatives; and technical assistance, guidelines, and newsletters on safety issues.

### *Threat and Intelligence Sharing*

Homeland Security Presidential Directive (HSPD) -7 encouraged the creation of private sector Information Sharing and Analysis Centers (ISACs) to protect various critical infrastructure areas, such as public transit, from intentional harm from individuals or groups. At the request of DOT, the Surface Transportation ISAC (ST-ISAC) was formed. The Public Transportation ISAC (PT-ISAC) operates as a node within the ST-ISAC to take advantage of the overarching issues specifically related to public transportation. On January 23, 2003, the American Public Transportation Association (APTA) was awarded status as Sector Coordinator by DOT in the creation of the PT-ISAC to further promote security for the public transportation industry. The FTA provided a grant of $1.2 million to APTA to fund the initial 2 years of this project, after which the ISAC was required to become self-sufficient. APTA is now working with the Department of Homeland Security (DHS) and will participate in the Homeland Security Information Network program that will allow for the continued dissemination of threat and intelligence information to the transit industry.

# Training and Education Program

The FTA provides safety and security training to the transit industry through the Transportation Safety Institute (TSI), the National Transit Institute (NTI), Johns Hopkins University, and the Volpe Center. The curriculum includes courses such as Transit Workplace Safety and Security, System Security Awareness for Transit Employees and Security Incident Management for Transit Supervisors, Effectively Managing Transit Emergencies, Counterterrorism Strategies for Transit Managers, Terrorist Activity Recognition and Reaction, Transit Rail Accident Investigation, Transit Rail System Safety, Fundamentals of Bus Accident Investigation, and Substance Abuse Management. Through TSI, FTA has provided training to over 85,000 transit industry employees since 1971, including more than 45,000 since 1998. Through NTI, FTA has conducted three Workplace Safety and Security train-the-trainer courses in FY 2003 and has delivered four additional courses in FY 2003 and FY 2004. In FY 2003, through the Volpe Center, FTA conducted nine drug and alcohol seminars drawing over 950 transit participants.

# Substance Abuse Program

The Omnibus Transportation Employee Act of 1991 authorized DOT to mandate substance abuse management for safety-sensitive employees in the transit industry. In February 1994, FTA published final drug and alcohol testing regulations for transit employers. The FTA is responsible for implementing these regulations and auditing the compliance of transit operators with these rules. As of September 30, 2004, FTA has conducted 233 audits since the inception of the drug and alcohol audit program in 1997.

# Security Initiative Program

In the post-9/11 environment, FTA has launched an extensive security initiative program, substantially funded by $23.5 million in security funds including in the Defense Department Supplemental Appropriation of 2002. Key elements of the FTA security initiative include the following:

- Security readiness assessments/threat and vulnerability assessments conducted at the 37 largest transit agencies
- Grants of up to $50,000 for conducting emergency drills and exercises provided to 83 of the largest transit agencies
- Security roundtables for transit security executives and officials representing the 30 largest transit agencies
- On-site security and emergency management technical assistance provided to the 50 largest transit agencies (currently in progress, with 15 sites now completed)
- Research and technology projects in areas such as chemical/biological detection, mapping based on geographic information systems, security design guidelines, emergency communications systems, and integrated intrusion detection
- Development of an FTA top 20 security action item list for transit agencies
- Enhancements and additions to the NTI and TSI transit security training curriculum, including new counterterrorism training

- Development of protective measures for transit agency implementation, based on the Homeland Security Advisory System color-coded threat level system
- Initiation of a public transit ISAC to facilitate improved intelligence sharing in the transit industry
- 19 Connecting Communities regional forums across the country to improve interagency awareness coordination by bringing together emergency first responders (at the local, regional, State, and Federal levels) and transit agency security and emergency management officials
- Development and launch of a Transit Watch security public awareness campaign for transit agencies, modeled after the Highway Watch Program and other similar "eyes and ears" awareness initiatives
- Development and publication of the *System Security and Emergency Planning Guide* to serve as a resource compendium for transit agencies.

Throughout the ongoing process of enhancing and improving the transit industry's state of security readiness in the post-9/11 climate, FTA has strategically focused its efforts and resources on three key priorities:

- Training (including general security awareness training for all transit employees and specialized advanced security training for law enforcement, first responder, and other personnel with direct responsibilities for transit security)
- Public awareness (as exemplified by the Transit Watch public awareness program)
- Emergency preparedness (the scope of which includes both natural and man-made disasters).

In concert with other Federal-level agencies, and as an integral modal agency of DOT, FTA has also focused considerable effort in working closely, sharing information, and coordinating programs with the Department of Homeland Security (including such agencies within DHS as the Transportation Security Administration, Office for Domestic Preparedness, U.S. Coast Guard, and Federal Emergency Management Agency).

## Data Collection and Analysis Program

All transit agencies must submit safety and security data into the FTA National Transit Database Safety and Security Module. These data are published annually in the *Transit Safety and Security Report* (formerly the *Safety Management Information Statistics Report*). It provides FTA and the transit industry with a basis for identifying key safety concerns as well as possible solutions. The FTA has extended its efforts by collecting transit vehicle accident and incident causal data through State Safety Oversight Annual Reporting and the February 2002 revision of the National Transit Database, which expands the range of causal data collected and the frequency of its reporting.

## Intelligent Vehicle Initiative

The FTA is also working to improve safety through the DOT's Intelligent Vehicle Initiative. Among the elements under investigation are precision docking systems and collision warning systems. Precision docking systems will allow buses to be automatically maneuvered into a loading zone or maintenance area, allowing easier access for passengers and more efficient maintenance operations. Collision warning systems will help the bus driver and surrounding vehicle drivers operate their vehicles more safely.

# CHAPTER 12

## 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 AM and PM "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 12-1.*

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.

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.

***Exhibit 12-1*** *Sources of Congestion*

| | |
|---|---|
| **Peaks in Demand** | Recurring weekday commuting in urban areas<br>Recurring weekend shopping in urban areas<br>Seasonal vacation travel on rural and intercity highways<br>Major generators of freight traffic (ports, factories, distribution centers)<br>Large events (sporting venues, concerts, disasters) |
| **Capacity Limitations** | Network extent and coverage<br>Bottlenecks (interchanges and intersections, converging lanes, steep slopes, sharp turns)<br>Impediments (toll booths, border crossings, truck inspection stations)<br>Poor traffic control (traffic signal coordination)<br>Traffic calming |
| **Temporary Capacity Reductions** | Crashes and breakdowns<br>Work zones<br>Weather<br>Street closures for events (parades, street fairs, marathons, disasters)<br>Rail-highway grade crossings<br>Temporary curb-side obstructions (especially curb-side parking and construction adjacent to rights-of-way)<br>Law enforcement actions |

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 requirements presented in Chapter 7 and developed using the 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 three and a half 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 13, 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 12-2,* 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 by Cambridge Systematics, Inc., *Traffic Congestion and Reliability: Linking Solutions to Problems.*

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

**Exhibit 12-2** *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<br>Work zones<br>Bad weather<br>Vehicle crashes and breakdowns<br>Double-parked vehicles<br>Lack of information on route conditions and alternatives | Reroute traffic or adjust lanes and traffic control<br>Snow and ice removal<br>Incident response vehicles<br>Parking management<br>Traveler information on disruptions and alternatives |
| **Timeliness** | All of the above plus:<br>Daily and seasonal peaks of heavy traffic<br>Bottlenecks and impediments<br>Poorly coordinated traffic control | All of the above plus:<br>Adaptive signal control<br>Ramp meters<br>Reversible lanes<br>Electronic toll collection<br>Curbside parking management<br>Adjustments to carrier schedules |
| **Safety** | Vehicle crashes and breakdowns, work zones, and bad weather<br>Driver behavior<br>Poor facility design and traffic control<br>Poor physical condition of facilities | Detect and respond to crashes<br>Traveler information on location of crashes and problem areas and on alternative routes<br>Emergency medical services<br>Driver education<br>Better signage and markings<br>Identify and correct unsafe conditions |
| **Security** | Property theft<br>Personal assaults<br>Military logistics<br>Terrorism<br>Regional disasters | Visible monitoring as a deterrence<br>Reroute traffic or adjust lanes and traffic control<br>Detect and respond to threats and incidents<br>Identify and correct unsafe conditions<br>Threat assessments and countermeasures and disaster response plans<br>Traveler information |

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.

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

**Q.** **How do Intelligent Transportation Systems relate to operations strategies?**

**A.** 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 its ITS systems: the Road Flood Warning Systems and the Regional Incident Management System.

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, managing resources at the incident, and providing area-wide traffic control 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 traffic management centers.

## Q. How does the FHWA monitor the deployment of operations strategies?

**A.** The FHWA monitors the progress of several organizational objectives as part of its performance measurement program. This includes the level of Intelligent Transportation Systems (ITS) deployment; the status of 511 deployment; the development of ITS architectures; the creation of congestion partnerships; and the effectiveness of state and regional roadway operations and work zone, incident, and safety management.

A goal of the U.S. Department of Transportation since 1996 is to integrate deployment of ITS in the top 75 (later expanded to 78) metropolitan areas. To monitor progress toward fulfilling this goal, the ITS Joint Program Office tracks deployment of the nine components that make up ITS infrastructure: Freeway Management, Incident Management, Arterial Management, Emergency Management, Transit Management, Electronic Toll Collection, Electronic Fare Payment, Highway-Rail Intersections, and Regional Multimodal Traveler Information. In addition, the integration of links between agencies operating the infrastructure is also tracked (see http://itsdeployment2.ed.ornl.gov).

The FHWA also separately tracks the implementation of 511 systems and the development of ITS architectures. The 511 tracking system monitors states and cities where 511 service is currently available as well as states that have received funding under the 511 Planning Assistance Program (see http://www.fhwa.dot.gov/trafficinfo/511.htm). The state and regional ITS architecture tracking system monitors the level of architecture development in all 50 states, the District of Columbia, and Puerto Rico. Architectures are classified in one of four levels of development: not needed, have not started, under development, and ready for use (http://ops.fhwa.dot.gov/Travel/Deployment_Task_Force/ ReglArch.htm).

Another goal of the FHWA is to foster regional partnerships aimed at mitigating congestion. To monitor progress, the FHWA is tracking on an annual basis the number of new congestion partnerships developed in each state or metropolitan area. In addition to assessing the status of congestion partnerships in the top 75 metropolitan regions, the FHWA surveys its Division offices on the maturity and effectiveness of partnerships in each state.

Over the past few years, the FHWA has developed several self-assessment tools for states and regions to measure their success in several areas of operations management. These tools are based on concepts developed for the Baldridge Award and are intended to help transportation agencies identify areas for improvement.

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 transportation management centers. 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.

# Conclusion

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.

# CHAPTER 13

## Freight Transportation

# Freight Transportation

Trucking is both a critical component of the Nation's economy and a concern to the traveling public, which shares increasingly crowded highways with freight-hauling vehicles. For reasons discussed in this chapter, freight is a growing part of traffic on our Nation's highways. This growth is straining the condition and performance of the highway system, which in turn affects 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 three-fourths of the value and two-thirds of the tons of everything shipped by manufacturers, wholesalers, and other industries in the United States in 1997. An additional 12 percent of the value of everything shipped by those establishments went by mail and courier services that used trucks for at least part of their trip. The Nation's highways handled over 1 trillion ton miles of commodities in 1997. This task was accomplished by approximately 21 million trucks traveling a total of more than 412 billion miles. The number and mileage of trucks by industry is shown in *Exhibit 13-1.*

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 13-2,* this growth shows no signs of abating. Freight tonnage is forecast to increase by 70 percent between 1998 and 2020. Trucking is forecast to account for the majority of the projected increase.

## Trucks and Congestion

In recent decades, trucking grew from a small portion of highway traffic to a significant component of intercity traffic and a major contributor to urban congestion. Although commercial vehicles account for less than 10 percent of all vehicle miles of travel, truck traffic is growing faster than passenger vehicle traffic on U.S. highways. On one-fifth of the mileage of the Interstate System, trucks account for more than 30 percent of all vehicles. The percentage of trucks in the traffic stream is likely to grow substantially if the growth in trucking continues to outpace the growth in passenger travel.

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 grades, lane width, and type of highway.

**Exhibit 13-1** *Trucks, Truck Miles, and Average Miles Per Truck by Major Use*

| | 1997 Trucks (Thousands) | Percent Change from 1992 to 1997 | 1997 Truck Miles (millions) | Percent Change from 1992 to 1997 | Average Miles per Truck 1997 (thousands) | Percent Change from 1992 to 1997 |
|---|---|---|---|---|---|---|
| Total Trucks | 72,800.3 | 23.0 | 1,044,235.0 | 32.8 | 14.3 | 7.5 |
| Agriculture | 3,377.8 | –5.0 | 37,495.4 | –5.1 | 11.1 | V |
| Forestry and Lumbering | 276.7 | 4.6 | 5,579.8 | –8.0 | 20.2 | –11.8 |
| Mining and Quarrying | 250.7 | 13.7 | 4,679.3 | 5.9 | 18.7 | –6.5 |
| Construction | 6,033.9 | 21.0 | 108,145.0 | 38.4 | 17.9 | 14 |
| Manufacturing | 729.4 | –7.3 | 16,965.8 | –2.5 | 23.3 | 5.4 |
| Wholesale Trade | 1,264.6 | 11.3 | 32,462.4 | 24.4 | 25.7 | 11.7 |
| Retail Trade | 2,243.8 | 15.0 | 40,273.7 | 15.6 | 17.9 | V |
| For Hire Transportation | 1,059.4 | 19.1 | 72,854.9 | 40.5 | 68.8 | 18 |
| Utilities | 663.8 | 22.7 | 9,437.6 | 25.8 | 14.2 | 2.2 |
| Services | 4,233.5 | 35.5 | 71,034.5 | 45.7 | 16.8 | 7.7 |
| Daily Rental | 508.0 | 65.1 | 13,067.7 | 90.4 | 25.7 | 15.2 |
| One Way Rental | 31.2 | 82.5 | 656.4 | 71.7 | 21.1 | –5.8 |
| Personal Transportation | 50,934.5 | 25.9 | 631,346.5 | 36.1 | 12.4 | 7.8 |
| Not in Use | 1,193.1 | 21.6 | 236.0 | –50.0 | 0.2 | –60.0 |

*Source: U.S. Dept of Commerce, Bureau of the Census, Vehicle Inventory and Use Survey, 1997, Report EC97TV-US, Table 2a.*

**Exhibit 13-2** *Estimates and Forecasts of Total Freight*

| | Tons (Millions) | | | Value (Billions $) | | |
|---|---|---|---|---|---|---|
| | 1998 | 2010 | 2020 | 1998 | 2010 | 2020 |
| **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 * | 864 | 1,090 | 1,259 | NA | NA | NA |
| **Total International** | **1,787** | **2,556** | **3,311** | **1,436** | **3,187** | **5,879** |
| **Total Domestic and International** | **15,271** | **21,376** | **25,848** | **9,312** | **18,339** | **29,954** |

* Includes international shipments moved via pipeline or by unspecified mode.

*Source: FHWA, Freight Analysis Framework.*

**Q.** How is freight transportation performance measured?

**A.** The volume of freight moved on the U.S. transportation system has grown dramatically in recent years and is expected to increase by 70 percent by 2020. As demand for freight services grows, concerns intensify about capacity sortfalls and congestion. Understanding and improving freight flows is becoming a high priority among decision makers 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, is sponsoring the Travel Time in Freight Significant Corridors project to develop real-time performance measures for key freight corridors. This project supports the DOT's strategic goals of mobility and global connectivity.

The project uses advanced vehicle tracking and mapping technologies to determine trucks' average vehicle speeds and travel times for segments of "freight-significant" highway corridors or for the entire length of a corridor. Changes in travel speeds and times could be correlated with bottlenecks and other impediments to freight movement. Transportation planners and other professionals could use this information to identify areas in need of improvements and to prioritize future projects.

A related effort is Transport Canada's Border Wait-Time Project, which used a Global Positioning System (GPS) to estimate truck wait-times at the U.S.-Canada border. The project demonstrated the value of using GPS as a source of empirical data on wait-times and congestion patterns. The results of this effort will be used to further expand R&D efforts of mutual interest to the Canadian government and the trucking industry.

Trucks contribute significantly to congestion in urban centers. Trucks account for at least one-fifth of delay for all vehicles in the 50 worst urban bottlenecks in the Nation identified by the American Highway Users Alliance. 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.

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. In 2002, 434,000 trucks with gross vehicle weight ratings greater than 10,000 pounds were involved in traffic crashes in the United States. Of this total, 4,542 were involved in fatal crashes. As indicated in Chapter 11, a total of 4,939 people died and another 130,000 were injured in truck crashes.

Truck occupants accounted for only 14 percent of those who died in crashes involving a large truck. The majority of the fatalities in these crashes were occupants of another vehicle (79 percent). The remaining 7 percent were pedestrians or bicyclists. Truck tractors pulling semi-trailers accounted for 63 percent of the trucks involved in fatal crashes and approximately 50 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 2002, trucks involved in fatal and nonfatal crashes while carrying hazardous materials were 4 percent and 2 percent respectively. 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 1997 Vehicle Inventory and Use Survey, 70,000 trucks with typical operating weights at or above 80,000 pounds drove 3.8 billion miles (U.S. Department of Commerce Census 1997). The wear and damage to the highways caused by heavy vehicles is a frequent topic of highway cost allocation studies. The last FHWA cost allocation study found that trucks are responsible for 40 percent of FHWA program costs, while accounting for less than 10 percent of total VMT.

## 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 $310 billion to U.S. Gross Domestic Product and employed approximately 4.2 million people in 2003.

Trucking is a significant component of the cost of doing business in the United States. According to 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.

Estimates of the cost of unreliable transportation have been presented in two recent academic papers. Shirley and Winston estimate that because of congestion, each 10 percent increase in vehicle miles traveled produces at least a $1 billion increase in annual logistics costs. They state their belief 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. Academic work by Winston and Langer estimate that the cost of congestion to the highway freight sector in 1997 was about $10 billion (in 2000 dollars), with a cost to motor carriers of about $2.5 billion and to shippers of about $7.6 billion.

## Special Investment Needs of Freight

Most investment requirements related to truck movement are captured in the estimates provided in Chapter 7, which are largely derived from the Highway Economic Requirements System (HERS) and National Bridge Investment Analysis System (NBIAS) models. The modeling procedures used in HERS take into account such factors as trucks' share of average daily traffic on each segment and ascribe higher values of time to commercial truck movements than to trips by passenger vehicles.

**Q.** **What is the value of time assumed for large trucks in this report?**

**A.** This report assumes a value of time of $25.24 per vehicle hour for large trucks, compared with $15.71 for cars. Timely and reliable trucking is essential to an economy in which businesses keep inventories low and use just-in-time delivery to keep costs down. This report assumes a "reliability premium" of 200 percent, meaning that estimated nonrecurring delay is valued at twice the cost of estimated recurring delay.

In other studies in the United States and in Europe, estimated values of time for trucking range as high as $193.80, with a median value among the studies of $40 and a mean of $51.80. The value of reliability (i.e., the cost of unexpected delay) is another 50 to 250 percent higher.

The HERS and NBIAS models, however, do not directly estimate investment requirements for system components such as rest areas, intermodal connectors or border crossings (discussed below), or for rail-highway grade crossings (discussed in Chapter 19). The investment requirements identified for these system components cannot be viewed as being strictly additive to the amounts reported in Chapter 7 because some of these costs may be accounted for indirectly within the analytical models. Chapter 22 describes some of the long-term issues relating to capturing these types of costs more directly in future analyses.

## *Rest Areas*

Crash data from the Federal Motor Carrier Safety Administration indicate that driver fatigue is a primary factor in 4.5 percent of truck-related crashes and a secondary factor in an additional 10.5 percent. The lack of parking for fatigued drivers may be a contributor to these incidents. Therefore, the probability that an insufficiency of safe parking places contributes to crashes, along with the public recognition of the greatly expanded level of commercial vehicle activity and the tighter time frames for product delivery, has helped to highlight the need for abundant, safe, and secure commercial vehicle parking for off-duty rest.

In response, TEA-21 called for a study of commercial vehicle rest parking facilities to inventory available spaces nationwide, determine current and projected shortages, and recommend solutions that could help satisfy the need for more parking, especially at night. Now completed, the *Report to Congress on the Adequacy of Parking Facilities* makes four recommendations.

- First, the report found that there is an estimated peak demand for approximately 287,000 truck parking spaces at both privately owned truck stops and travel plazas (hereinafter referred to as "privately run facilities") and at public rest areas serving those Interstate Highways and National Highway System (NHS) routes carrying more than 1,000 trucks per day.

- Second, the report found that an estimated 315,850 public and privately owned parking spaces are currently available to serve Interstate and NHS routes carrying more than 1,000 trucks daily. Roughly 10 percent of these available spaces are found at public rest areas and 90 percent at the privately owned facilities.

- Third, surveyed drivers overwhelmingly prefer privately run facilities for rest of two hours or more. Public rest areas are preferred for stops of less than 2 hours (45 to 19 percent). Private parking is preferred for its amenities (e.g., showers, food service), while public parking is preferred for ease of access and convenience to the roadway.

- Finally, 21 percent of the parking now used by drivers to obtain required rest appears to come from nontraditional rest parking locations (e.g., loading docks, company terminals, fast food restaurants, shopping centers).

Results of a driver survey, inventory, and modeling activity indicated that shortages of both public and private parking spaces may exist in at least 12 States, with shortages generally far less common at the privately run facilities.

Similarly, 23 percent of the demand for truck parking spaces was determined to be at public rest areas, although only 10 percent of the supply is available there, according to surveyed drivers. To the extent that drivers will substitute available parking at a privately run facility for that unavailable at a public one is uncertain. However, space at privately owned truck stops may be able to offset identified shortages at public rest areas in up to 35 States.

In the *Report to Congress on the Adequacy of Parking Facilities,* the U.S. Department of Transportation recognized that the larger, privately run facilities should continue to be the principal suppliers of commercial parking. Actions to expand or improve both public and private facilities, however, should be supported through (1) innovative funding initiatives, (2) cultivation and expansion of joint public-private initiatives to supply needed spaces, (3) greater use of non-traditional parking sites for truckers, (4) use of emerging technologies to provide "real-time" information to drivers about parking availability, and (5) improved signage along NHS rights-of-way to inform drivers about upcoming facilities.

## *Intermodal Connectors*

The investment needs of intermodal connectors were estimated in a 2000 FHWA study for Congress. Many large intermodal terminals are connected to the intercity highway network by small, under-maintained roads. The report on the condition and performance of intermodal connectors identified 517 freight-only terminals, including ocean and river ports, truck/rail facilities, and pipeline/truck facilities. In addition to these freight-only terminals, 99 airports that handle both passenger and significant amounts of freight were included in the list of freight intermodal terminals. The report concluded that highway connectors to ports had twice the percentage of mileage with pavement deficiencies as non-Interstate routes on the NHS. Connectors to rail terminals had 50 percent more mileage in the deficient category than non-Interstate NHS routes. Connectors to airport and pipeline terminals appeared to be in better condition than connectors to rail terminals; they showed about the same percentage of mileage with pavement deficiencies as non-Interstate NHS routes. The report also identified geometric and physical conditions of connectors. However, it did not include an assessment of needed improvements or investment requirements. Supplemental analysis conducted since the release of that report has indicated that approximately one-third of the connector system is in need of additional capacity based on current congestion levels. Of the remaining connector mileage, 469 miles need pavement or lane width improvements, while 243 miles have adequate pavement, lane, and shoulder width.

## *Border Crossings*

In addition to the intermodal connector problem and congestion on urban and intercity highways, many trucks have to deal with increasing delay at border crossings and other gateways. The United States shares a 5,525-mile border with Canada and a 1,989-mile border with Mexico. The U.S. maritime border includes 95,000 miles of shoreline and navigable waterways. Additionally, many airports handle international traffic throughout the country. All people and goods entering the United States legally must enter through one of over 300 land, air, or sea ports-of-entry (POEs), which are controlled POEs into the United States from foreign countries. In 2001, $1.35 trillion in imports and $1 trillion in exports passed through POEs. The Federal Motor Carrier Safety Administration is present at land POEs for truck safety inspections; and other transportation agencies play a vital role in building, operating, and maintaining the roads, rails, bridges, and tunnels connecting to POEs. To ensure safe, secure, and efficient trade requires close and continuous coordination among inspection and enforcement agencies operating within the POEs and transportation agencies that directly and indirectly support border operations.

# Conclusion

Highway condition and performance, including congestion, have a significant effect on the costs and efficiency of trucking. The importance of freight transportation in general and trucking in particular is increasingly recognized by agencies at all levels of government and will be the subject of extensive analyses and policy considerations in the years ahead.

# CHAPTER 14

# The Importance of Transit

# The Importance of Transit

## Transit Benefits

Transit provides benefits for people who choose to ride it, as well as for people who do not. Those who ride transit because they have no alternative means to travel reap the rewards of enhanced mobility, including access to jobs, education, health services, community activities, and friends and family. Those who choose to ride transit despite access to private transportation alternatives do so for a variety of reasons, including faster travel times, safer travel conditions, reduced stress, and even the ability to engage in activities such as reading while commuting. When transit serves a community well, even those who do not ride it enjoy the benefits of reduced traffic congestion, improved air quality, energy conservation, and a healthier local economy.

### *Mobility*

Many people who ride transit do not have access to a private automobile. Many are unable to afford a car; but others, particularly in transit-intensive cities like New York, may choose not to own a car simply because convenient, reliable transit is available. Still others may be unable to drive due to physical disabilities or age-related conditions.

In 2000, there were more than 30 million older adults in America, and that number is expected to double by 2030; almost 54 million people were reported to have disabilities; and more than 34 million people have household incomes that are below the poverty line. For many of these individuals, transit is their sole means to access employment and community services and to conduct the basic business of everyday life, whether that is traveling to the grocery store, the dry cleaner, a family member's home, or the dentist office.

Since the passage of the Americans with Disabilities Act (ADA) in 1990, transit has played an expanding role in proving basic mobility to people with disabilities. The ADA required that all fixed-route transit services and facilities be made accessible to people with disabilities. Complementary paratransit services must be provided to individuals whose disabilities prevent them from using fixed-route services. Today, over 90 percent of America's public transit buses are accessible, and every new bus or transit system must be accessible. Further, 86 percent of the 685 rail stations that have been designated as "Key Stations" are ADA-compliant or, in the case of 44 stations, are operating under a voluntary compliance agreement.

Most fixed-route transit and paratransit is funded by a combination of Federal Department of Transportation programs, State and local tax revenue, fare-box revenue, and other transit-related earned income. However, there are 62 programs in 10 Federal departments that fund transportation services for individuals who have low incomes, persons with disabilities, or older adults. Generally, these human service transportation programs restrict their transportation service to a specific destination (such as medical care or a particular human service center), a limited timeframe, and the eligible clients of the human service agency. Often, service routes overlap; but lack of coordination among providers, as well as rules that restrict services and eligibility, prevents agencies from sharing these important transportation resources across programs.

On February 24, 2004, President Bush issued Executive Order 13330 on Human Service Transportation Coordination, which required 11 Federal agencies to work together to simplify access to transportation services, identify useful practices to enhance coordination and improve services, eliminate duplication and overlap among Federally funded programs, and improve the coordination of Federally supported transportation services at all levels. Through the Federal Coordinating Council on Access and Mobility, chaired by Secretary of Transportation Norman Y. Mineta, these Federal agencies have pursued education and outreach strategies, identified key regulatory barriers to coordination, created programs and tools to enhance coordinated transportation planning at the community level, tackled the challenging issue of how to allocate costs among programs that share transportation services, and developed a Web site that provides universal access to useful practices for improving the coordination of transportation services.

## *Location Efficiency and Economic Growth*

Investment in transit generates real and substantial economic returns. It sets off an economic chain reaction that generates business activity, creates jobs, boosts property values and tax earnings, and improves productivity. Not surprisingly, more and more communities, developers, and financial investors are recognizing the appeal of transit-oriented development. Commercial activities such as retail, restaurants, theaters, and legal and financial services thrive on the concentration of large numbers of people and businesses in close geographic proximity. Households recognize the advantages of reduced transportation costs and the convenience of walking, biking, or taking transit to employment, entertainment, and businesses.

The American Association of Retired Persons reports that fully 71 percent of older Americans—the Nation's fastest-growing population group—want to live within walking distance of transit. The composition of American households is also changing. The traditional nuclear families that made up 40 percent of households in 1970 now comprise less than 25 percent of households. In just one generation, the "typical" American household won't have children living in it. In fact, nearly 70 percent of households will not include children; they will consist of singles, empty nesters, and couples without children. These are groups with a proven preference for a "mixed use" living environment that combines interesting housing options with the amenities of the city.

The Center for Transit Oriented Development recently released a national market assessment of demand for housing near transit in the next two decades. Even using a very conservative methodology, it reached what the authors call a "staggering" conclusion. They project that, over the next 20 years, at least a quarter of all American households are likely to seek housing near transit. There is, in fact, the potential to *more than double* the amount of housing in transit zones in the next 20 years.

The Surface Transportation Policy Project has found that the cost of *car* ownership can put the American dream of *home* ownership out of reach for families with lower incomes. According to a July 2003 STPP report, American households spent 19 cents of every household dollar on transportation expenses in 2001—and lower-income households are forced to spend an even higher percentage on transportation. In fact, transportation is the second largest household expense, after housing, and is three times the cost of health care. It amounts to, on average, over $7,600 dollars each year, just to get around; and saving for a home becomes that much more difficult.

## *Congestion Management*

Traffic congestion impacts the movement of goods and the movement of people—at a significant cost to the American economy. Travel time generally costs freight carriers between $144 and $192 dollars an hour, but an unscheduled delay nearly doubles those costs, to $371 an hour. At the same time, businesses that depend upon freight movement to support just-in-time delivery systems must increase inventories—and, therefore, costs. In fact, because of congestion, a 10 percent increase in vehicle miles traveled over the existing road system produces a $1 billion increase in annual logistics costs.

The efficient movement of people on our highways is also critical to the economy. Today, 91 percent of all person miles traveled are on highways. The U.S. population grew more than 20 percent in the last 18 years, highway travel increased 80 percent, and the number of drivers increased by 30 percent—but miles of highways increased only 2 percent. Not surprisingly, drivers are spending more and more time stuck in traffic. The 2002 Texas Transportation Institute (TTI) study of 75 urban areas found that congestion is growing in cities of every size, and the average rush hour driver spends 62 hours a year stuck in traffic, up from just 16 hours a year in 1982. According to the study, the total congestion "bill" for the 75 areas came to $67.5 billion in 2000, which was the value of 3.6 billion hours of delay and 5.7 billion gallons of excess fuel consumed.

To improve the mobility of people and the movement of freight requires a multimodal transportation investment. Investments in public transportation that give people the choice to move from single-occupant cars onto transit, coupled with investments in our highway infrastructure that speed the movement of freight as well as cars, represent an opportunity to recapture the lost productivity, wasted fuel, and unnecessary air pollution caused by traffic congestion.

For every $1 million in transit investment, over $1.5 million can be saved. A $10 million investment in transit generates an increase of $2 million in business output and $0.8 million in personal income in the first year; over 20 years, these benefits increase to $31 million in business output and $18 million in personal income.

Some argue that, because roads "fill up" soon after new transit is added or roads are widened, these investments are a waste of money. But this argument ignores the role of mobility in facilitating economic transactions. While capacity expansion in dense areas may not permanently eliminate congestion, it can still bring significant economic benefit by accommodating more activity.

## *Saving Energy and Protecting the Environment*

With greater fuel efficiency and lower emissions per passenger mile, transit is uniquely positioned to help America save energy and protect the environment without imposing new taxes, government mandates, or regulations on businesses or consumers. Currently, public transportation saves America more than 855 million gallons of gasoline each year—or 45 million barrels of oil, the equivalent of about three months of energy used to heat, cool, and operate American homes. And current public transit use helps avoid the release of nearly 745,000 tons of carbon monoxide (CO)—roughly 75 percent of the CO emissions from all U.S. chemical companies. It also avoids the release of more than 7.4 million tons of carbon dioxide each year.

## *Saving Lives and Responding to Emergencies*

Public transportation continues to be one of the safest modes of travel. Riding a transit bus is 91 times safer than car travel, and rail passengers are 15 times safer. Investments that induce more people to choose transit will save lives and save money. Although transit is a potential target of terrorism, it is also a solution for communities during emergencies. Transit serves as an important means for evacuation from affected areas. It is used to transport emergency workers to and from an emergency site; and transit buses are often used as temporary shelters for victims and workers, and even as emergency medical triage facilities. Investments in public transportation help American communities prepare to effectively respond to terrorist acts, as well as other disasters and emergencies.

# Surveys of Transit Ridership

This chapter draws on two surveys that collect information on the characteristics of transit users and the types of trips they make. These are the National Household Travel Survey (NHTS) undertaken by the Federal Highway Administration (FHWA), and the Transit Performance Monitoring System (TPMS) undertaken by Federal Transit Administration (FTA) in cooperation with the American Public Transportation Association.

## *National Household Travel Survey*

The NHTS was conducted from April 2001 through May 2002. It collected travel data from a national sample of the civilian, non-institutionalized population of the United States, excluding persons living in large college dormitories, nursing homes, other medical institutions, prisons, and military bases. Travel data were collected from a sample of 69,800 households. The final data set included approximately 2,550 responses by persons who had used transit as their principal mode of travel on their day trip and 700 additional responses by people who had used transit as a secondary mode of travel, i.e., most of their trip had been made on another mode.

**Q.** What factors could have affected the NHTS telephone survey results?

**A.** The NHTS adjustment factors may not have taken into account several growing problems in telephone surveys. The 2001 NHTS was conducted before the Do Not Call List was instituted. American households were saturated with calls from telemarketers making them less likely to participate in a telephone survey. More people have caller ID and phone messaging and can more easily avoid participating in a telephone survey.

Most of the analysis in this section is based on the responses of travelers who had used transit as their principal mode of travel. These responses were expanded using statistically developed sample weights, i.e., factors that expand the data collected from sample households to represent the entire nation. On a weighted-average basis, passengers who used transit as their principal mode of travel accounted for 90 percent of all transit trips. Adjustment factors also were applied to correct for what is generally believed to be an undersampling of low-income households without telephones. An increasing number of households have only cellular phones and are not reachable by standard telephone survey techniques. For this reason, lower-income people who use transit more frequently may still be underrepresented in the survey.

## *Transit Performance Monitoring System*

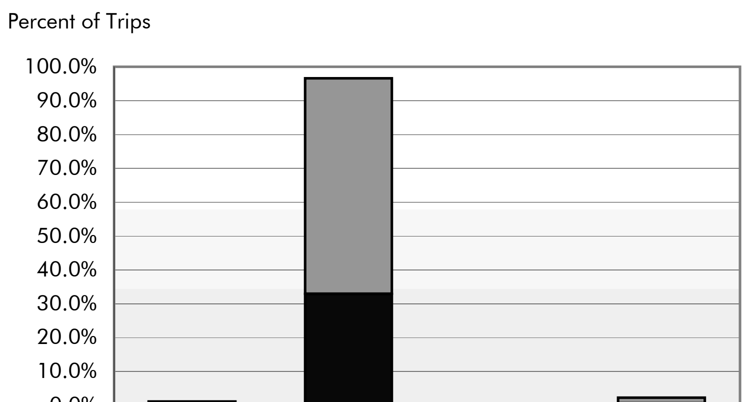
Information on characteristics of transit riders and trip purpose also have been collected from onboard surveys by the American Public Transportation Association (APTA) under a cooperative agreement with the FTA. There have been three distinct collection efforts since the implementation of the TPMS agreement in 1995. Information from the first two collection efforts was presented in the 2002 edition of the C&P Report. This edition presents results from the third data collection effort, in which 30 transit systems participated. Each of the Phase III onboard surveys provided by these systems was undertaken at some time between February 1, 2000, and November 30, 2003. This time span of almost four years was necessary in order to collect the maximum amount of survey information. All 30 participating systems operated bus services, and three systems operated both bus and rail services.

Since TPMS collected data from onboard surveys, it was more likely to capture a representative set of responses for a particular operator in a particular area than a telephone survey such as NHTS. However, the aggregated TPMS data are not necessarily representative of the Nation. Therefore, where there is an overlap of information, the data collected by NHTS are presented first, with the data collected by TPMS serving as a comparison. It also should be noted that TPMS statistics are trip-based and reflect choices only for a particular trip.

TPMS also conducted a telephone survey of users who had participated in an onboard survey in Buffalo, New York, in 2000. The purpose of this survey was to collect information on the benefits that they had received from transit over the three-year period and over their lifetimes. A summary of this information is provided at the end of the chapter. The TPMS reports can be found on the FTA Web site at http://www.fta.dot.gov/16053_ENG_HTML.htm.

# User Characteristics

***Exhibit 14-1*** *Location of Transit Use*




| | In Urban Cluster | In Urban Area | Surrounded by Urban Areas | Not in an Urban Area |
|---|---|---|---|---|
| Bus | 0.6% | 63.6% | 0.0% | 1.7% |
| Rail | 0.5% | 32.6% | 0.1% | 0.4% |
| Boat | 0.0% | 0.3% | 0.0% | 0.2% |

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

## *Location of Transit Usage*

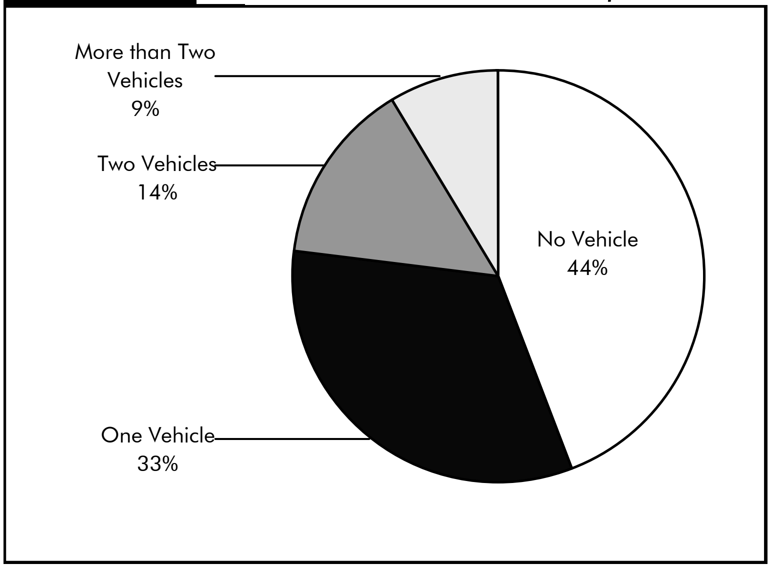
According to the NHTS, 97 percent of all transit trips are made in urbanized areas as defined by the U.S. Bureau of the Census and used by the National Transit Database *(Exhibit 14-1).* Trips made by bus in urban areas account for 64 percent of all transit trips, and trips by rail in urban areas account for 33 percent of all transit trips. Trips made by boat (passenger line/ferry) account for less than 1 percent of all transit trips.

## *Car Availability*

The NHTS found that 33 percent of all passengers using transit as their principal mode of travel on their day trip were from households with one vehicle, 14 percent were from households with two vehicles, and 9 percent were from households with more than two vehicles. *Forty-four percent of these passengers combined or 49 percent of bus passengers and 39 percent of rail passengers were from households without cars.* Five percent of the passengers using transit as their principal mode of travel used a car for their trip, compared with 7 percent of all passengers who used transit *(Exhibit 14-2).*

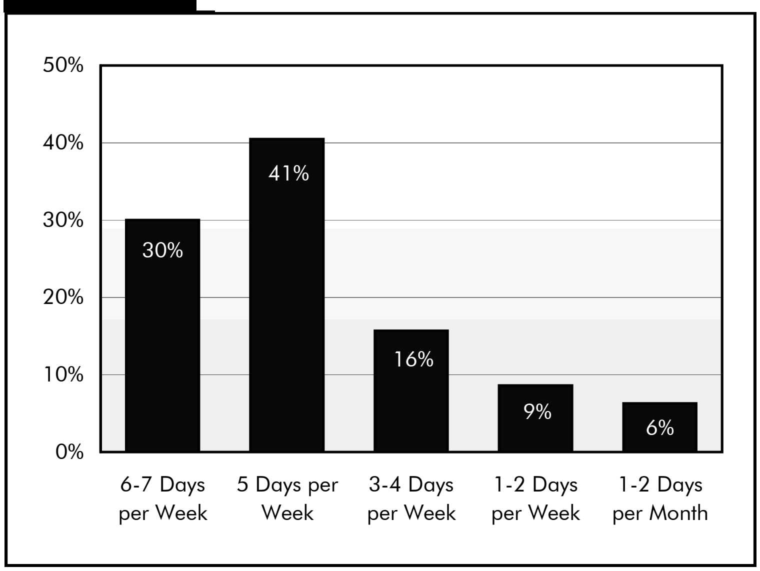
Compared with the NHTS, TPMS surveys were concentrated in areas more dependent on transit. Seventy percent of TPMS trips were made by people with no car available for the trip. This included both households without cars and households with cars where another household member was using the car.

**Exhibit 14-2** *Transit Passengers According to Household Automobile Ownership*




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

**Exhibit 14-3** *Transit Passengers by Frequency of Use*




*Source: Transit Performance Monitoring System, Phase III, 2004.*

## Frequency of Use

Information on trip frequency was collected by TPMS only. *TPMS found that most trips on transit are made by people who ride it frequently.* Slightly more than 70 percent of all transit trips in the TPMS Phase III survey were made by passengers using transit 5 days or more a week. Forty percent of the trips surveyed were made by passengers using transit 5 days a week, and 30 percent were made by passengers using transit 6 to 7 days a week. Phase III results on frequency of use are identical to the Phase I and Phase II results, discussed in the 2002 C&P Report *(Exhibit 14-3).*

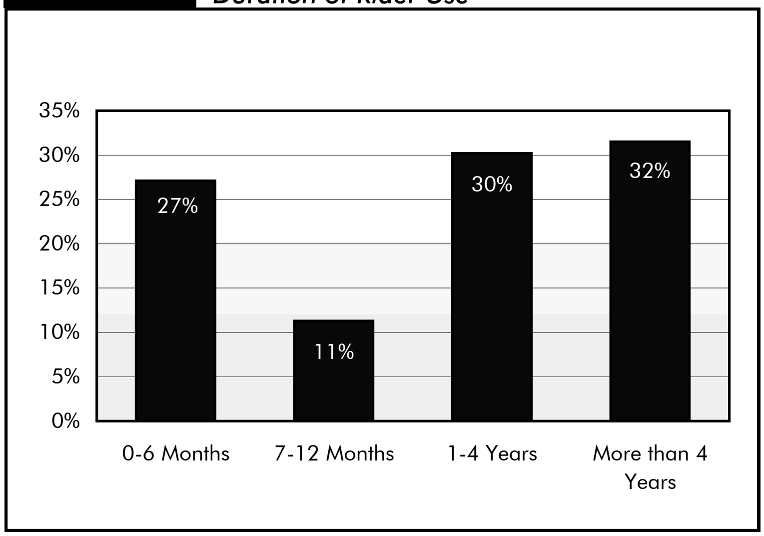
## Persons Served in the Community

*Transit serves a larger number of individuals in the community than is suggested by daily ridership as a result of the daily turnover in riders.* Based on sample concepts, a rider who reports using transit once a week on a system that operates six days actually represents six riders. TPMS found that the average ratio of the number of different people using transit to the average number of daily trips is 2.89. If the transit trips made by people using transit 4 days a week or less (which account for 30 percent of transit trips) are converted to the number of people riding transit based on a people-to-trip multiplier, these less-frequent riders are estimated to account for 67 percent of all people using transit. The experiences of these infrequent riders on transit may, therefore, have a large effect on the perception of transit in the community.

## Duration of Use

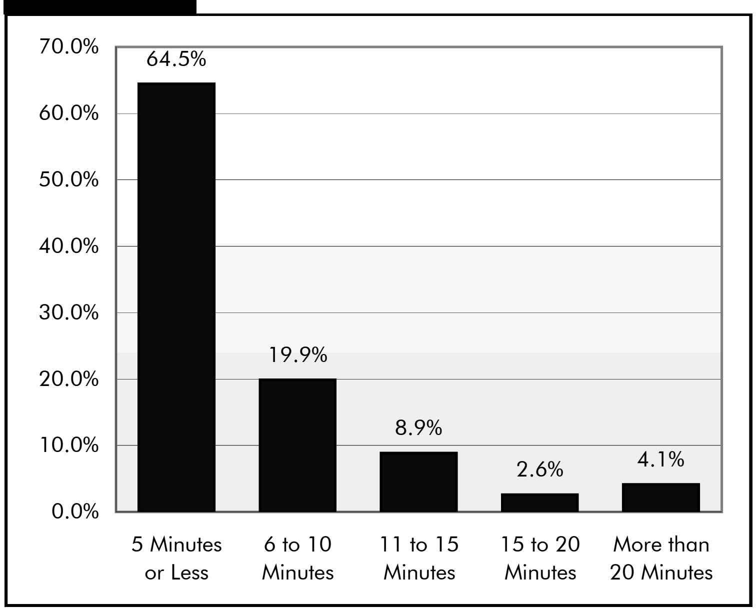
*Thirty-two percent of the trips in the TPMS Phase III survey were made by passengers who had been using transit for more than 4 years, and 30 percent of the trips were made by passengers who had been using transit for 1 to 4 years.* The fact that 62 percent of all trips were made by passengers who had been using transit for more than 1 year suggests that, for these riders, transit is a more efficient choice than an automobile. However, 38 percent of the trips surveyed were made by passengers who had been using transit for less than 1 year, and 27 percent were made by passengers who had been using transit for less than 6 months. This finding indicates that transit is important to a large number of people on a short-term basis *(Exhibit 14-4).*

**Exhibit 14-4** *Transit Trips According to Duration of Rider Use*




*Source: Transit Performance Monitoring System, Phase III, 2004.*

**Exhibit 14-5** *Transit Passengers by Access Time*




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

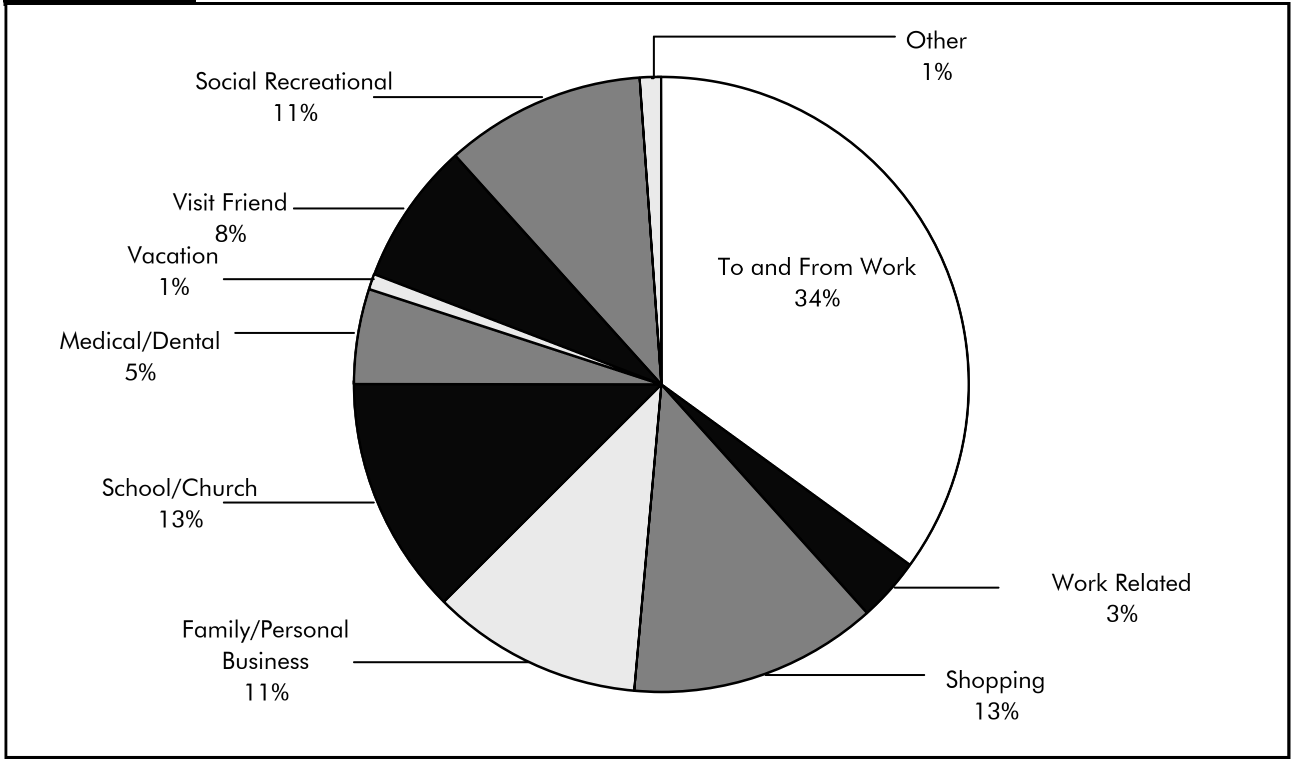
## Transit Access and Egress

*Transit principally serves those who can access it easily.* According to the NHTS, 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, and 20 percent were able to access transit within 6 to 10 minutes of starting their trip *(Exhibit 14-5).* Sixty-two percent of these transit passengers were able to reach their final destination within 5 minutes, and 18 percent within 6 to 10 minutes of exiting their transit trip. *Walking is the most common way of beginning and ending a transit trip*. Of passengers using transit as their primary mode of travel, 87 percent started their trip and 84 percent ended their trip by walking. Six percent of these transit passengers used a car to start their trip, and 3 percent used a car upon their exit. Five percent of these passengers reported that they had started on transit, and 11 percent reported continuing their trip on transit. By comparison, 70 percent of the TPMS trips were made by passengers who walked to transit and 7 percent were continuing a trip that had begun in a car. (Twenty-one percent of TPMS passengers were continuing a trip that had begun on a bus or train.)

## Trip Purpose

*Work accounts for the largest percentage of transit trips.* The NHTS reported that 37 percent of all passengers using transit as their principal mode of travel were on their way to or from work or work-related business. Transit also enables people to manage their personal or family business (11 percent), to shop (13 percent), to engage in social or recreational activities (11 percent), or to visit friends (8 percent). It also helps people pursue educational opportunities and attend places of worship (13 percent) and to obtain medical or dental services (5 percent) *(Exhibit 14-6).* Work trips account for a larger percentage of

**Exhibit 14-6** *Trip Purpose as a Percentage of Total Passenger Trips*




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

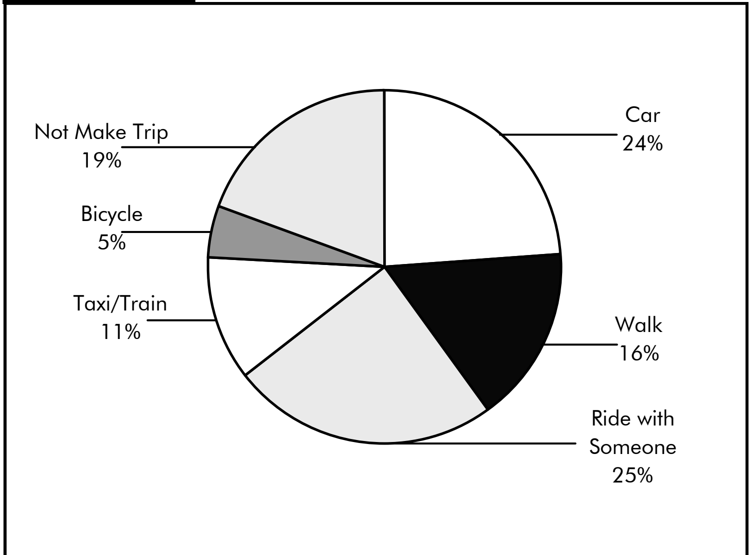
transit trips in more populous areas—40 percent in areas with populations of 500,000 or more compared with 19 percent in areas with populations under 500,000. School and church trips combined account for a higher percentage of transit trips in less populous areas—20 percent in areas with populations under 500,000 compared with 12 percent in areas with populations of 500,000 or more.

TPMS surveys were conducted in areas where a higher percentage of work trips (53 percent) were reported. Sixteen percent of TPMS trips were for school, 11 percent were for shopping, and 20 percent were for other purposes. TPMS found that riders who use transit frequently are more likely to use it to travel to and from work than infrequent riders. Sixty percent of TPMS frequent riders were traveling to or from work, compared with 35 percent of infrequent riders. Infrequent riders are more likely to use transit to shop, attend school, and for other nonwork purposes.

## Alternative Mode of Travel

TPMS surveys asked passengers how they would have made their trip if transit had not been available. Sixteen percent of the passengers surveyed would have walked, 11 percent would have taken a taxi or train, and 5 percent would have bicycled. Forty-nine percent responded that they would have taken a car, of which half would have driven themselves and half would have ridden with someone else. These numbers indicate that transit makes an important contribution to reducing road congestion. *The availability of transit was particularly crucial to the 19 percent who reported that without transit they would not have made the trip at all.* This finding underscores the reliance of a significant number of TPMS passengers on transit for basic mobility services (*Exhibit 14-7*).

**Exhibit 14-7** *Alternative Mode of Travel*

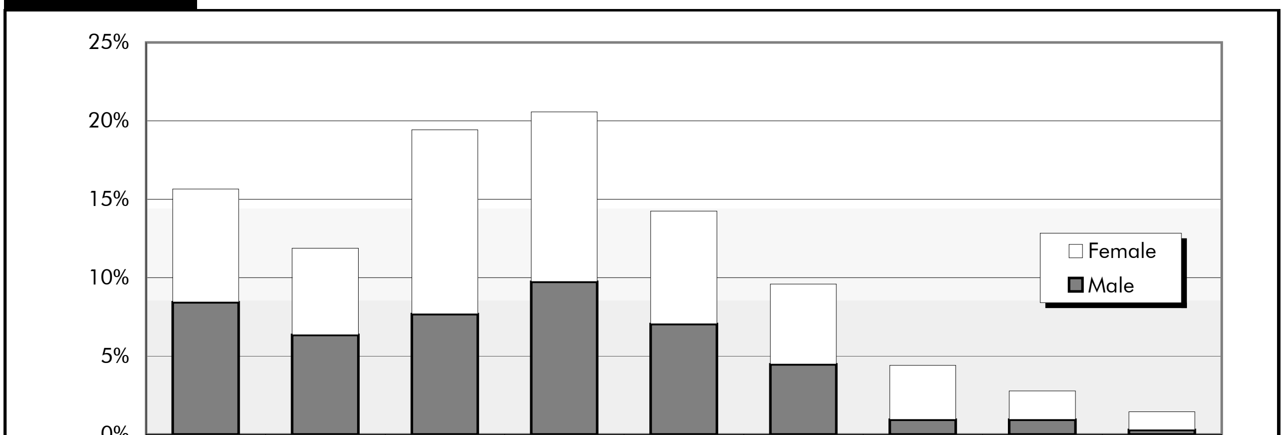



*Source: Transit Performance Monitoring System, Phase III, 2004.*

## Gender and Age

According to the NHTS, a larger percentage of transit riders are women (54 percent) than men (46 percent). The same was true for TPMS trips. According to the NHTS, females make up a larger percentage of transit passengers for all age groups, except for riders 22 years or younger for which a slightly higher percentage of passengers are males. Most transit riders are of working age. Seventy-five percent of all transit passengers are between the ages of 23 and 60. (Fifty percent are between the ages of 23 and 40, and 25 percent are between the ages of 41 and 60). Nine percent of all riders are 61 years or older. Seventy-five percent of these older riders are females *(Exhibit 14-8).*

**Exhibit 14-8** *Transit Passenger Distribution by Age and Gender*



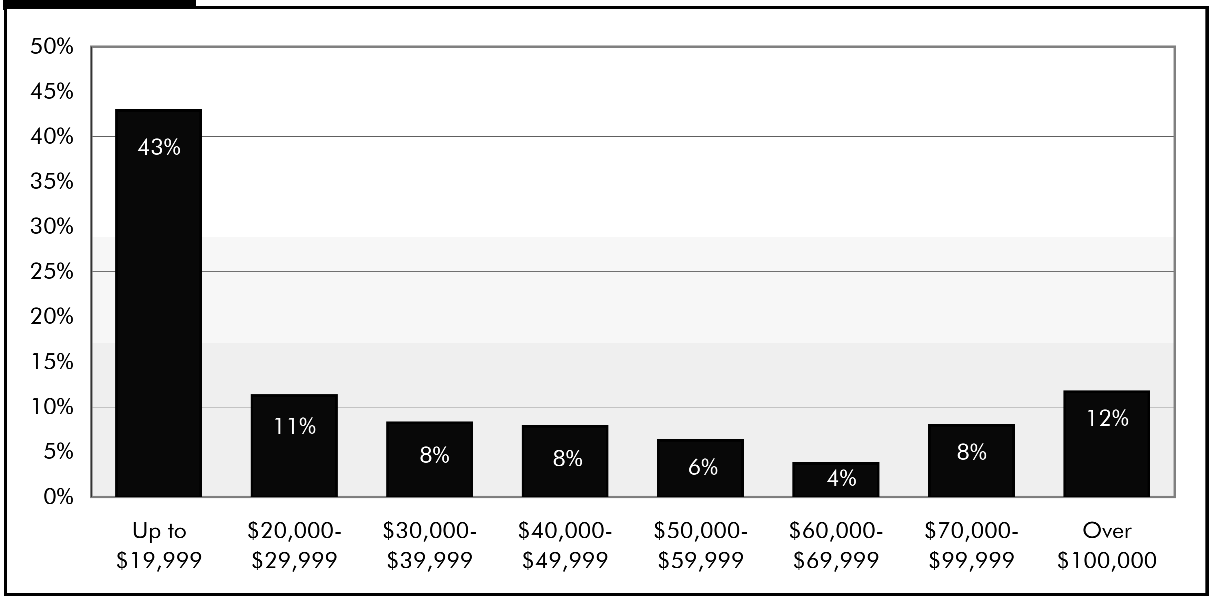

| | 18 and Younger | 18 to 22 | 23 to 30 | 31 to 40 | 41 to 50 | 51 to 60 | 61 to 70 | 71 to 80 | 81 and Older |
|---|---|---|---|---|---|---|---|---|---|
| Female | 7.2% | 5.5% | 11.8% | 10.8% | 7.2% | 5.1% | 3.5% | 1.8% | 1.2% |
| Male | 8.4% | 6.4% | 7.7% | 9.7% | 7.0% | 4.5% | 0.9% | 0.9% | 0.3% |

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

### *Income Distribution*

The availability of transit is particularly important to people with limited incomes. Based on the NHTS, 43 percent of all transit users live in households with incomes of less than $20,000, indicating that many riders are from households at or below the poverty level. (The U.S. Bureau of the Census reported a 2002 poverty-level income threshold for a family of four with two children of $18,244, and for a family of one under the age of 65 years of $9,359.) Transit also serves the affluent. Twelve percent of transit users come from households with annual incomes of $100,000 or more *(Exhibit 14-9).*

**Exhibit 14-9** *Transit Ridership by Income*

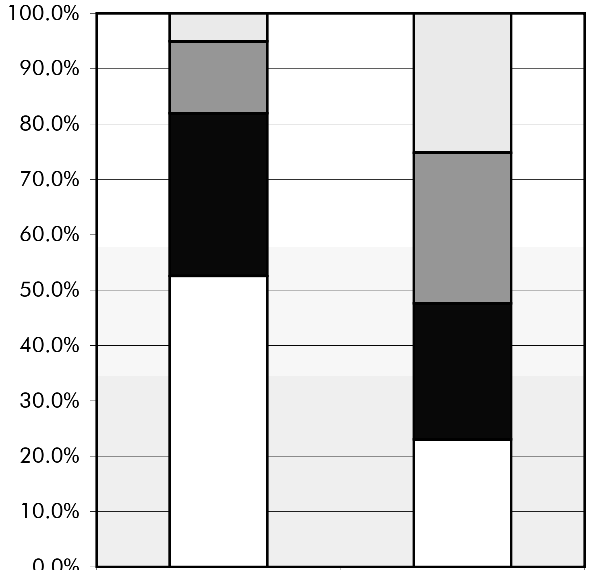



*Source: National Household Travel Survey, FHWA, 2001.*

Bus service is relatively more important than rail service at lower income levels. Fifty-two percent of all bus trips were made by people with annual household incomes of less than $20,000 compared with 5 percent by people with annual household incomes of $100,000 or more. Rail service is equally important to both groups. Twenty-three percent of all rail trips were made by people with annual household incomes of less than $20,000, compared with 25 percent by people with annual household incomes of over $100,000 *(Exhibit 14-10).*

TPMS surveys were undertaken in areas where people with limited incomes make a larger percentage of transit trips. Forty-six percent of TPMS trips were by people with annual household incomes of $20,000 or less, and 13 percent by people with annual household incomes of $20,000 to $39,900. Only 13 percent of TPMS trips were by people with annual household incomes of $60,000 or more. TPMS found that low-income riders are more reliant on bus services than high-income earners and that rail attracts more riders from higher-income groups.

**Exhibit 14-10** *Income Distribution of Bus and Rail Riders by Income*




| | Bus | Rail |
|---|---|---|
| Over $100,000 | 5.1% | 25.2% |
| $50,000-$99,999 | 13.0% | 27.2% |
| $20,000-$49,999 | 29.4% | 24.5% |
| Less than $20,000 | 52.5% | 23.0% |

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

# User Benefits of Transit

As discussed in the beginning of this chapter, transit provides a wide range of benefits to communities, including access to employment and a wide range of community resources and services. Transit also contributes to a healthier environment by improving air quality, reducing oil consumption, and providing better land-use policies. It also helps to expand business development and work opportunities.

Data gathered through TPMS provide insight into how transit provides one or more of three basic benefits to its riders. Transit may provide *basic mobility* to a rider who has no other means of transportation available; it may contribute to *location efficiency* by providing service that is easily accessible and more convenient than a car in densely developed areas; or it may provide *competitive travel times,* particularly during peak working hours, by offering a service on dedicated guideways that is equal to or faster than travel by car on roads. People traveling on roads in areas with strong transit systems also benefit from *less congested roads*, i.e., people who would otherwise be using the roads in private vehicles are traveling by transit. Note that information on the percentage of people traveling by car, who benefit from reduced road congestion as a result of transit services, is not captured by this analysis.

To determine how transit benefited riders, the TPMS Phase III passengers surveyed were asked to respond either "yes" or "no" to the following questions:

- Did they have access to a car at the time the trip was made?
- Were they going to work?
- Would they have made the trip if transit had not been available?

Each trip was then classified into one of the eight following groups and assigned a public benefit. In most cases (68 percent), each transit trip provided more than one benefit *(Exhibit 14-11).* (The same analysis was undertaken for TPMS Phases I and II and is presented in the 2002 edition of this report. Note that the classification used to assign trips to each benefit for this analysis is slightly different from the one used in Chapter 15 for the analysis of these benefits by time of day. These differences exist because the analysis presented here is based on TPMS data and the analysis in Chapter 15 is based on NHTS data.)

On the basis of these categorizations:

- Thirty-five percent of all TPMS Phase III transit trips provided mobility and location-efficiency benefits to passengers without cars who chose to make a nonwork trip by transit because they lived in an area with convenient, highly accessible transit services. (Compared with 36 percent in Phases I and II.) Sixty-two percent of these passengers said they still would have made their trip if transit had not been available, and 38 percent said they would not have *(Exhibit 14-12).* People who stated that they would have chosen to make the trip if transit had not been available would have taken a car, walked, rode with someone else, taken a taxi, or bicycled.

- Twenty-three percent of all Phase III trips provided basic mobility to passengers without access to a car who were traveling to work. (Compared with 21 percent for Phases I and II.) These people reported that they would have made their work trip even if transit had not been available. Transit provided these people with a travel time as competitive or better than traveling on the road in a private car. The fact that these passengers were not traveling in cars led to reduced road congestion.

- Eighteen percent of all Phase III trips offered competitive travel times for passengers and contributed to reduced road congestion. (Compared with 18 percent in Phases I and II.) These were work trips made by people with access to cars. Sixty-two percent of these people stated that they would have made the trip if transit had not been available, and 38 percent stated that they would not have made the trip if transit were not available. This measure may overstate transit's contribution to reducing road congestion because all work trips are not made at peak travel times.

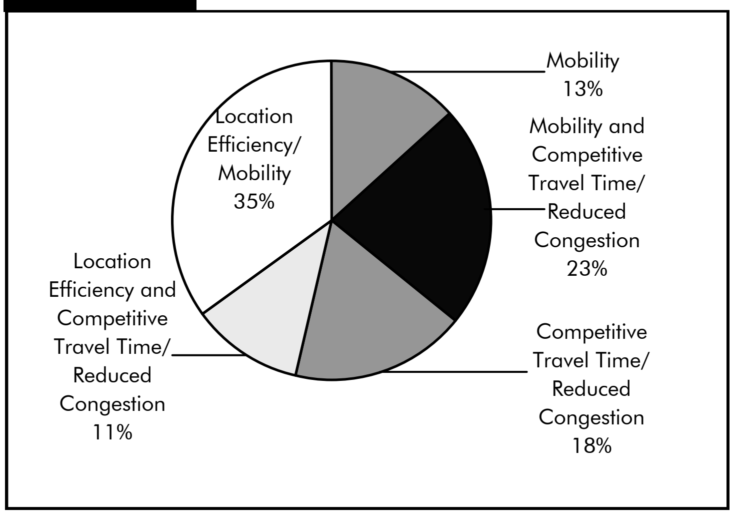
- Eleven percent of all Phase III trips provided location efficiency and competitive travel times. (Compared with 11 percent in Phases I and II.) These trips were made because the passenger lived in an area highly accessible to transit. In these cases, the passenger traveling had access to a car, but chose to

**Exhibit 14-11** *Classification of Transit Trips by Public Benefit Provided*

| Public Benefit | Car | Work | Make Trip Without Transit |
|---|---|---|---|
| Competitive Travel Time/ Reduced Congestion | Yes | Yes | Yes |
| Competitive Travel Time/ Reduced Congestion | Yes | Yes | No |
| Competitive Travel Time/Reduced Congestion & Location Efficiency | Yes | No | Yes |
| Competitive Travel Time/Reduced Congestion & Location Efficiency | Yes | No | No |
| Mobility & Competitive Travel Time/Reduced Congestion | No | Yes | Yes |
| Mobility | No | Yes | No |
| Mobility & Location Efficiency | No | No | Yes |
| Mobility & Location Efficiency | No | No | No |

*Source: Transit Performance Monitoring System.*

**Exhibit 14-12** *The Benefits of Transit*




*Source: Transit Performance Monitoring System, Phase III, 2003.*

make a non-work trip on transit. Seventy-five percent of these people would have chosen to make the trip without transit, and 25 percent would have chosen not to make the trip without transit. Transit trips also provided reduced road congestion to people traveling by car at the same time in the same corridor.

- Thirteen percent of all Phase III trips provided basic mobility only. (Compared with 13 percent in Phases I and II.) These passengers reported that they had no access to a car, were making a work trip, and would not have been able to make the trip if transit services had not been available.

# Longitudinal Survey of Benefits of Transit

In addition to immediate benefits, transit provides lifetime benefits to people even when they are no longer passengers. In 2003, TPMS conducted a telephone survey of people who had participated in an onboard survey three years earlier in Buffalo. The purpose of this longitudinal survey was to obtain information on the benefits that these passengers had received from transit over the three years between surveys and over their lifetimes.

The subset of passengers participating in the 2003 longitudinal survey was reasonably comparable to the group of passengers who had participated in the original onboard survey. The benefits results for the longitudinal survey represent reasonably accurately the benefits accruing to all riders on the Buffalo system where the 2000 onboard survey was administered.

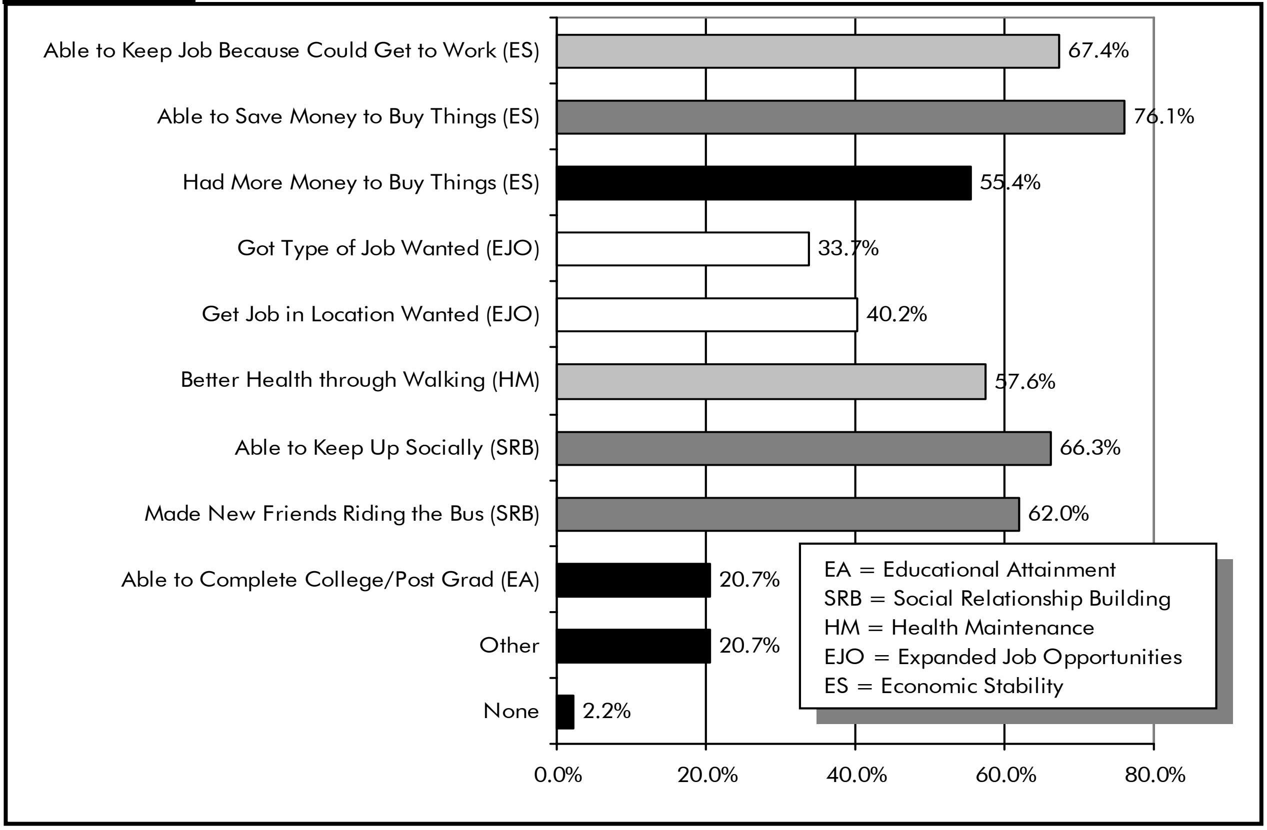
Forty-seven percent of the participants in the longitudinal survey, who were still riding transit three years after the original onboard survey, reported that their frequency of use was different at the end of the three-year period than it had been at the beginning. Thirty percent of these participants were riding transit less, and 17 percent were riding it more. The reasons for frequency-of-use changes were varied, but typically reflected a change in a participant's life (e.g., a new job, a new car, or a change in their physical condition). None of the riders mentioned changes in service as a reason for a change in their use.

When longitudinal-survey participants who had continued to use transit were posed with an opened-ended question as to whether or not they had benefited from being able to use transit, 84 percent reported that they had. When they were asked if they had received benefits with an aided question, which mentioned specific benefits that they could have received, 98 percent reported that they had received a benefit. The benefits received were organized into the five categories—educational attainment, expanded job opportunities, economic stability, health maintenance, and social relationship building.

In response to the aided question, between 55 and 76 percent of the longitudinal-survey participants who had continued to use transit cited each of the three economic stability benefits related to keeping a job and saving/having money to buy things. Nearly two-thirds of these continued-use participants cited each of the two social relationship benefits of making friends and keeping up socially. Health maintenance through walking was also a benefit for 58 percent of these continued-use respondents *(Exhibit 14-13).*

When all longitudinal-survey participants, including those who had not continued to ride transit, were asked an open-ended question about the benefits that they had received transit over their lifetimes, 81 percent reported that they had received at least one benefit.

**Exhibit 14-13** *Benefits in the Past Three Years—Aided Question*



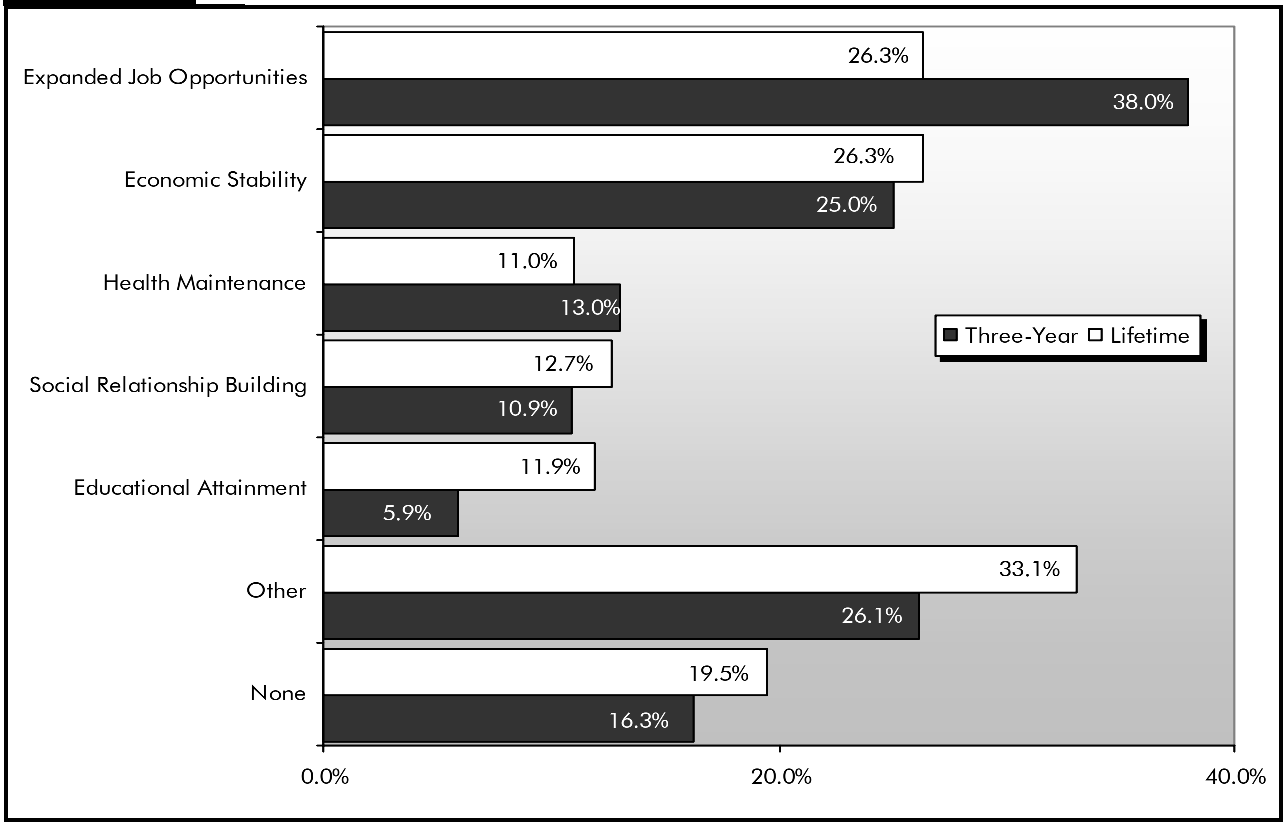

*Source: Transportation Performance Monitoring System, Longitudinal Survey, 2003.*

Over one-fourth of the longitudinal-survey participants gave responses that were categorized as providing "Expanded Job Opportunities" *(Exhibit 14-14).* Most people who indicated that they had received an "Expanded Job Opportunities" benefit did not own a private vehicle and would have found it impossible or much more difficult to take advantage of work opportunities without transit. Transit not only helped these individuals to find and accept better jobs in the first place, but also provided a means of keeping these jobs over the longer term.

One-quarter of the longitudinal-survey participants gave responses that were categorized as providing "Economic Stability." Nearly 75 percent of the longitudinal-survey participants who said that transit had contributed to their economic stability at some point during their life also reported that they depended on transit to get to and from work. These individuals were often of prime working age.

One in eight of the longitudinal-survey participants provided answers that were categorized as "Educational Attainment." While many participants had depended on transit to attend school, many had stopped using transit once they had graduated or completed their training. Twenty-three percent of the longitudinal-survey participants who were no longer riding transit provided answers indicating that they had received an educational benefit from riding transit. By comparison, 12 percent of all longitudinal-survey participants and 9 percent of participants still riding indicated that they had received an educational benefit.

**Exhibit 14-14** *Comparison of Open-Ended Three-Year and Lifetime Benefits*




*Source: Transportation Performance Monitoring System, Longitudinal Survey, 2003.*

Other responses by participants were categorized as "Social Relationship Building" and "Health Maintenance" benefits. Eleven percent of the participants provided answers that were categorized as providing "Health Maintenance," and 13 percent provided answers that were categorized as "Social Relationship Building." These benefits were received by participants who were of working age or older, a high percentage of whom were over the age of 64.

# CHAPTER 15

## Bridges

# Bridges

## The National Bridge Inspection Program and the Highway Bridge Replacement and Rehabilitation Program

Bridges are critical elements within the highway transportation network supporting commerce, economic vitality, and personal mobility. Every day, close to 4 billion vehicles cross bridges in the United States. The public expects these structures to be safe and to have the capability to support their transportation. The safety of the bridge network came into question in the late 1960s when, on December 15, 1967, the Silver Bridge spanning the Ohio River between West Virginia and Ohio collapsed during rush-hour traffic. This catastrophic event resulted in 46 fatalities and numerous injuries, prompting national concern about bridge conditions and safety. Following this disastrous event, programs were established to ensure periodic safety inspection of bridges and provide mechanisms for funding of bridge replacement and rehabilitation needs. The primary bridge programs include the National Bridge Inspection Program (NBIP) and the associated Highway Bridge Replacement and Rehabilitation Program (HBRRP).

General information on the composition and conditions of bridges has been presented in Chapter 2 and Chapter 3. These chapters provide an overview of bridge composition and performance with a focus on ownership and functional classification. As bridges are vital elements within the system, additional detail is provided on the conditions, composition, and performance of the U.S. highway bridge network in this chapter. Additional information concerning bridges on the National Highway System (NHS) can be found in Chapter 17.

As shown in the tables and discussions that follow, the Nation's highway bridges have remained safe as a result of the bridge programs, and progress has been made toward the Federal Highway Administration (FHWA) strategic goals of reducing deficiencies. However, with an ever-aging population of highway structures, increasing traffic demands, and limited budgets, it is important to examine transportation system preservation strategies, such as preventative maintenance, and improved bridge inspection and management techniques to continue to ensure the safety of the motoring public and effective stewardship of the public trust.

### *Overview and Evolution of the Bridge Programs*

For the last 30 years, bridges in excess of 6.1 meters in total length located on public roads have received periodic inspections to ensure safety to the traveling public. Inspections are guided by Federally defined minimum data collection requirements. Every year, bridge information collected for that year is submitted from the States and Federal Agencies to FHWA. Information collected and maintained by FHWA forms the basis for determining the condition of the Nation's bridges and for the apportionment of bridge replacement and rehabilitation funds to the States. Since initiation of the legislation guiding the development of the National Bridge Inspection Standards (NBIS) and associated funding programs, over $60 billion in HBRRP funding alone has been allocated and utilized to improve the condition of the Nation's bridges. Other sources of funding from Federal and State programs are also utilized for bridge activities.

Bridges are critical elements within the highway transportation network. Deterioration of structures must be periodically mitigated through proactive interventions to ensure safety of the traveling public, ensure connectivity of the network, and retain the significant intrinsic asset value of the bridge stock. These preservative actions cost significantly more than highway pavement activity on a unit cost basis. In addition, bridges may become functionally obsolete due to changing traffic demands. Actions must be taken to avoid adverse economic impacts to the traveling public, which may result from this functional obsolescence of the structures.

Programs have been developed and legislated to ensure bridge safety and provide funding for rehabilitation, improvement, and replacement of the structures. These programs are summarized in this section. The information collected through the bridge inspection process, which represents the most comprehensive source of bridge condition and composition data at the national level, is summarized to give a background for the in-depth examination presented later in this chapter.

On December 15, 1967, the Silver Bridge carrying U.S. 35 between Point Pleasant, West Virginia, and Gallipolis (Kanauga), Ohio, collapsed during rush-hour traffic. Thirty-one vehicles fell into the Ohio River or onto the Ohio shore, killing 46 people and injuring nine. The collapse, which was the first major failure of a structure since the wind-induced failure of the Tacoma Narrows Bridge in 1940, prompted national concern about bridge conditions and safety.

Congressional hearings on the failure resulted in mandates requiring the U.S. Secretary of Transportation to develop and implement the NBIS. The NBIS, developed by FHWA in cooperation with the American Association of State Highway and Transportation Officials, was enacted as part of the Federal-Aid Highway Act of 1970. This landmark legislation was enacted on December 31, 1970, and established, for the first time in U.S. history, uniform, national-level standards for bridge inspection and safety evaluation. The Act also designated funding for the replacement of deficient bridges on the Federal-aid highway system. Through the legislation:

- All States were required to perform periodic inspection of bridges in excess of 6.1 meters (20 feet) located on Federal-aid highway systems.
- Bridge inspection data collection requirements were established.
- Qualifications for key bridge inspection personnel were defined.
- Training programs for bridge inspectors were developed and implemented.
- The Special Bridge Replacement Program (SBRP) was established to provide funding for the replacement of bridges located on the Federal-aid system.

Over time, the NBIS has been fine-tuned, additional inspection requirements have been added, and funding programs have been updated. It quickly became evident that safety assurance was required for all structures located on public roadways. The requirement to inventory and inspect bridges on Federal-aid highways was extended to all bridges in excess of 6.1 meters (20 feet) located on public roads. Data collection requirements were enhanced, and training programs continued to be developed and expanded as more knowledge became available through research and experience. Funding programs were expanded to permit the use of Federal funds for replacement of both Federal-aid and non-Federal-aid bridges.

Despite efforts to continually enhance the process of bridge inspection, unforeseen events periodically necessitated expansion. The scene was Interstate 95, the primary highway on the Atlantic seaboard that connects Florida and Maine, approximately 30 miles east of New York City, near Greenwich, Connecticut. On June 28, 1983, a section of the Mianus River Bridge catastrophically failed because of instantaneous fracture of a pin and hanger detail. This failure resulted in several fatalities and disrupted commerce in the northeastern United States for several months. Following this event, significant research into fatigue of steel connections was performed, and tremendous insight into the behavior of steel connections was obtained. The program was enhanced to incorporate more rigorous inspection procedures for fracture critical structures. Training programs were developed, putting the research results and accumulated experience and understanding of fatigue and fracture into practice.

On April 5, 1987, disaster struck again with the collapse of a bridge carrying the New York State Thruway (Interstate 90) across the Schoharie Creek. With rising water levels from localized flooding, the soil around the pier was simply washed or scoured away. The loss of soil around the pier resulted in the subsequent loss of bearing capacity for the foundation of the center pier, which collapsed. Several fatalities resulted from this collapse. A failure due to the washing or scouring of supporting soil from a major pier or abutment of a structure is termed a scour-induced failure. Other notable scour-induced failures occurred throughout the country, including the collapse of the Hatchie River Bridge in Tennessee on April 1, 1989. These bridges indicated the potential problem, given that more than 80 percent of the bridges on public roads cross over waterways. With approximately 475,000 structures crossing waterways, program enhancement was required. The FHWA acted quickly, providing guidance for scour assessment and requiring periodic underwater inspection of all structures at risk and susceptible to scour damage.

The combination of research, experience, and technology transfer of knowledge acquired has been used to train professionals performing inspections of fatigue- and scour-susceptible structures. Catastrophic failures due to scour and fatigue, such as the Mianus River and the Schoharie Creek bridges, have been avoided. Additional knowledge is required on these and other extreme events, such as earthquakes and collisions, to avoid such calamities in the future. Research efforts performed by FHWA and transfer of results to experienced engineers practicing in the field continue to proactively mitigate potential failures.

Catastrophic events highlighted the need to replace bridges before they collapse. The SBRP, created by the Federal-Aid Highway Act that provided funds to help States replace bridges, required expansion to permit rehabilitative activities. Again, action was taken and, in 1978, the Surface Transportation Assistance Act replaced the SBRP with the HBRRP.

The program initiated through the Federal-Aid Highway Act has been incrementally enhanced so that, today, all structures in excess of 6.1 meters on public roads receive, in general, biennial safety inspections. Notable changes in legislation can be seen in *Exhibit 15-1*. "Best practices" for routine, fracture-critical, and underwater inspections have been defined and published. Qualifications of inspection personnel have been established and training programs implemented to ensure completeness of engineering reviews and consistency of inspection condition assessments.

**Exhibit 15-1** *Summary of Major Bridge Inspection and Bridge Program Funding Legislation and Noteworthy Changes*

| Act and Date | Requirements |
|---|---|
| Federal-Aid Highway Act of 1970: (P.L. 91-605) | Inventory requirement for all bridges on the Federal-aid system<br>Established minimum data collection requirements<br>Established minimum qualifications and inspector training programs<br>Established Special Bridge Replacement Program |
| Surface Transportation Assistance Act of 1978 (P.L. 95-599) | Provided $4.2 billion for the HBRRP over 4 years<br>Extended inventory requirement to all bridges on public roads in excess of 6.1 meters<br>Established Highway Bridge Rehabilitation and Replacement Program (extending funding to Rehab) to replace Special Bridge Replacement Program |
| Highway Improvement Act of 1982 | Provided $7.1 billion for the HBRRP over 4 years |
| Surface Transportation and Uniform Relocation Assistance Act of 1987 | Provided $8.2 billion for the HBRRP over 5 years<br>Added requirements for underwater inspections and fracture-critical inspections<br>Allowed increased inspection intervals for certain types of bridges |
| Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) | Provided $16.1 billion for the HBRRP over 6 years<br>Mandated State implementation of bridge management systems<br>Increased funding in HBRRP |
| National Highway System Designation Act of 1995 | Repealed mandate for management system implementation |
| Transportation Equity Act for the 21st Century (TEA-21, 1998) | Provided $20.4 billion in HBRRP funding over 6 years |

## *Information Collected Through the Bridge Inspection Program*

As part of the NBIS, qualifications of key personnel have been identified, training programs developed and offered to bridge owning agencies, assistance with bridge program development provided, and minimum data collection requirements defined. The information that is obtained through the process defined by the NBIS is discussed below. This information forms the basis for the subsequent examinations of the conditions and performance later in this chapter.

For most structures, the NBIS requires visual inspection once every 2 years. For structures with safety concerns, inspections may be performed more frequently. Likewise, for structures with special favorable characteristics, the period of observation may be increased. The bridge owners (States, cities, municipalities, etc.) are responsible for these inspections with oversight by the State department of transportation. Information is collected on the bridge composition and conditions and reported to FHWA where the data are maintained in the National Bridge Inventory (NBI) database. This information forms the basis of the bridge safety assurance efforts and provides the mechanism for the determination of fund requirements and fund apportionments.

The NBI database maintains inventory information characterizing the structure, condition ratings, appraisal ratings, and calculated fields. This information has been collected and maintained in the NBI database for over two decades. The NBI database represents the most comprehensive source of information available on the national level.

Inventory information includes location and description fields, geometric data (lengths, clearances, lane widths), functional descriptions (classification, NHS designation, service carried and crossed, etc.), and design characteristics (superstructure designs and materials, deck types, design load, etc.). This information permits classification of structures according to serviceability and essentiality for public use. The composition of structures in the network can be ascertained through examination of the inventory data.

Through periodic safety inspections, data are collected on the condition of primary components of a structure. Condition ratings are collected for the following components of a bridge:

- The bridge deck, including the wearing surface
- The superstructure, including all primary load-carrying members and connections
- The substructure, considering the abutments and all piers
- Culverts, recorded only for culvert designs
- Channel/channel protective systems, for all structures crossing waterways.

In general, each traditional bridge design has distinct deck, superstructure, and substructure components that are each rated independently. Culvert designs are also included in the bridge inventory, if they are located on a public road and have a total length in excess of 6.1 meters. As culverts are considered as "bridges" under the NBIS for funding purposes, they are inspected biennially. Culverts have different design properties, behave differently under subject loads, and have different considerations than traditional bridge designs. Culvert designs are typically used for short-span, low-volume channel flow situations. Since culverts do not have distinct deck, superstructure, and substructure components, an individual culvert condition rating is assigned during the inspection process. These culvert ratings are used to guide deficiency status determination and eligibility of the structure for Federal fund participation.

Condition ratings are also developed for the channel and the channel protection system during the bridge inspection process. The channel/channel protective system rating describes the physical conditions of slopes and the channel for water flow through a bridge. Condition evaluation of these elements is increasingly important for structures susceptible to scour, which can occur and increase in situations due to channel degradation or failed channel protection.

Condition ratings are assigned by bridge inspectors utilizing a 10-point rating system, as described in Chapter 3 [*see Exhibit 3-22*]. Code 9 indicates excellent, as-new condition, and code 0 indicates a failed condition. Codes 7 through 9 indicate satisfactory to excellent conditions. Codes 5 and 6 indicate either fair or satisfactory conditions of the components. Codes 4 through 0 indicate poor, serious, critical conditions, and conditions representing imminent failure of the component or failed conditions. Inspectors assess the ratings in a visual fashion based on engineering expertise and experience. Extensive training for inspectors is provided, and references are available to guide assignment of the ratings. These ratings form the basis for assessing the structural condition of a bridge.

Functional adequacy is also a concern in the bridge population. Following collection of the inventory information and condition ratings, appraisal ratings are calculated to assess the adequacy of a structure to provide the required service. Appraisal ratings are quantified for

- Structural evaluations (load-carrying capacities);
- Deck geometry (indicating constrictions that affect safety);
- Underclearances (which, if insufficient, result in detours); and
- Waterway adequacy (the ability of the opening to handle the flow rates).

A bridge may be structurally deficient and/or functionally obsolete. These determinations are assessed based on the condition and appraisal ratings. Structural deficiencies result from poor condition ratings or from low load ratings. Functional obsolescence results from low appraisal ratings or from low design-load capacities. Inadequate waterway adequacy can be a contributing factor for either structural deficiencies or functional obsolescence.

# Composition of the Bridge Network

An overview of the composition and conditions of the bridge system was presented in Chapter 2. This chapter presents additional detail for the system of bridges as a whole and according to traffic volumes, functional classifications, age, and superstructure materials and designs.

The 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 are 591,707 bridges over 6.1 meters (20 feet) in total length located on public roads in the United States. These bridges, on average, carry nearly 4 billion vehicles per day and comprise a total deck area in excess of 300 million square meters.

**Q.** How do the bridge ownership percentages compare with road ownership percentages?

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

The discussion of bridges in Chapters 2 and 3 primarily considered the number of bridges in different classifications. Using this approach, every bridge in the inventory is counted equally. Thus, large suspension bridges, such as the Golden Gate or the George Washington Bridges, are considered equivalent to small, two-lane bridges carrying low volumes of traffic. In some cases, better insights into the condition or the composition of bridges can be obtained by considering the size of the structure and/or the traffic carried. Considerations of size of the structure can be incorporated through presentation of information using the deck area of the bridge. Considerations of the volume of traffic served by the structure can be incorporated through presentation of information using average daily traffic (ADT).

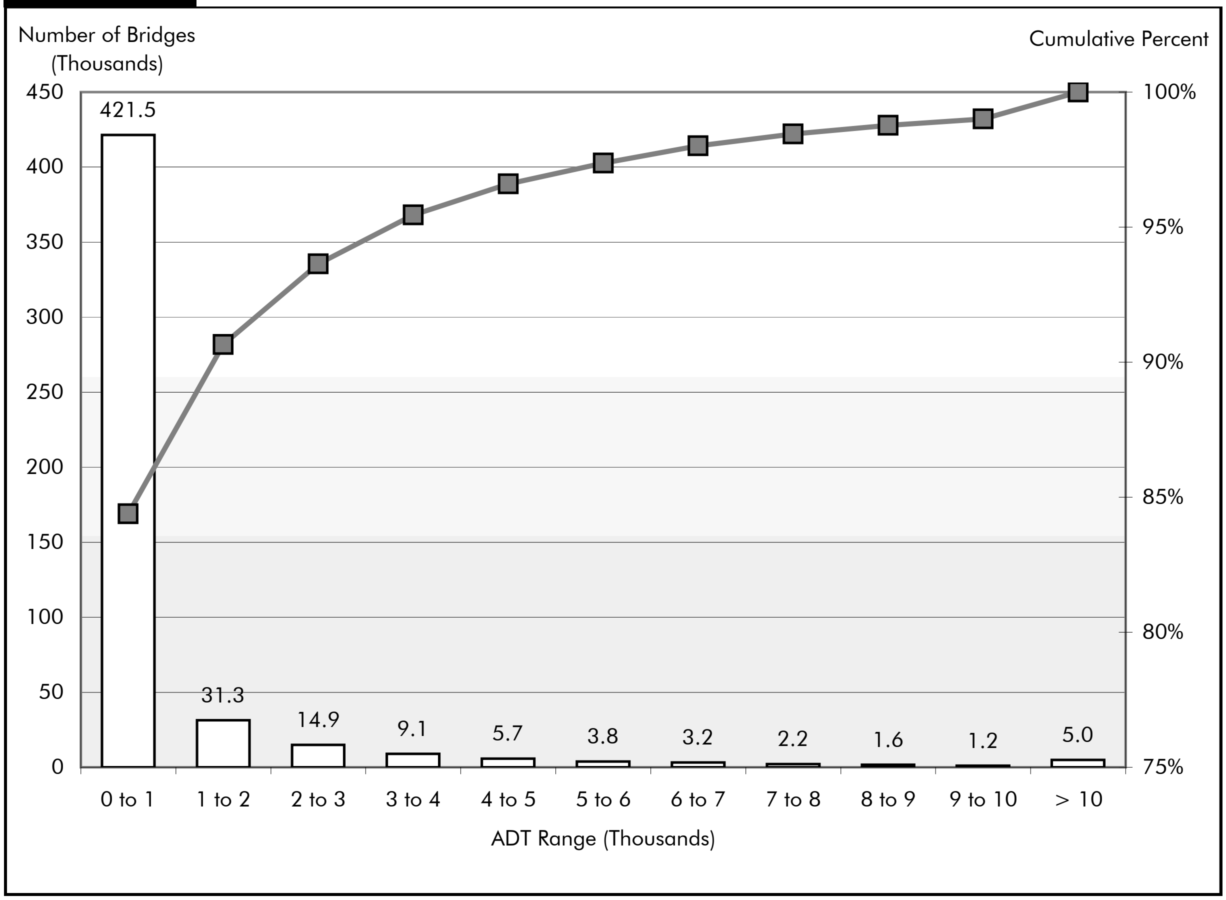
## *Bridges by ADT*

Approximately 27 percent of structures in terms of numbers have an ADT of 100 or less. In excess of 50 percent of these structures have an ADT lower than 700. 96.5 percent of structures have an ADT of 40,000 or below and 97.5 percent have an ADT of 50,000 or below.

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 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. *Exhibit 15-2* shows that the distribution is significantly skewed to lower values of ADT.

**Exhibit 15-2** *Bridges by ADT Values, Distribution, and Cumulative Percentages*




## *Bridges by Functional Classification*

*Exhibit 15-3* shows the percentage of bridges by functional classification with bridges equally weighted by numbers, weighted by ADT, and weighted by deck area. Rural bridges are predominant when the percentages are determined by numbers, as 77.1 percent of all structures are located in a rural environment. Urban bridges, which comprise 22.9 percent of the inventory, carry over 73 percent of all daily traffic. Not surprisingly, urban structures are generally larger in terms of deck area as additional lanes are required to carry larger volumes of traffic. Urban structures constitute 52.6 percent of all total deck area on bridges in the inventory.

The disparity between urban and rural structures in terms of traffic carried and size is readily evident on the national level by comparing the percentages. Further examination of Exhibit 15-3 reveals similar trends across functional classification. Whereas bridges on Interstate and other arterial routes comprise

**Exhibit 15-3** *Bridges by Functional Class Weighted by Numbers, ADT, and Deck Area*

| Functional Class | Total | % by Nos. (% of All) | % of ADT | % of Deck Area |
|---|---|---|---|---|
| ***Rural*** | | | | |
| Interstate | 27,316 | 4.6% | 10.2% | 8.0% |
| Other Principal Arterials | 35,227 | 6.0% | 6.5% | 9.0% |
| Minor Arterial | 39,587 | 6.7% | 3.7% | 6.6% |
| Major Collector | 94,781 | 16.0% | 3.8% | 10.0% |
| Minor Collector | 49,320 | 8.3% | 0.9% | 3.6% |
| Local | 209,722 | 35.4% | 1.6% | 10.2% |
| **Rural Total** | **455,953** | **77.1%** | **26.6%** | **47.3%** |
| ***Urban*** | | | | |
| Interstate | 27,929 | 4.7% | 35.2% | 19.2% |
| Other Expressways | 16,844 | 2.8% | 14.3% | 9.2% |
| Other Principal Arterials | 24,307 | 4.1% | 12.1% | 10.7% |
| Minor Arterial | 24,516 | 4.1% | 7.1% | 7.0% |
| Collectors | 15,171 | 2.6% | 2.3% | 2.8% |
| Local | 26,609 | 4.5% | 2.3% | 3.5% |
| **Urban Total** | **135,376** | **22.9%** | **73.3%** | **52.6%** |
| Unclassified | 378 | 0.1% | 0.0% | 0.1% |
| **Total** | **591,707** | | | |

*Source: National Bridge Inventory.*

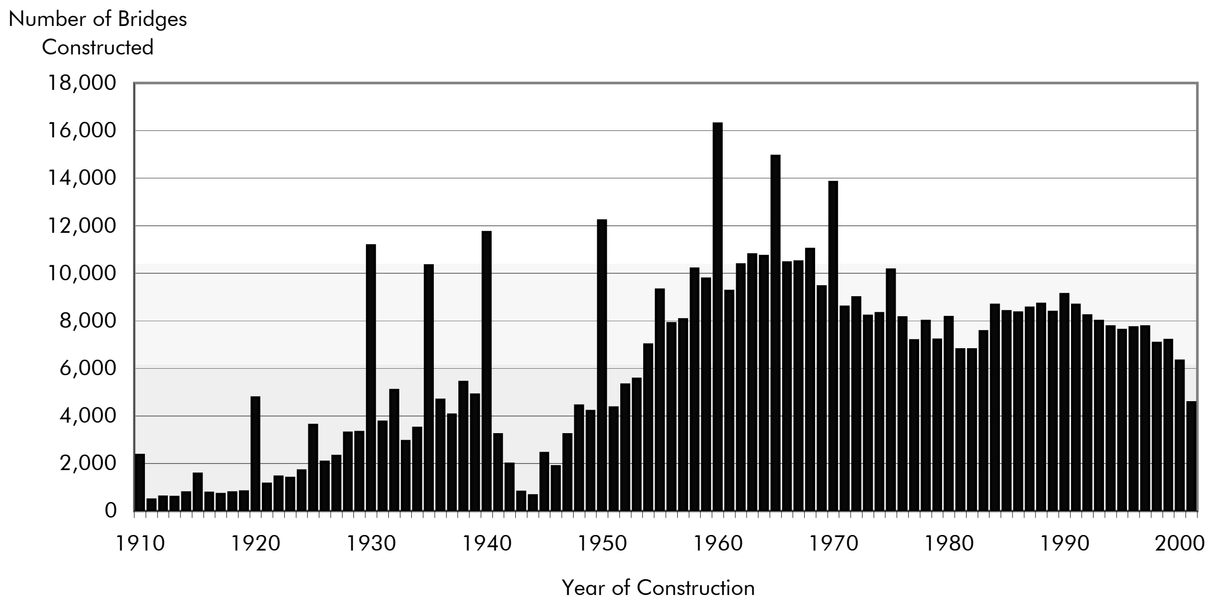
approximately one-third of the inventory by numbers, they carry close to 90 percent of all daily traffic and approximately 70 percent of the deck area. Likewise, the local and collector roads constitute two-thirds of the inventory by numbers, but carry only 10 percent of total daily traffic volume.

## *Bridges by Age of Construction*

For each bridge in the NBI, the year of construction is recorded and a year of construction distribution may be generated. This is shown in *Exhibit 15-4* where the number of bridges constructed by year is presented for all owners and for all functional classifications. Note that some of the annual "spikes" seen in the number of bridges constructed before 1970 are artificial, as some localities have recorded year of construction information using 5-year increments for older bridges. Peak periods of construction are seen mainly before World War II and during the Interstate construction era.

*Exhibit 15-5* shows the average year of bridge construction by functional classification and owner. Standard deviations are provided with the mean values in order to give additional information on the distributions. Bridges in the 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 other owners, 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 to 10 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.

**Exhibit 15-4** *Bridges: Year of Construction Distribution*




*Source: National Bridge Inventory.*

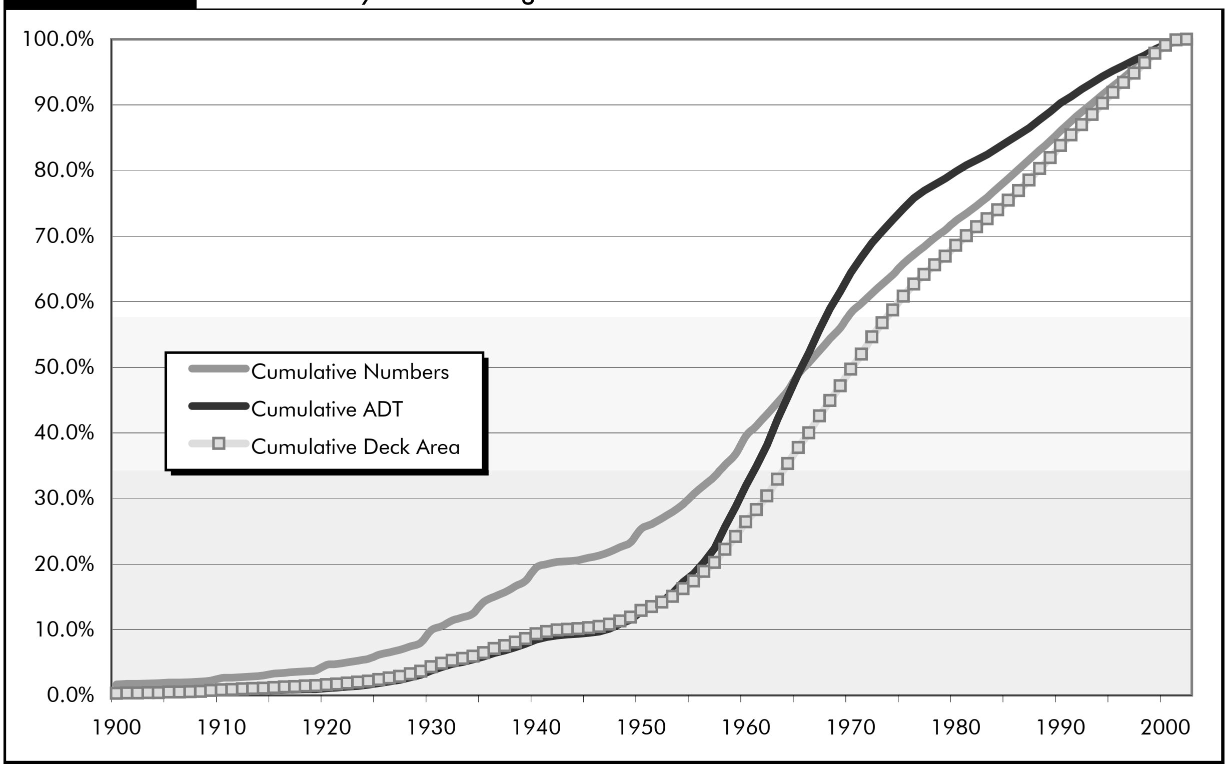
**Exhibit 15-5** *Average Year of Bridge Construction by Owner and Functional Classification*

| | Average Year of Construction and Standard Deviation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Functional Class** | **State** | | **Local** | | **Federal** | | **Other** | | **All Owners** | |
| ***Rural*** | | | | | | | | | | |
| Interstate | 1968 | (11) | 1959 | (28) | 1963 | (6) | 1965 | (11) | 1968 | (11) |
| Other Principal Arterial | 1965 | (22) | 1968 | (24) | 1967 | (18) | 1973 | (19) | 1966 | (22) |
| Minor Arterial | 1958 | (23) | 1972 | (28) | 1968 | (21) | 1966 | (27) | 1959 | (23) |
| Major Collector | 1960 | (21) | 1963 | (22) | 1968 | (18) | 1949 | (32) | 1962 | (22) |
| Minor Collector | 1962 | (20) | 1964 | (24) | 1962 | (19) | 1950 | (32) | 1963 | (23) |
| Local | 1966 | (22) | 1963 | (28) | 1965 | (20) | 1946 | (33) | 1963 | (27) |
| ***All Rural Bridges*** | **1963** | **(21)** | **1963** | **(26)** | **1965** | **(20)** | **1952** | **(32)** | **1963** | **(24)** |
| ***Urban*** | | | | | | | | | | |
| Interstate | 1970 | (12) | 1963 | (17) | 1956 | (8) | 1975 | (19) | 1970 | (12) |
| Other Freeways and Expressways | 1973 | (16) | 1971 | (20) | 1945 | (37) | 1980 | (15) | 1973 | (16) |
| Other Principal Arterial | 1964 | (22) | 1962 | (25) | 1961 | (30) | 1960 | (32) | 1964 | (23) |
| Minor Arterial | 1964 | (22) | 1964 | (25) | 1965 | (21) | 1946 | (33) | 1964 | (24) |
| Collector | 1966 | (22) | 1965 | (25) | 1959 | (18) | 1953 | (34) | 1965 | (24) |
| Local | 1969 | (20) | 1966 | (25) | 1958 | (21) | 1949 | (36) | 1966 | (25) |
| ***All Urban Bridges*** | **1968** | **(18)** | **1965** | **(25)** | **1959** | **(22)** | **1960** | **(33)** | **1967** | **(21)** |
| ***Rural and Urban*** | | | | | | | | | | |
| Interstate | 1969 | (11) | 1963 | (17) | 1962 | (6) | 1973 | (18) | 1969 | (11) |
| Other Principal Arterials | 1967 | (21) | 1964 | (24) | 1965 | (22) | 1974 | (22) | 1967 | (21) |
| Minor Arterials | 1960 | (23) | 1965 | (26) | 1968 | (21) | 1951 | (32) | 1961 | (24) |
| Collectors | 1961 | (21) | 1964 | (23) | 1963 | (19) | 1951 | (33) | 1963 | (22) |
| Local | 1966 | (22) | 1963 | (28) | 1965 | (20) | 1947 | (34) | 1964 | (27) |
| ***All: Rural and Urban*** | **1964** | **(20)** | **1964** | **(26)** | **1965** | **(20)** | **1957** | **(33)** | **1964** | **(24)** |

*Source: National Bridge Inventory.*

The cumulative distributions shown in *Exhibit 15-6* depict the increased rate of construction during the Interstate era. Cumulative distribution curves are presented for the numbers, ADT, and deck area. The mean year of construction occurs where the curves pass through the 50 percent value and is roughly equivalent when bridges are weighted equally (numbers) or when bridges are weighted by traffic carried (ADT). Half of all the bridges in the country were built before 1964, and 50 percent of all daily traffic carried by the system travels over these structures. 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 conforms with conventional wisdom as standards have changed over time.

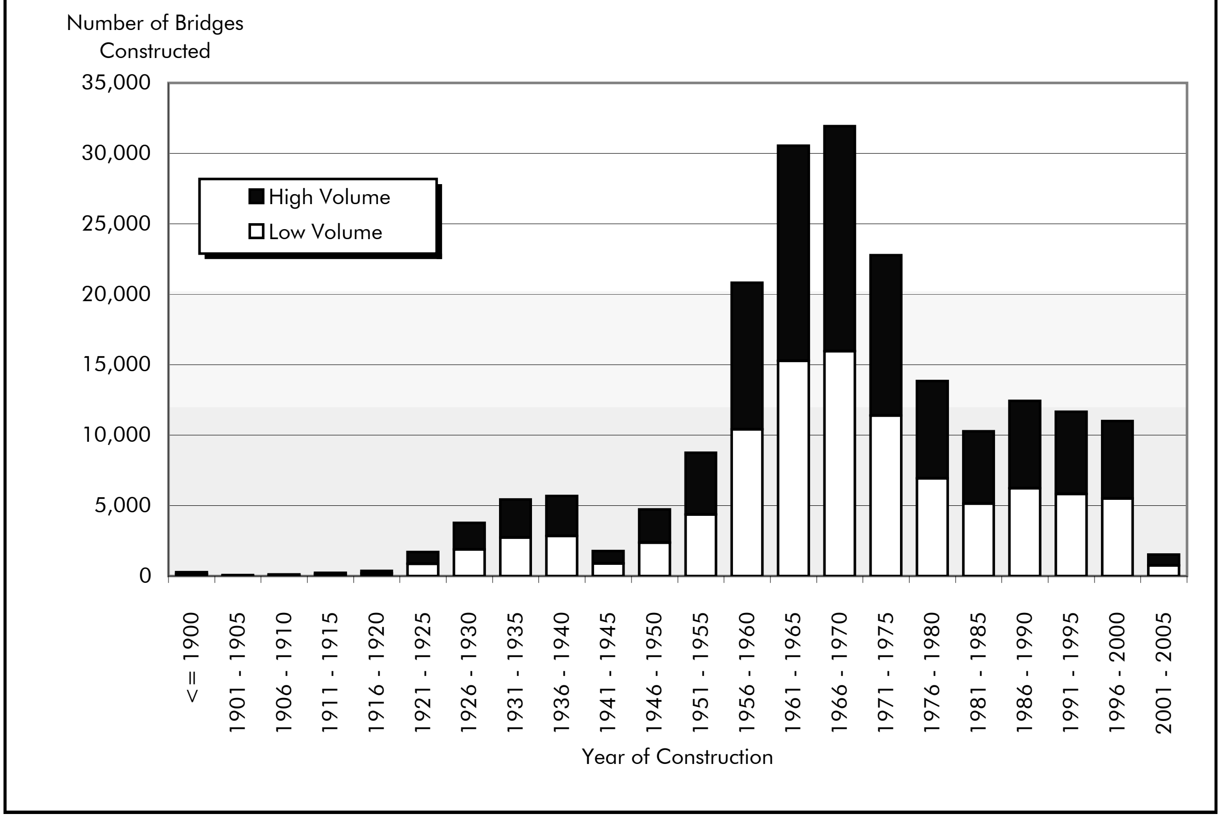
**Exhibit 15-6** *Cumulative Percentage of Numbers, ADT, and Deck Area by Year of Bridge Construction*




*Source: National Bridge Inventory.*

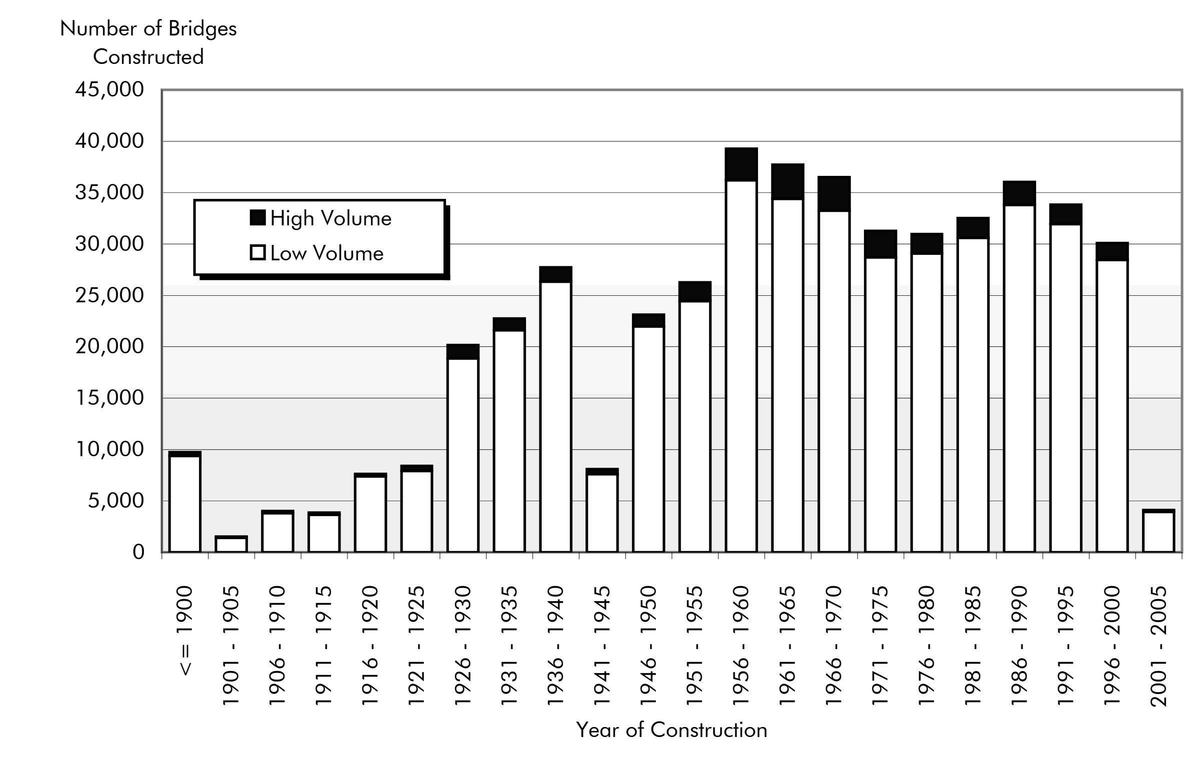
Chapter 17 provides information on the composition and conditions of high- and low-volume bridges on and off the NHS. The majority of traffic is carried on NHS structures, which include the Interstate System. High- and low-volume NHS structures are defined using a threshold of 50,000 vehicle crossings daily. NHS structures include the majority of higher functional classifications and are typically owned by State agencies. The threshold value for distinguishing between high- and low-volume NHS structures is 10,000. Local ownership tends to focus on low-volume non-NHS structures. *Exhibits 15-7* and *15-8* show the year of construction distributions for high- and low-volume NHS and non-NHS bridges.

**Exhibit 15-7** *Year of Construction Distribution for High- and Low-Volume NHS Bridges*




*Source: National Bridge Inventory.*

**Exhibit 15-8** *Year of Construction Distribution for High- and Low-Volume Non-NHS Bridges*

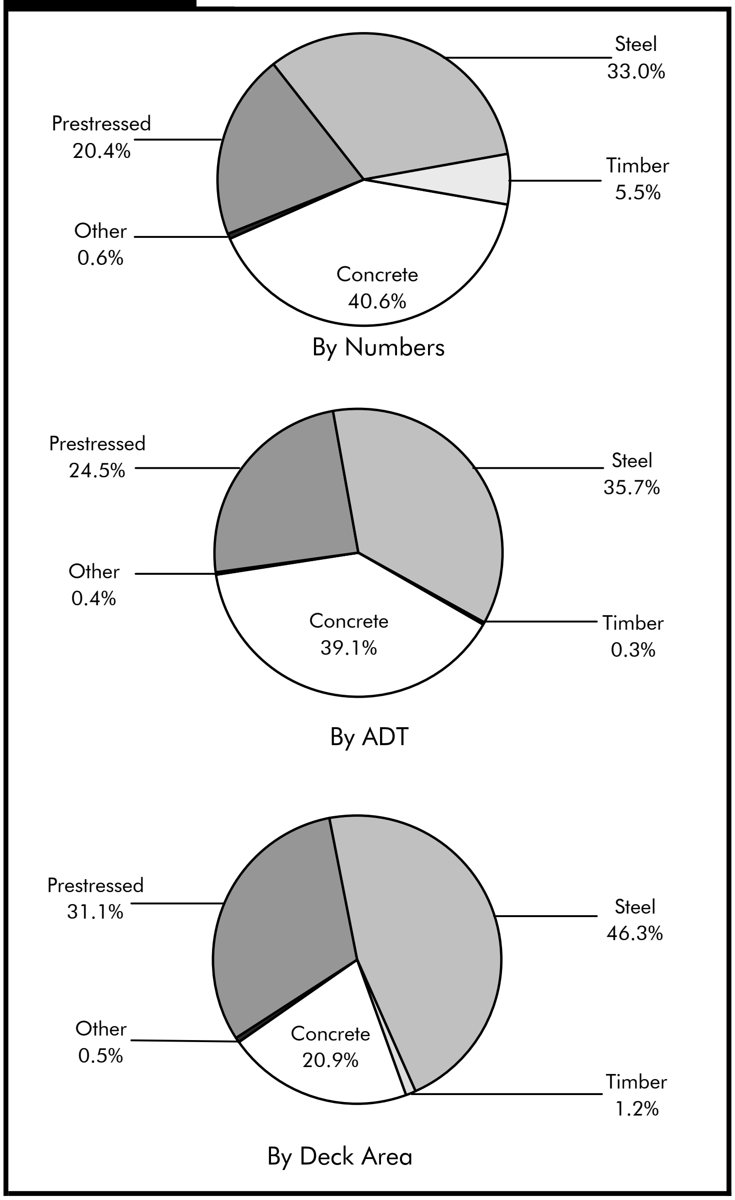



*Source: National Bridge Inventory.*

## *Bridges by Type of Superstructure Material*

Superstructure material types are maintained in the 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. The percentage of superstructure materials utilized is shown in *Exhibit 15-9* weighting bridges equally by numbers, weighting by ADT, and weighting by deck area. While only 33.0 percent of bridges have steel superstructures, these bridges carry 35.7 percent of bridge traffic, and represent 46.3 percent of total deck area on all bridges. From these percentages, it may be inferred that steel bridges tend to be utilized for longer-than-average structures carrying higher-than-average volumes of traffic. Timber bridges, which constitute 5.5 percent of the inventory by numbers, carry small volumes of traffic and are smaller than average in terms of deck area.

**Exhibit 15-9** *Percentage of Superstructure Material Types: Bridges Weighted by Numbers, ADT, and Deck Area*




*Source: National Bridge Inventory.*

The number of bridges by type, superstructure material, functional classification, and ownership are shown in *Exhibit 15-10.* The average year of construction and the standard deviation are shown for these combinations in *Exhibit 15-11.* 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.

**Exhibit 15-10** *Number of Bridges by Superstructure Material, Functional Classification, and Ownership*

| Material & Functional Class | Ownership | | | | |
|---|---|---|---|---|---|
| | State | Local | Federal | Other | All Owners |
| **Interstate** | | | | | |
| Concrete | 19,843 | 61 | 10 | 3 | 19,917 |
| Steel | 21,532 | 222 | 7 | 16 | 21,777 |
| Prestressed | 13,429 | 30 | 3 | 5 | 13,467 |
| Timber | 4 | 3 | | | 7 |
| Other | 54 | 1 | | | 55 |
| **Total** | **54,862** | **317** | **20** | **24** | **55,223** |
| **Other Principal Arterial** | | | | | |
| Concrete | 30,243 | 3,003 | 15 | 151 | 33,412 |
| Steel | 20,102 | 1,889 | 37 | 165 | 22,193 |
| Prestressed | 18,082 | 1,595 | 21 | 497 | 20,195 |
| Timber | 275 | 28 | | | 303 |
| Other | **176** | **72** | **1** | **4** | **253** |
| **Total** | **68,878** | **6,587** | **74** | **817** | **76,356** |
| **Minor Arterial** | | | | | |
| Concrete | 26,040 | 7,424 | 160 | 101 | 33,725 |
| Steel | 13,197 | 3,299 | 133 | 153 | 16,782 |
| Prestressed | 8,681 | 3,456 | 112 | 64 | 12,313 |
| Timber | 519 | 300 | 30 | 14 | 863 |
| Other | 181 | 199 | 9 | 3 | 392 |
| **Total** | **48,618** | **14,678** | **444** | **335** | **64,075** |
| **Collector** | | | | | |
| Concrete | 40,392 | 37,684 | 849 | 84 | 79,009 |
| Steel | 19,933 | 23,392 | 199 | 208 | 43,732 |
| Prestressed | 12,117 | 17,108 | 278 | 110 | 29,613 |
| Timber | 1,670 | 4,306 | 31 | 45 | 6,052 |
| Other | 313 | 522 | 20 | 7 | 862 |
| **Total** | **74,425** | **83,012** | **1,377** | **454** | **159,268** |
| **Local** | | | | | |
| Concrete | 8,507 | 63,212 | 2,002 | 211 | 73,932 |
| Steel | 16,222 | 71,976 | 1,677 | 469 | 90,344 |
| Prestressed | 6,923 | 36,542 | 1,165 | 147 | 44,777 |
| Timber | 1,215 | 21,337 | 2,400 | 237 | 25,189 |
| Other | 263 | 1,546 | 50 | 9 | 1,868 |
| **Total** | **33,130** | **194,613** | **7,294** | **1,073** | **236,110** |
| **All Bridges** | | | | | |
| Concrete | 125,025 | 111,384 | 3,036 | 550 | 239,995 |
| Steel | 90,986 | 100,778 | 2,053 | 1,011 | 194,828 |
| Prestressed | 59,232 | 58,731 | 1,579 | 823 | 120,365 |
| Timber | 3,683 | 25,974 | 2,461 | 296 | 32,414 |
| Other | 987 | 2,340 | 80 | 23 | 3,430 |
| **Total** | **279,913** | **299,207** | **9,209** | **2,703** | **591,032** |

* Note: Records with unknown or incorrectly coded materials, functional classifications, or ownership codes were not included.

*Source: National Bridge Inventory.*

**Exhibit 15-11** *Average Year of Construction and Standard Deviation for Superstructure, Functional Classification, and Ownership Combinations*

| Material & Functional Class | Ownership | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | State | | Local | | Federal | | Other | | All Owners | |
| **Interstate** | | | | | | | | | | |
| Concrete | 1966 | (10) | 1969 | (23) | 1963 | (2) | 1974 | (19) | 1966 | (10) |
| Steel | 1968 | (11) | 1958 | (11) | 1958 | (9) | 1966 | (17) | 1968 | (11) |
| Prestressed | 1975 | (11) | 1989 | (12) | 1968 | (5) | 1993 | (5) | 1975 | (12) |
| Timber | 1971 | (13) | 1969 | (15) | 0 | (0) | 0 | (0) | 1970 | (13) |
| Other | 1987 | (16) | 1979 | (0) | 0 | (0) | 0 | (0) | 1986 | (16) |
| **All Materials** | 1969 | (11) | 1963 | (17) | 1962 | (6) | 1973 | (18) | 1969 | (11) |
| **Other Principal Arterial** | | | | | | | | | | |
| Concrete | 1959 | (21) | 1960 | (23) | 1965 | (17) | 1963 | (24) | 1960 | (21) |
| Steel | 1965 | (19) | 1959 | (24) | 1954 | (20) | 1964 | (30) | 1965 | (19) |
| Prestressed | 1981 | (15) | 1979 | (18) | 1985 | (9) | 1981 | (14) | 1981 | (15) |
| Timber | 1942 | (12) | 1957 | (22) | 0 | (0) | 0 | (0) | 1944 | (14) |
| Other | 1943 | (51) | 1913 | (36) | 1918 | (0) | 1910 | (19) | 1933 | (49) |
| **All Materials** | 1967 | (21) | 1964 | (24) | 1965 | (22) | 1974 | (22) | 1967 | (21) |
| **Minor Arterial** | | | | | | | | | | |
| Concrete | 1954 | (22) | 1965 | (24) | 1961 | (23) | 1953 | (33) | 1957 | (23) |
| Steel | 1959 | (20) | 1956 | (27) | 1968 | (20) | 1943 | (30) | 1958 | (22) |
| Prestressed | 1979 | (18) | 1977 | (19) | 1978 | (12) | 1970 | (29) | 1978 | (18) |
| Timber | 1945 | (14) | 1968 | (29) | 1958 | (14) | 1947 | (29) | 1953 | (23) |
| Other | 1916 | (41) | 1910 | (41) | 1983 | (13) | 1909 | (9) | 1914 | (42) |
| **All Materials** | 1960 | (23) | 1965 | (26) | 1968 | (21) | 1951 | (32) | 1961 | (24) |
| **Collector** | | | | | | | | | | |
| Concrete | 1957 | (20) | 1963 | (22) | 1959 | (17) | 1951 | (33) | 1960 | (21) |
| Steel | 1959 | (20) | 1956 | (24) | 1962 | (20) | 1943 | (31) | 1958 | (22) |
| Prestressed | 1979 | (17) | 1978 | (17) | 1977 | (12) | 1977 | (25) | 1978 | (17) |
| Timber | 1952 | (16) | 1959 | (22) | 1955 | (15) | 1931 | (23) | 1957 | (21) |
| Other | 1933 | (41) | 1938 | (40) | 1954 | (43) | 1925 | (24) | 1936 | (41) |
| **All Materials** | 1961 | (21) | 1964 | (23) | 1963 | (19) | 1951 | (33) | 1963 | (22) |
| **Local** | | | | | | | | | | |
| Concrete | 1961 | (22) | 1966 | (26) | 1960 | (19) | 1957 | (36) | 1965 | (26) |
| Steel | 1964 | (20) | 1954 | (29) | 1963 | (22) | 1940 | (32) | 1956 | (28) |
| Prestressed | 1979 | (15) | 1980 | (18) | 1977 | (14) | 1974 | (26) | 1980 | (17) |
| Timber | 1959 | (22) | 1960 | (23) | 1964 | (19) | 1937 | (26) | 1960 | (23) |
| Other | 1953 | (52) | 1936 | (43) | 1951 | (35) | 1906 | (27) | 1939 | (44) |
| **All Materials** | 1966 | (22) | 1963 | (28) | 1965 | (20) | 1947 | (34) | 1964 | (27) |
| **All Classes** | | | | | | | | | | |
| Concrete | 1959 | (20) | 1965 | (25) | 1960 | (18) | 1957 | (32) | 1962 | (22) |
| Steel | 1964 | (18) | 1955 | (28) | 1963 | (22) | 1945 | (32) | 1959 | (24) |
| Prestressed | 1978 | (15) | 1980 | (18) | 1977 | (13) | 1978 | (20) | 1979 | (16) |
| Timber | 1953 | (19) | 1960 | (23) | 1964 | (19) | 1937 | (26) | 1959 | (23) |
| Other | 1940 | (48) | 1934 | (43) | 1954 | (37) | 1913 | (23) | 1936 | (44) |
| **All Materials** | 1964 | (20) | 1964 | (26) | 1965 | (20) | 1957 | (33) | 1964 | (24) |

*Source: National Bridge Inventory.*

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 (1964/1965) are 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.

# Conditions of Bridges

In Chapter 3, an overview of the condition of the highway bridge network was presented. Chapter 17 presented information on structural deficiencies and functional obsolescence for high- and low-volume NHS and non-NHS mobility measure categories.

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 structurally deficient, functionally obsolete, or nondeficient. 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 that must be addressed. Bridges that are indicated as functionally obsolete do not have structural deficiencies.

**Q. What makes a bridge structurally deficient, and are structural deficient bridges unsafe?**

**A.** 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 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. In order 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.

Overall, there are 162,869 bridges that are deficient within the highway bridge network. This represents 27.5 percent of the total inventory of highway bridges when bridges are weighted equally. The overall percentage of deficiencies is roughly the same when considering traffic carried (27 percent deficient) and deck area (27.5 percent deficient). Over 1 billion vehicles cross deficient bridges daily, and close to 90 million square meters of deck area are on deficient bridges.

*Exhibit 15-12* shows the percentage of structurally deficient (SD) and functionally obsolete (FO) bridges by functional classification and owner. The overall percentage of structurally deficient bridges is approximately equal to the percentage of functionally obsolete bridges. There are nearly twice as many functionally obsolete bridges across all functional classifications for State and Federal owners. For bridges owned by local agencies, private entities, and others, the number of structural deficiencies outweigh the number of functionally obsolete bridges.

## Exhibit 15-12 *Bridge Deficiency Percentages by Functional Class and Owner*

| Description | State # of Bridges %SD / %FO | Local # of Bridges %SD / %FO | Federal # of Bridges %SD / %FO | Other # of Bridges %SD / %FO | Total # of Bridges %SD / %FO |
|---|---|---|---|---|---|
| **Rural** | | | | | |
| Interstate | 27283 | 10 | 18 | 5 | 27316 |
| | 4.0% / 11.7% | 10.0% / 30.0% | 0.0% / 5.6% | 0.0% / 40.0% | 4.0% / 11.8% |
| Other Principal Arterial | 34686 | 300 | 55 | 186 | 35227 |
| | 5.4% / 9.5% | 7.0% / 13.7% | 5.5% / 25.5% | 2.2% / 4.3% | 5.4% / 9.6% |
| Minor Arterial | 36682 | 2414 | 402 | 89 | 39587 |
| | 8.5% / 11.1% | 9.0% / 12.2% | 17.2% / 15.2% | 22.5% / 25.8% | 8.6% / 11.2% |
| Major Collector | 52737 | 41742 | 179 | 123 | 94781 |
| | 11.2% / 13.5% | 13.1% / 7.3% | 13.4% / 10.6% | 34.2% / 19.5% | 12.1% / 10.8% |
| Minor Collector | 16602 | 31423 | 1178 | 117 | 49320 |
| | 12.4% / 13.9% | 14.7% / 9.7% | 5.7% / 17.4% | 38.5% / 12.0% | 13.8% / 11.3% |
| Local | 28177 | 173578 | 7255 | 712 | 209722 |
| | 14.3% / 16.9% | 22.6% / 11.0% | 7.5% / 15.0% | 39.8% / 22.3% | 21.1% / 11.9% |
| **All Classes** | 196167 | 249467 | 9087 | 1232 | 455953 |
| | 9.2% / 12.6% | 19.9% / 10.2% | 7.8% / 15.2% | 32.0% / 18.7% | 15.1% / 11.4% |
| **Urban** | | | | | |
| Interstate | 27601 | 307 | 2 | 19 | 27929 |
| | 6.0% / 20.0% | 21.2% / 30.6% | 50.0% / 0.0% | 0.0% / 26.3% | 6.1% / 20.1% |
| Other Freeways and Expressways | 15429 | 970 | 2 | 443 | 16844 |
| | 6.1% / 20.3% | 8.9% / 26.3% | 0.0% / 0.0% | 0.5% / 10.8% | 6.1% / 20.4% |
| Other Principal Arterial | 18785 | 5317 | 17 | 188 | 24307 |
| | 8.9% / 20.9% | 10.3% / 27.5% | 11.8% / 29.4% | 22.3% / 16.5% | 9.4% / 22.3% |
| Minor Arterial | 11939 | 12288 | 42 | 247 | 24516 |
| | 10.8% / 27.7% | 10.0% / 24.6% | 26.2% / 11.9% | 28.7% / 27.5% | 10.6% / 26.1% |
| Collector | 5086 | 9850 | 20 | 215 | 15171 |
| | 11.6% / 30.7% | 11.1% / 21.9% | 20.0% / 30.0% | 23.3% / 27.4% | 11.5% / 24.9% |
| Local | 4956 | 21096 | 195 | 362 | 26609 |
| | 10.4% / 29.6% | 11.8% / 16.1% | 10.8% / 34.4% | 31.2% / 23.2% | 11.8% / 18.8% |
| **All Classes** | 83796 | 49828 | 278 | 1474 | 135376 |
| | 8.0% / 22.6% | 11.1% / 20.8% | 14.0% / 29.9% | 18.9% / 20.0% | 9.2% / 21.9% |
| **All: Rural and Urban** | | | | | |
| Interstate | 54884 | 317 | 20 | 24 | 55245 |
| | 5.0% / 15.9% | 20.8% / 30.6% | 5.0% / 5.0% | 0.0% / 29.2% | 5.1% / 16.0% |
| Other Principal Arterials | 68900 | 6587 | 74 | 817 | 76378 |
| | 6.5% / 15.0% | 10.0% / 26.7% | 6.8% / 25.7% | 5.9% / 10.6% | 6.8% / 16.0% |
| Minor Arterials | 48621 | 14702 | 444 | 336 | 64103 |
| | 9.0% / 15.2% | 9.9% / 22.5% | 18.0% / 14.9% | 27.1% / 27.1% | 9.4% / 16.9% |
| Collectors | 74425 | 83015 | 1377 | 455 | 159272 |
| | 11.5% / 14.8% | 13.5% / 9.9% | 6.9% / 16.7% | 30.1% / 21.3% | 12.5% / 12.3% |
| Local | 33133 | 194674 | 7450 | 1074 | 236331 |
| | 13.7% / 18.8% | 21.5% / 11.5% | 7.6% / 15.5% | 36.9% / 22.6% | 20.0% / 12.7% |
| **All Classes** | 279963 | 299295 | 9365 | 2706 | 591329 |
| | 8.8% / 15.6% | 18.4% / 12.0% | 8.0% / 15.7% | 24.8% / 19.4% | 13.7% / 13.8% |

SD = Structurally Deficient

FO = Functionally Obsolete

*Source: National Bridge Inventory.*

Deficiencies can be examined by functional classification irrespective of ownership. With bridges carrying higher functional classifications, such as the Interstates and arterials, the percentages of structural deficiencies is significantly lower than the percentages of functionally obsolete bridges. For bridges carrying collector roadways, the percentage of structurally deficient bridges is roughly equal to the percentage of functionally obsolete bridges. For bridges carrying local roadways, 20 percent are structurally deficient, outweighing the 12.7 percent functionally obsolete.

Rural functional classifications and ownership percentages follow the same general trend as the overall population. With bridges carrying higher functional classifications, such as Interstates and principal arterials, functional obsolescence percentages exceed the structural deficiency percentages. The reverse is true for bridges carrying lower functional classification roadways in rural environments where the structural deficiencies outweigh the functional issues. In the urban environment, functional obsolescence percentages were higher than structural deficiency percentages for all functional classifications and for all owners.

*Exhibit 15-13* shows the percent of structural deficiencies and functional obsolescence where bridges are weighted using different methods. Percentages determined by equal weighting through counting of the number of bridges are compared with percentages where bridges are weighted by ADT and deck area. In general, if the percent deficiencies by ADT are higher than those determined using number of bridges, it may be inferred that the deficiencies are occurring on bridges with higher-than-average traffic volumes. Likewise, where the deck area percentages exceed the percentages determined by numbers, it may be inferred that the deficiencies are occurring on bridges with higher-than-average deck areas. For both cases, the converse is also true; with lower percentages, it may be inferred that the deficiencies are occurring on bridges with lower-than-average traffic or area.

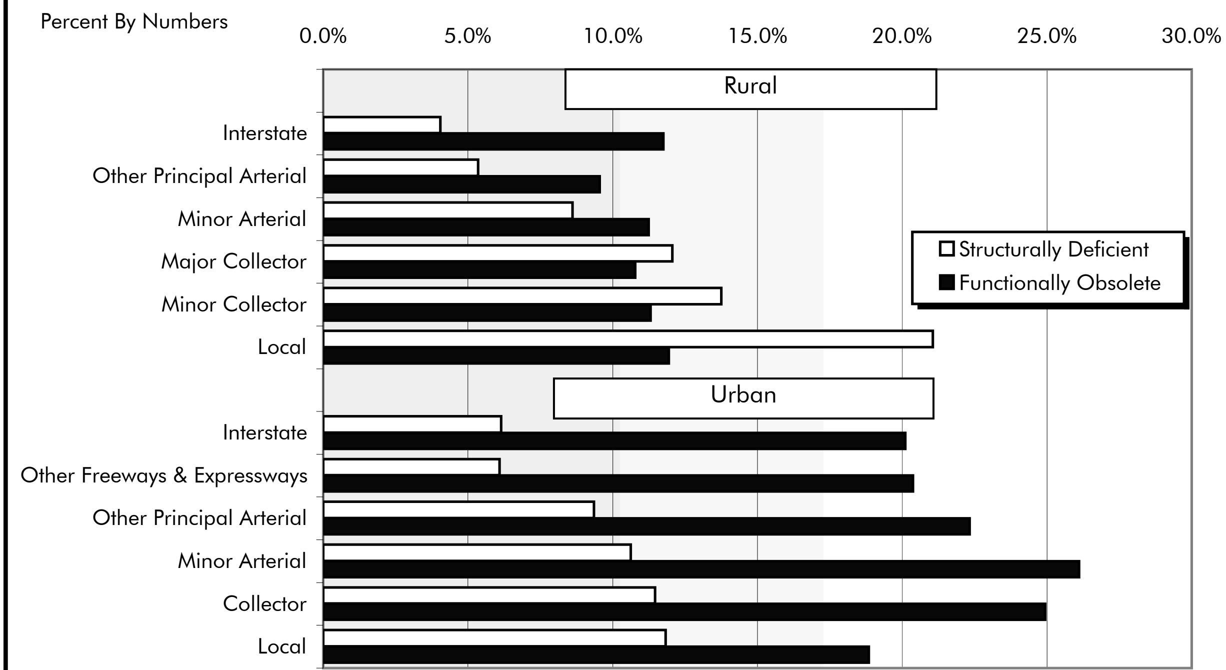
The stacked bars in Exhibit 15-13 allow evaluation and comparison of deficiencies. For both rural and urban structures, percentages of deficiencies increase for the lower functional classifications. Bridges carrying principal arterials clearly have lower deficiency percentages than bridges carrying local roadways. Percentages of functionally obsolete bridges remain relatively constant across the functional classifications, and the increases shown are primarily attributable to structural deficiencies.

# Actions Taken to Remove Deficiencies

Over $60 billion in HBRRP funding alone has been allocated and utilized to ensure safety and continuing functionality of the bridge network. Historically, HBRRP funds have been utilized only for repair, rehabilitation, or replacement of deficient bridges. An examination of bridge construction and bridge rehabilitation activity with Federal fund participation, including HBRRP and other funding programs through 1998 reveals the following:

- Over 50 percent of all activity focuses on replacement of deficient bridges.
- Approximately 40 percent of activity is used for major or minor rehabilitation of deficient bridges.
- The remaining 10 percent of activity is used for new bridge construction.

**Exhibit 15-13** *Percent of Bridge Deficiencies by Numbers, ADT, and Deck Area*




| Functional Classification | % by Numbers | | % by ADT | | % by Area | |
|---|---|---|---|---|---|---|
| | SD | FO | SD | FO | SD | FO |
| ***Rural*** | | | | | | |
| Interstate | 4.0% | 11.8% | 4.5% | 10.8% | 4.9% | 9.7% |
| Other Principal Arterial | 5.4% | 9.5% | 5.4% | 10.3% | 6.8% | 10.4% |
| Minor Arterial | 8.6% | 11.2% | 8.8% | 15.2% | 9.8% | 12.9% |
| Major Collector | 12.1% | 10.8% | 10.4% | 18.8% | 11.4% | 11.1% |
| Minor Collector | 13.8% | 11.3% | 11.7% | 20.0% | 10.9% | 10.6% |
| Local | 21.1% | 11.9% | 11.8% | 26.3% | 14.7% | 13.0% |
| ***Urban*** | | | | | | |
| Interstate | 6.1% | 20.1% | 6.9% | 19.3% | 9.0% | 22.0% |
| Other Freeways & Expressways | 6.1% | 20.4% | 7.4% | 19.6% | 8.8% | 20.1% |
| Other Principal Arterial | 9.4% | 22.3% | 9.8% | 23.1% | 12.1% | 23.7% |
| Minor Arterial | 10.6% | 26.1% | 9.7% | 27.9% | 11.8% | 25.5% |
| Collector | 11.5% | 24.9% | 10.2% | 28.8% | 10.8% | 25.6% |
| Local | 11.8% | 18.8% | 8.5% | 31.8% | 10.1% | 26.8% |

*Source: National Bridge Inventory.*

In 1990, 17 percent of activity with Federal fund participation involved new bridge construction. This percentage has decreased from 1990 to 1998, and today approximately 90 percent of all projects receiving Federal fund participation involve reconstruction or rehabilitation.

*Exhibit 15-14* shows the number and percent of deficient bridges reconstructed, as indicated in the NBI database. The information is presented by functional classification, rural/urban designation, and owner. The average number of years before the reconstruction was undertaken is also indicated.

| Exhibit 15-14 | *Rehabilitation Summary by Functional Class and Owner (% Reconstructed/Average Number of Years to Reconstruction)* |
|---|---|

| Functional Class | State | Local | Federal | Other | All |
|---|---|---|---|---|---|
| **Rural** | | | | | |
| Interstate | 6220<br>23% / 21 | 2<br>20% / 49 | 1<br>6% / 25 | 0<br>0% / 0 | 6223<br>23% / 21 |
| Other Principal Arterial | 7526<br>22% / 30 | 51<br>17% / 34 | 16<br>29% / 33 | 61<br>33% / 29 | 7654<br>22% / 30 |
| Minor Arterial | 8012<br>22% / 33 | 287<br>12% / 36 | 36<br>9% / 28 | 8<br>9% / 60 | 8343<br>21% / 33 |
| Collector | 8189<br>12% / 27 | 7312<br>10% / 41 | 88<br>6% / 36 | 40<br>17% / 49 | 15629<br>11% / 34 |
| Local | 2335<br>8% / 27 | 18576<br>11% / 40 | 1646<br>23% / 17 | 77<br>11% / 43 | 22634<br>11% / 37 |
| **Urban** | | | | | |
| Interstate | 6782<br>25% / 23 | 66<br>21% / 25 | 2<br>100% / 37 | 2<br>11% / 28 | 6852<br>25% / 23 |
| Other Principal Arterial | 7272<br>21% / 29 | 1315<br>21% / 33 | 5<br>26% / 38 | 100<br>16% / 32 | 8692<br>21% / 29 |
| Minor Arterial | 2115<br>18% / 30 | 2153<br>18% / 36 | 4<br>10% / 39 | 49<br>20% / 62 | 4321<br>18% / 33 |
| Collector | 713<br>14% / 29 | 1311<br>13% / 37 | 4<br>20% / 17 | 49<br>23% / 65 | 2077<br>14% / 35 |
| Local | 512<br>10% / 27 | 2140<br>10% / 38 | 56<br>29% / 30 | 65<br>18% / 48 | 2773<br>10% / 36 |
| **All: Rural and Urban** | | | | | |
| Interstate | 13002<br>24% / 22 | 68<br>21% / 26 | 3<br>15% / 33 | 2<br>8% / 28 | 13075<br>24% / 22 |
| Other Principal Arterial | 14798<br>21% / 29 | 1366<br>21% / 33 | 21<br>28% / 34 | 161<br>20% / 31 | 16346<br>21% / 29 |
| Minor Arterial | 10127<br>21% / 33 | 2440<br>17% / 36 | 40<br>9% / 29 | 57<br>17% / 61 | 12664<br>20% / 33 |
| Collector | 8902<br>12% / 27 | 8623<br>10% / 40 | 92<br>7% / 35 | 89<br>20% / 58 | 17706<br>11% / 34 |
| Local | 2847<br>9% / 27 | 20716<br>11% / 40 | 1702<br>23% / 17 | 142<br>13% / 45 | 25407<br>11% / 37 |

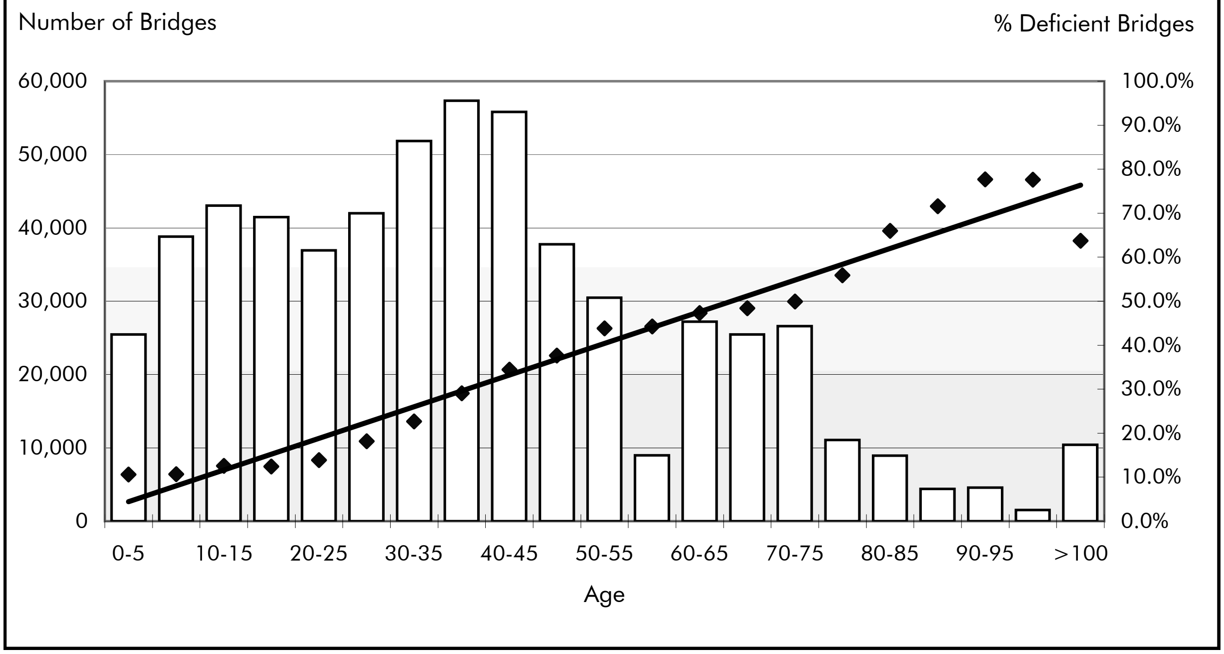
*Source: National Bridge Inventory.*

Historically, Interstate bridges undergo rehabilitation approximately 22 years after they are placed in service. The time to rehabilitation is longer for other functional classifications. Bridges carrying higher functional classifications, such as Interstates and principal arterials, are rehabilitated sooner than bridges carrying lower functional classifications, such as collectors and local routes. This trend is seen for rural and urban functional classifications for all owners and does not necessarily apply for all owner/functional classification combinations.

Progress has been made in reducing the deficiencies. More than 85,000 structures (15 percent of the inventory) have been reconstructed or rehabilitated and are in service today. These reconstruction and rehabilitation efforts have contributed to the reduction in deficiencies discussed in Chapter 3.

*Exhibit 15-15* shows the relationship between bridge age and the percentage of bridges that are classified as deficient. When a structure is placed in service, the deterioration process begins on the components of the bridge. As bridges age, increasing numbers of structures become deficient and increasing funds are required

**Exhibit 15-15** *Age and Deficiency Percentages*




*Source: National Bridge Inventory.*

to address these deficiencies. This is a concern with the increasing age of the large Interstate population and the relatively short period of time for the average reconstruction effort on Interstate bridges. With this ever-aging, continually deteriorating population of highway structures, increasing traffic demands, and limited budgets, the FHWA and the Nation need to take a closer look at transportation system preservation strategies. This includes increased activity in preventative maintenance and improved bridge inspection and management techniques to continue to ensure the safety of the motoring public and effective stewardship of the public trust.

# Conclusions

As can be seen from the information presented in this chapter, the Nation's bridges are aging and traffic demands are increasing. Asset management principles through bridge management systems and transportation system preservation techniques are becoming more important as the States, locals, and Federal government struggle to maintain the safe condition of the Nation's bridges, while at the same time providing for increased demands on the highway bridge network. Improved bridge inspection techniques, through the use of new and innovative equipment, are needed to better ensure the safety of the motoring public. Longer design life structures, using the latest material and design technologies, are needed so that the Nation can maintain a safe bridge network that provides the life span needed to avoid congestion and improve safety of the highway bridge network. Such goals can be achieved only through an emphasis on fundamental long-term research.


# Supplemental Analyses of System Components

# Part IV

# Introduction

Chapters 16 through 22 provide a more in-depth look at specific components of the Nation's transportation system. The information presented in these chapters is intended to provide additional insight into these components.

The seven supplementary analysis chapters in this edition of the report are as follows:

Chapter 16, **Interstate System,** highlights the system characteristics, system conditions, operational performance, and financing of the Interstate System. The chapter also presents analyses of future investment requirements 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 17, **National Highway System (NHS),** is similar in scope and coverage to Chapter 16, 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.

Chapter 18, **Strategic Highway System (STRAHNET),** provides a more detailed look at the Nation's Strategic Highway System. The conditions of the components of STRAHNET are presented in this chapter.

Chapter 19, **Highway-Rail Grade Crossings,** focuses on the delay-related costs imposed on highway users. While grade crossings have traditionally been viewed as a safety concern, they also can have a considerable impact on the operational performance of highways.

Chapter 20, **Transit on Federal Lands,** identifies the future investment that would be required to address growing demands for transit in these areas.

# CHAPTER 16

# Interstate System

# Interstate System

This chapter describes the Dwight D. Eisenhower System of Interstate and Defense Highways, commonly known as the Interstate System. The Interstate System is the backbone of transportation and commerce in the United States. This chapter provides a snapshot of the physical conditions, operational performance, finance, and investment requirements of the Interstate System. This chapter also represents a supplementary analysis to those of the larger, national road network presented in Chapters 2 through 9 of the report.

## Background

On June 26, 1956, President Dwight Eisenhower signed the Federal-Aid Highway Act of 1956, one of his top domestic priorities. 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—the jobs it would produce in manufacturing and construction, the rural areas it would open up—was beyond calculation."

The 1956 legislation declared that the completion of a "National System of Defense and Interstate Highways" was essential to the national interest. This system was designed to facilitate military transportation during the Cold War, but it had countless other economic and social impacts. The Interstate System, for example, accelerated interstate and regional commerce, increased personal mobility, and led to metropolitan development throughout the United States.

The Federal-Aid Highway Act of 1956 called for new design standards, began an accelerated construction program, and established a new method for apportioning funds among the States. At the same time, the Highway Revenue Act of 1956 introduced a dedicated source for Federal highway expenditures. It created a Federal Highway Trust Fund financed by highway users, allowing massive investment in infrastructure projects. Between 1954 and 2001, the Federal government invested over $387 billion on Interstates through apportionments to the States.

The National Highway System Designation Act of 1995 included the Interstate System as the core of a National Highway System (NHS), described in Chapter 17.

## System and Use Characteristics

*Exhibit 16-1* describes the total public road length of the Interstate System (data for all roads can be found in Exhibit 2-6). The route miles of the Interstate System in the United States increased from 46,675 in 2000 to 46,747 in 2002. About 70.8 percent (33,107 route miles) were in rural areas, 3.9 percent (1,808 route miles) were in small urban areas, and 25.3 percent (11,832 route miles) were in urbanized areas. By comparison, of the total 3,981,670 route miles for all roads in the United States, 77.4 percent (3,079,757 route miles) were in rural areas, 4.6 percent (183,503 route miles) were in small urban areas, and 18 percent (718,410 route miles) were in urbanized areas.

The number of Interstate route miles in rural areas declined from 33,152 in 2000 to 33,107 in 2002. During the same period, the number of Interstate System miles in small urban areas increased from 1,794

**Exhibit 16-1** *Interstate Route and Lane Miles, 1993–2002*

| | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Route Miles** | | | | | | |
| Rural | 32,795 | 32,703 | 32,919 | 33,152 | 33,107 | 0.1% |
| Small Urban | 1,694 | 1,731 | 1,744 | 1,794 | 1,808 | 0.7% |
| Urbanized | 11,313 | 11,569 | 11,651 | 11,729 | 11,832 | 0.5% |
| **Total** | **45,802** | **46,003** | **46,314** | **46,675** | **46,747** | 0.2% |
| **Lane Miles** | | | | | | |
| Rural | 132,559 | 132,346 | 133,573 | 135,000 | 135,032 | 0.2% |
| Small Urban | 7,141 | 7,269 | 7,365 | 7,626 | 7,776 | 1.0% |
| Urbanized | 62,754 | 64,865 | 65,603 | 67,020 | 68,088 | 0.9% |
| **Total** | **202,454** | **204,480** | **206,541** | **209,647** | **210,896** | 0.5% |

*Source: Highway Performance Monitoring System.*

in 2000 to 1,808 in 2002 and in urbanized areas the number of route miles increased from 11,729 in 2000 to 11,832 in 2002. The decrease in rural route miles is the result of changes in urban boundaries based on the 2000 decennial Census, which caused 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; consequently, the next edition of the C&P report may show additional rural Interstate mileage having been reclassified as urban.

Between 1993 and 2002, rural Interstate route miles increased by about 0.1 percent annually, small urban Interstate route miles increased at an average annual rate of 0.7 percent, and Interstate route miles in urbanized areas increased 0.5 percent annually. The 0.2 percent overall annual growth rate for Interstates roughly matches that for all roads during that time period.

Exhibit 16-1 also describes the number of Interstate lane miles between 1993 and 2002 (lane mileage data for all functional systems can be found in Exhibit 2-7). In 2002, there were 210,896 lane miles of Interstates in the United States. About 64.0 percent (135,032 lane miles) were in rural communities, 3.6 percent (7,776 lane miles) were in small urban areas, while 32.3 percent (68,088 lane miles) were in urbanized areas. By comparison, about 75.7 percent of all highway lane miles in the United States were in rural areas, 4.7 percent were small urban areas, and 19.6 percent of lane miles were in urbanized areas.

Between 1993 and 2002, rural Interstate lane miles grew by 0.2 percent annually, small urban Interstate lane miles grew at 1.0 percent annually, and urbanized Interstate lane miles grew by 0.9 percent annually. The annual growth rate of lane miles from 1993 to 2002 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 16-2* describes the number of Interstate bridges in 1996, 1998, 2000, and 2002. (Data for all bridges can be found in Exhibit 2-15.) Between 1996 and 2002, the number of rural Interstate bridges dropped from 28,638 to 27,316 bridges, while during the same period, the number of urban Interstate bridges increased from 26,596 to 27,929.

**Exhibit 16-2** *Number of Interstate Bridges, 1996–2002*

| | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|
| Rural | 28,638 | 27,530 | 27,797 | 27,316 |
| Urban | 26,596 | 27,480 | 27,882 | 27,929 |
| **Total** | **55,234** | **55,010** | **55,679** | **55,245** |

*Source: National Bridge Inventory.*

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 16-3* describes vehicle miles traveled (VMT) on Interstate highways between 1993 and 2002. Use data for all roads can be found in Exhibits 2-8, 2-9, and 2-10. In 2002, Americans traveled approximately 282 billion vehicle miles on rural Interstates, 22.6 billion vehicle miles on small urban Interstates, and in excess of 389 billion vehicle miles on urban Interstates. Interstate travel continued to represent the fastest growing portion of VMT between 1993 and 2002. Interstate VMT grew at an average annual rate of approximately 3.1 percent between 1993 and 2002, while VMT on all roads grew by about 2.5 percent annually.

**Exhibit 16-3** *Interstate Vehicle Miles Traveled (Annual VMT), 1993–2002 (Millions of VMT)*

| | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| Rural | 209,470 | 224,705 | 241,451 | 269,533 | 281,461 | 3.3% |
| Small Urban | 16,297 | 17,310 | 18,393 | 21,059 | 22,578 | 3.7% |
| Urbanized | 303,324 | 327,329 | 346,376 | 375,088 | 389,903 | 2.8% |
| **Total** | **529,091** | **569,345** | **606,220** | **665,681** | **693,941** | 3.1% |

*Source: Highway Performance Monitoring System.*

*Exhibit 16-4* describes Interstate highway travel by vehicle type between 1993 and 2002. In 2002, 80.5 percent of travel on rural Interstates was by passenger vehicle; 3.1 percent was by single-unit truck; and 16.4 percent was by combination truck. About 91.9 percent of urban Interstate travel was by passenger vehicle; 2.2 percent was by single-unit truck; and 5.9 percent was by combination truck. By contrast, passenger vehicle travel represented 92.5 percent of travel on all roads in 2002. Single-unit truck travel represented 2.6 percent of travel, and combination truck travel represented 4.9 percent.

**Exhibit 16-4** *Annual Interstate Miles Traveled by Vehicle Type, 1993–2002 (Millions of VMT)*

| | 1993 | 1995 | 1997 | 2000 | 2002 | Annual Rate of Change 2002/1993 |
|---|---|---|---|---|---|---|
| **Rural** | | | | | | |
| PV | 169,500 | 180,031 | 188,969 | 214,175 | 224,375 | 3.2% |
| SU | 5,982 | 6,708 | 7,667 | 8,260 | 8,745 | 4.3% |
| Combo | 32,826 | 36,644 | 41,642 | 44,377 | 45,633 | 3.7% |
| **Urban** | | | | | | |
| PV | 294,703 | 315,888 | 330,668 | 358,906 | 373,957 | 2.7% |
| SU | 6,513 | 7,148 | 7,906 | 8,719 | 9,106 | 3.8% |
| Combo | 16,183 | 18,492 | 20,641 | 23,472 | 23,887 | 4.4% |

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, Summary to 1995, Table VM-201; Highway Statistics, 1997, VM-1; November*

Travel on rural and urban Interstates grew faster than on any other functional system. Between 1993 and 2002, for example, combination truck travel grew by 4.4 percent annually on urban Interstates and by 3.7 percent on rural Interstates. By comparison, combination truck travel on all roads increased by 3.3 percent annually between 1993 and 2002.

# Physical Conditions

Chapter 3 describes the physical conditions of highways throughout the United States. There are numerous ways to examine physical conditions. This section focuses on Interstate pavement condition, lane width, alignment adequacy, bridge deficiencies, and bridge age.

## *Pavement Condition*

*Exhibit 16-5* shows the percentage of total Interstate miles with "Acceptable" or better ride quality by function class for select years from 1995 to 2002. *Exhibit 16-6* shows the percentage of Interstate pavement meeting a standard of "Good" ride quality. (Data for other functional systems can be found in Exhibit 3-14.) Since 1995, the number of Interstate miles rated as having "Good" ride quality has increased for all three population subsets of Interstate highways.

**Exhibit 16-5** *Percent of Interstate Miles with Acceptable Ride Quality, 1995–2002*

| Location of Interstates | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|
| Rural Areas | 94.5% | 95.9% | 97.6% | 97.8% | 97.8% |
| Small Urban Areas | 94.4% | 95.8% | 95.4% | 95.7% | 95.3% |
| Urbanized Areas | 90.0% | 90.0% | 92.2% | 93.0% | 91.7% |

*Source: Highway Performance Monitoring System.*

**Exhibit 16-6** *Percent of Interstate Miles with Good Ride Quality, 1995–2002*

| Location of Interstates | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|
| Rural Areas | 51.8% | 56.9% | 65.4% | 68.5% | 71.9% |
| Small Urban Areas | 49.8% | 51.4% | 58.2% | 61.6% | 64.9% |
| Urbanized Areas | 41.4% | 39.3% | 45.0% | 48.2% | 48.7% |

*Source: Highway Performance Monitoring System.*

In 2002, rural area Interstates had the greatest percentage of miles with "Acceptable" or better ride quality. About 98 percent of rural area Interstates met this standard. As a subset of the miles with "Acceptable" ride quality, 71.9 percent of rural Interstate miles met standards required for classification as "Good" ride quality.

For small urban Interstate miles, 95.3 percent met the criteria for "Acceptable" ride quality. As a subset of the miles with "Acceptable" ride quality, 64.9 percent met the standards to be classified as "Good" ride quality in the year 2002.

**Q.** **How has the percent of Interstate travel occurring on pavements with "Acceptable "and "Good" ride quality changed since 1995?**

**A.** As discussed in Chapter 3, another way to evaluate ride quality is to consider the vehicle miles traveled on routes with "Acceptable" or "Good" ride quality, rather than simply looking at the miles of pavement themselves (see Exhibit 3-15). On this basis, the percentage of rural Interstate travel on pavements with "Acceptable" ride quality rose from 94.5 percent in 1995 to 97.3 percent in 2002, while the percentage of travel on pavements with "Good" ride quality rose from 53.3 percent to 72.2 percent.

Conditions also improved for urbanized Interstates, as the percentage of travel on pavements with "Acceptable" ride quality rose from 88.8 percent to 89.3 percent, while the percentage of travel on pavements with "Good" ride quality rose from 39.1 percent to 43.8 percent.

For small Urban Interstates, performance was mixed, as the percentage of travel on pavements with "Acceptable" ride quality declined from 94.9 percent to 94.6 percent, while the percentage of travel on pavements with "Good" ride quality rose from 51.4 percent to 65.1 percent.

In 2002, 91.7 percent of urbanized Interstate miles met the criteria for "Acceptable" ride quality. As a subset of this group meeting "Acceptable" ride quality, 48.7 percent of the urbanized Interstate miles met the standards to be classified as having "Good" ride quality.

## *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 16-7* summarizes alignment for rural Interstates (alignment is normally not an issue in urban areas). More than 93.3 percent of rural Interstate miles are classified as Code 1 for vertical and 95.7 percent are classified as Code 1 for horizontal alignment.

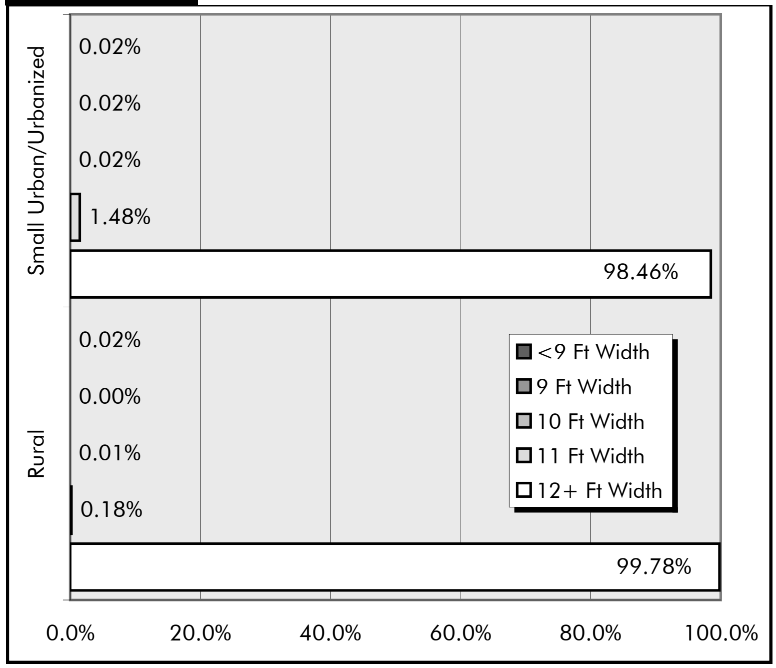
***Exhibit 16-7*** *Rural Interstate Vertical/Horizontal Alignment Status for 2002 (Percent of Miles)*

| | | Vertical | Horizontal |
|---|---|---|---|
| **Code 1:** | All curves and grades meet appropriate design standards. | 93.3% | 95.7% |
| **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. | 5.9% | 1.1% |
| **Code 3:** | Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits. | 0.3% | 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. | 0.5% | 2.4% |

*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 16-8,* approximately 99.8 percent of rural Interstate miles and 98.5 percent of urban Interstate miles have minimum 12-foot lanes widths (see also Exhibits 3-19 and 3-20 in Chapter 3).

**Exhibit 16-8** *Interstate Lane Width*




*Source: Highway Performance Monitoring System.*

The vast majority of the Interstate mileage consists of divided highways with a minimum of four lanes and with 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 Conditions*

Exhibit 3-33 in Chapter 3 identifies bridge deficiencies by functional system, while Exhibit 3-35 shows the percentage of rural and urban bridge deficiencies for the Interstate System in particular. Approximately 15.8 percent of all rural Interstate bridges were deficient in 2002, including 1,104 that were structurally deficient (about 4.0 percent of the total number) and 3,210 that were functionally obsolete (11.8 percent of the total number). Among rural functional systems, only other principal arterials had a lower percentage of bridge deficiencies.

About 26.3 percent of all urban Interstate bridges were deficient in 2002. This included 1,715 structurally deficient bridges (6.1 percent of total urban Interstate bridges), and 5,617 functionally obsolete bridges (20.1 percent of the total). Among urban functional systems, the Interstate System had the lowest percentage of deficient bridges.

The number of deficient bridges has steadily declined in recent years. In 1994, for example, 18.5 percent of rural Interstate bridges were deficient. That number has declined to 15.8 percent. The number of deficient urban Interstate bridges also declined, from 30.6 percent in 1994 to 26.3 percent.

The Federal Highway Administration also looks at bridge deficiencies by the percent of deficient deck area. Approximately 17.9 percent of the rural Interstate bridge deck area was deficient in 1996. This has decreased to 14.6 percent in 2002. This is the lowest percent deficient deck area for all rural functional classes.

The percent of deficient deck area on urban Interstate bridges was 34.2 percent in 1996. By 2002, this had decreased to 31.0 percent.

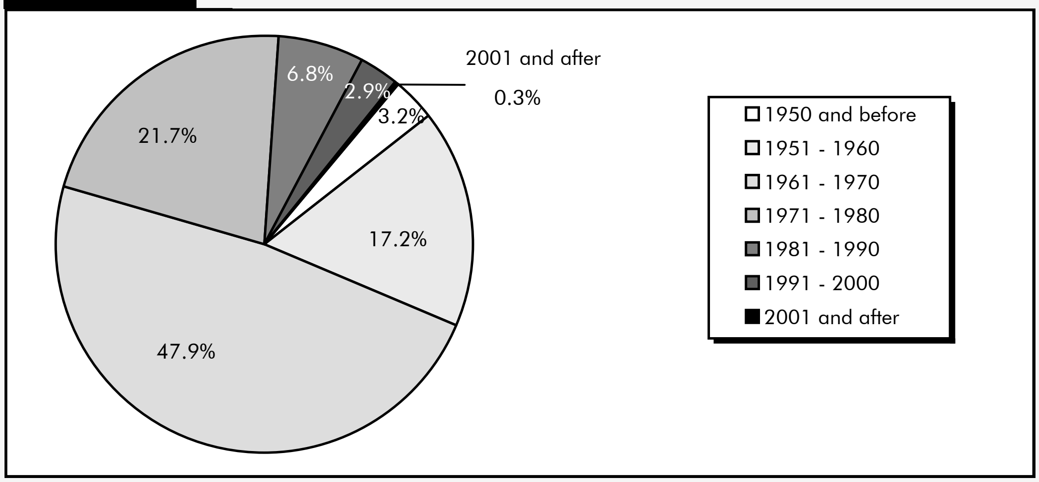
**Q.** How old are most Interstate bridges?

**A.** The aging of Interstate bridges is a significant concern for the Federal Highway Administration and its State and local partners.

*Exhibit 16-9* describes the age of rural Interstate bridges. About 47.9 percent of rural Interstate bridges were built during the early years of the Interstate System, from 1961 to 1970. More than 68.2 percent of all rural Interstate bridges in 2002 were at least 30 years old.

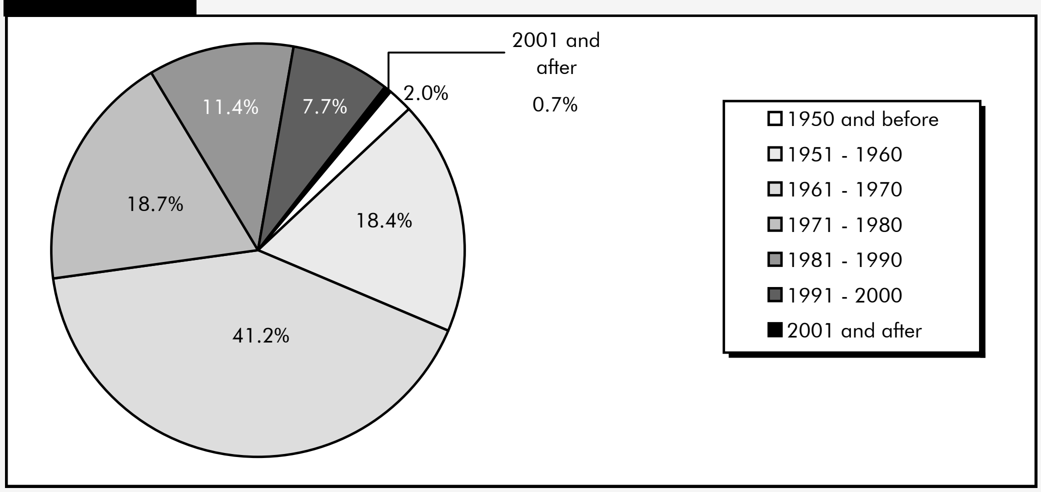
*Exhibit 16-10* describes the age of urban Interstate bridges. About 41.2 percent of urban Interstate bridges were built between 1961 and 1970. Over 61.5 percent of all urban Interstate bridges in 2002 were at least 30 years old.

**Exhibit 16-9** *Age Composition of Rural Interstate Bridges, 2002*




*Source: National Bridge Inventory.*

**Exhibit 16-10** *Age Composition of Urban Interstate Bridges, 2002*




*Source: National Bridge Inventory.*

# Operational Performance

As discussed in Chapter 4, the operational performance of the highway system has been declining in urbanized areas based on a variety of measures.

The Percent of Additional Travel Time, Annual Hours of Delay, and Percent of Travel Under Congested Conditions measures highlighted in Chapter 4 are not computed separately by functional class. However, the Daily Vehicle Miles Traveled (DVMT) per Lane Mile statistics shown in Exhibits 4-12 through 4-14 show the increasing demands being placed on the Interstate System.

From 1993 to 2002, DVMT per lane mile increased from 4,329 to 5,711 on rural Interstate highways, from 6,252 to 7,955 on small urban Interstate highways and from 13,243 to 15,689 on Interstate highways in urbanized areas.

# Safety

*Exhibits 16-11* and *16-12* describe the number of fatalities and the fatality rate for Interstates between 1994 and 2002. 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 classes. The fatality rate on rural Interstates has remained lower than any other rural functional class, and the fatality rate on urban Interestates has remained the lowest of any functional class. More detailed information about highway safety can be found in Chapter 5.

**Exhibit 16-11** *Number of Fatalities on the Interstate System, 1994–2002*

| | 1994 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|
| Rural Interstates | 2,566 | 2,924 | 3,105 | 3,254 | 3,298 |
| Urban Interstates | 2,147 | 2,321 | 2,283 | 2,419 | 2,482 |

*Source: Fatality Analysis Reporting System.*

The rural Interstate fatality rate was almost double that of urban Interstates for the period from 1994 to 2002. This is consistent with the statistics presented in Chapter 5, which showed that fatality rates are generally higher in rural areas.

**Exhibit 16-12** *Fatality Rates (per 100 Million VMT) on the Interstate System, 1994–2002*

| | 1994 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|
| Rural Interstates | 1.19 | 1.26 | 1.23 | 1.21 | 1.18 |
| Urban Interstates | 0.65 | 0.66 | 0.61 | 0.61 | 0.61 |

*Source: Fatality Analysis Reporting System.*

## Finance

All levels of government spent $17.1 billion for capital improvements on Interstate highways and bridges in 2000, which constituted 25.1 percent of the $68.2 billion of capital outlay on all functional classes. *Exhibit 16-13* categorizes this total by type of improvement. System preservation expenditures constituted 53.0 percent of total capital spending on Interstates, system expansion 38.2 percent, and system enhancements 8.8 percent. See Chapter 6 for definitions of these three broad categories of improvement types.

**Exhibit 16-13** *Interstate Capital Expenditures, 2002*

| | Total Invested (Billions of Dollars) | | | Percent of Total | Percent of Total for all Functional Classes | | |
|---|---|---|---|---|---|---|---|
| | Rural | Urban | Total | Interstate | Rural | Urban | Total |
| **System Preservation** | | | | | | | |
| Highway Preservation | $2.8 | $3.1 | $5.9 | 34.5% | 11.4% | 12.7% | 24.1% |
| Bridge Preservation | $1.2 | $1.9 | $3.2 | 18.5% | 10.9% | 17.3% | 28.1% |
| **Subtotal** | **$4.0** | **$5.1** | **$9.1** | **53.0%** | **11.2%** | **14.1%** | **25.3%** |
| **System Expansion** | | | | | | | |
| Additions to Existing Roadways | $1.6 | $2.0 | $3.7 | 21.3% | 12.0% | 14.9% | 26.9% |
| New Routes | $0.5 | $2.2 | $2.7 | 15.8% | 4.6% | 18.4% | 23.0% |
| New Bridges | $0.0 | $0.2 | $0.2 | 1.0% | 1.8% | 13.8% | 15.6% |
| **Subtotal** | **$2.2** | **$4.3** | **$6.5** | **38.2%** | **8.3%** | **16.4%** | **24.7%** |
| **System Enhancements** | **$0.4** | **$1.1** | **$1.5** | **8.8%** | **6.7%** | **18.9%** | **25.5%** |
| **Total Investment** | **$6.6** | **$10.5** | **$17.1** | **100.0%** | **9.7%** | **15.4%** | **25.1%** |

*Sources: Highway Statistics 2002, Table SF-12A and unpublished FHWA data.*

Capital investment on Interstate highways increased sharply between 2000 and 2002, rising 21.6 percent; while total capital investment on all functional classes rose by only 11.2 percent. *Exhibit 16-14* shows that rural Interstate spending rose by 48.2 percent between these two years, driven by an increase in rural Interstate bridge preservation of 181.5 percent and rural Interstate widening of 137.3 percent.

It is important to note that for a particular functional class (such as rural Interstates) and a particular type of capital improvement (such as bridge preservation), 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 2000 and 2002 represent a long-term trend. This comparison is included primarily to help put into perspective the comparisons of 2002 spending with future capital investment requirements discussed later in this chapter.

**Exhibit 16-14** *Interstate Capital Expenditures, 2002 Versus 2000*

| | 2000 (Billions of Dollars) | | | 2002 (Billions of Dollars) | | | Percent Change 2002 Versus 2000 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rural | Urban | Total | Rural | Urban | Total | Rural | Urban | Total |
| **System Preservation** | | | | | | | | | |
| Highway Preservation | $2.8 | $3.2 | $5.9 | $2.8 | $3.1 | $5.9 | 0.8% | -1.4% | -0.3% |
| Bridge Preservation | $0.4 | $1.2 | $1.6 | $1.2 | $1.9 | $3.2 | 181.5% | 62.0% | 93.7% |
| **Subtotal** | **$3.2** | **$4.4** | **$7.6** | **$4.0** | **$5.1** | **$9.1** | **25.3%** | **16.1%** | **20.0%** |
| **System Expansion** | | | | | | | | | |
| Additions to Existing Roadways | $0.7 | $1.8 | $2.5 | $1.6 | $2.0 | $3.7 | 137.3% | 11.4% | 46.0% |
| New Routes | $0.3 | $2.4 | $2.7 | $0.5 | $2.2 | $2.7 | 87.0% | -8.6% | 1.7% |
| New Bridges | $0.0 | $0.4 | $0.4 | $0.0 | $0.2 | $0.2 | -23.4% | -58.9% | -56.6% |
| **Subtotal** | **$1.0** | **$4.6** | **$5.6** | **$2.2** | **$4.3** | **$6.5** | **118.6%** | **-4.8%** | **17.4%** |
| **System Enhancements** | **$0.2** | **$0.7** | **$0.9** | **$0.4** | **$1.1** | **$1.5** | **60.2%** | **58.3%** | **58.8%** |
| **Total Investment** | **$4.5** | **$9.6** | **$14.1** | **$6.6** | **$10.5** | **$17.1** | **48.2%** | **9.2%** | **21.6%** |

*Sources: Highway Statistics 2002, Table SF-12A and unpublished FHWA data.*

# Capital Investment Requirements

Exhibits 7-2 and 7-3 in Chapter 7 show the estimated average annual Maximum Economic Investment (Cost to Improve Highways and Bridges) and Cost to Maintain Highways and Bridges for 2003-2022, categorized by functional class and improvement type. For the Maximum Economic Investment scenario, investment requirements for rural and urban Interstates total $6.4 billion (5.4 percent of total) and $24.9 billion (20.9 percent of the total), respectively. At this level of investment, all cost-beneficial improvements would be implemented. See Chapter 7 and Appendix A for more on the investment requirements methodology used in this report.

For the Cost to Maintain scenario, the portion of estimated investment requirements on Interstates totals $5.0 billion for rural and $13.8 billion for urban. These amounts are 6.7 and 18.7 percent, respectively, of the total Cost to Maintain Highways and Bridges. At this level of investment, average user costs on all highways in 2022 would be maintained at their 2002 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 slightly.

Exhibits *16-15* through *16-18* 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 economically efficient level of investment. All investment levels are in constant 2002 dollars.

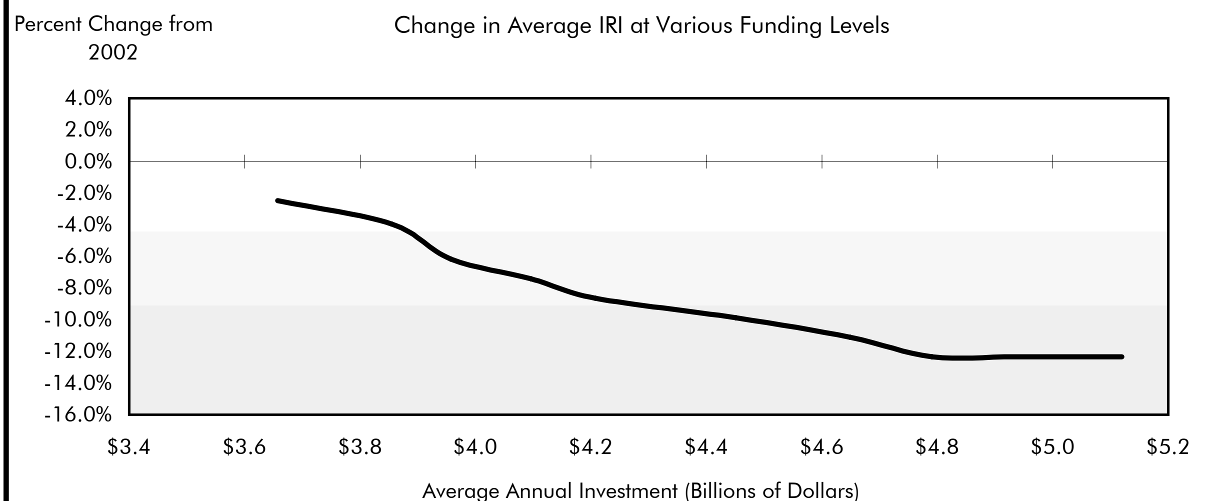
Exhibits 16-15 and 16-17 show the impact of different levels of combined highway preservation and expansion spending on pavement condition, and Exhibits 16-16 and 16-18 show the impact of these same outlays on measures of operational performance. Highway preservation and system expansion investment requirements are modeled by the Highway Economic Requirements System (HERS) (see Appendix A).

Expenditures on system enhancements (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 preservation investment requirements are discussed separately below.

## *Rural Interstates*

Exhibit 16-15 shows projected values for average International Roughness Index (IRI), a measure of average pavement condition, and the percentage of VMT at an IRI below 95 and below 170. These two levels are used to define "Good" and "Acceptable" levels of pavement ride quality. (Chapter 3 provides more information on how pavement condition is defined.) The exhibit shows that the 2002 preservation and expansion investment level of $4.99 billion on rural highways is only slightly below the maximum economic investment level of $5.12 billion estimated by HERS.

**Exhibit 16-15** *Projected Rural Interstate Pavement Condition in 2022 for Different Possible Funding Levels*



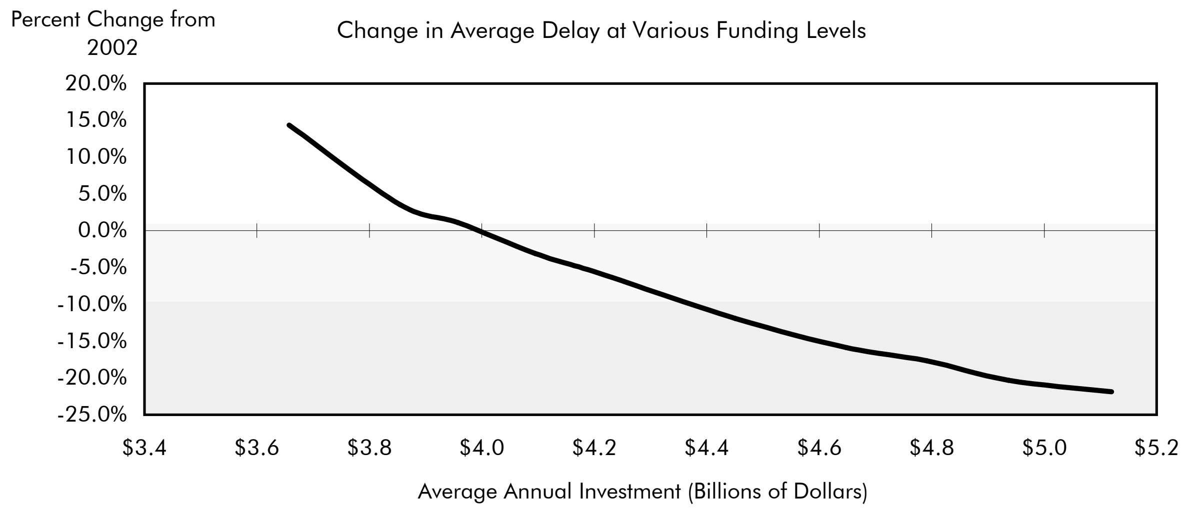

| Average Annual Highway Preservation + Expansion Investment (Rural Interstates) (Billions of 2002 Dollars) | Percent Change in Average IRI | Percent of VMT on Roads with IRI<95 | Percent of VMT on Roads with IRI<170 | Funding Level Description: Investment Required to... |
|---|---|---|---|---|
| **$4.99** | | **73.5%** | **97.3%** | 2002 Values |
| $5.12 | -12.3% | 86.5% | 100.0% | |
| $4.94 | -12.3% | 85.9% | 99.9% | |
| $4.79 | -12.3% | 85.4% | 99.9% | |
| $4.65 | -11.1% | 84.4% | 99.9% | |
| $4.45 | -9.9% | 82.4% | 99.8% | |
| $4.21 | -8.6% | 79.9% | 99.7% | |
| $4.10 | -7.4% | 78.3% | 99.5% | |
| $3.96 | -6.2% | 76.3% | 99.4% | |
| $3.85 | -4.0% | 74.6% | 99.3% | ...Maintain VMT with IRI<95 |
| $3.66 | -2.5% | 71.5% | 99.1% | ...Maintain Average IRI |

*Source: Highway Economic Requirements System.*

If current funding levels were sustained, and the mix of highway preservation and widening investments recommended by HERS were implemented, then average IRI would be projected to decline by 12.3 percent over 20 years, and the percentage of travel on roads with good pavement quality would rise to 86 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 is below $3.66 billion.

Exhibit 16-16 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 preservation and expansion investment. Average user costs on rural Interstates would be maintained at an average annual investment level of $3.66 billion, while average travel time costs would decrease at that funding level. Average delay on rural Interstates would be maintained at an investment level between $3.96 and $4.10 billion, and would decline by over 20 percent at 2002 preservation and expansion expenditure levels.

**Exhibit 16-16** *Projected Rural Interstate Conditions and Performance in 2022 for Different Possible Funding Levels*




| Average Annual Highway Preservation + Expansion Investment (Rural Interstates) (Billions of 2002 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... |
|---|---|---|---|---|
| $4.99 | | | | 2002 Values |
| $5.12 | -21.9% | -0.9% | -2.9% | |
| $4.94 | -20.3% | -0.9% | -2.6% | |
| $4.79 | -17.7% | -0.8% | -2.6% | |
| $4.65 | -15.9% | -0.8% | -2.3% | |
| $4.45 | -11.9% | -0.7% | -2.3% | |
| $4.21 | -5.7% | -0.5% | -1.6% | |
| $4.10 | -3.1% | -0.4% | -1.6% | ...Maintain Average Delay |
| $3.96 | 1.1% | -0.3% | -1.3% | |
| $3.85 | 3.5% | -0.2% | -0.8% | |
| $3.66 | 14.3% | 0.0% | -0.3% | ...Maintain Average User Costs |
| | | | | ...Maintain Average Travel Time Costs |

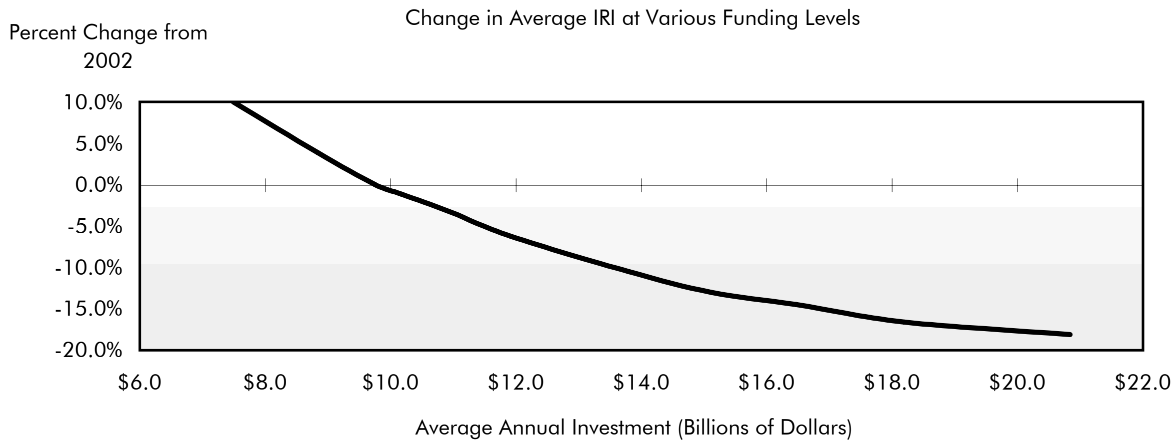
*Source: Highway Economic Requirements System.*

If current funding levels were sustained, and the mix of highway preservation and widening investments recommended by HERS were implemented, then significant reductions could be achieved in average total delay, total user costs and total travel time costs. However, as noted above, spending for additions to existing rural Interstates rose 137.3 percent between 2000 and 2002. If future spending reverts back to a level more in line with what was observed in 2000, then average total delay would be expected to increase.

## *Urban Interstates*

Exhibits 16-17 and 16-18 show the impacts on the same measures of conditions and performance for different levels of capital spending on urban Interstates. Exhibit 16-17 shows that an average annual highway preservation investment of approximately $10.0 billion would be required to maintain average IRI at 2002 levels. As with rural Interstates, the percentage of travel on urban Interstate pavements with good ride quality would increase at this level of investment, while investment would need to increase to over $12 billion to maintain the percentage of VMT on roads with acceptable ride quality.

**Exhibit 16-17** *Projected Urban Interstate Pavement Condition in 2022 for Different Possible Funding Levels*



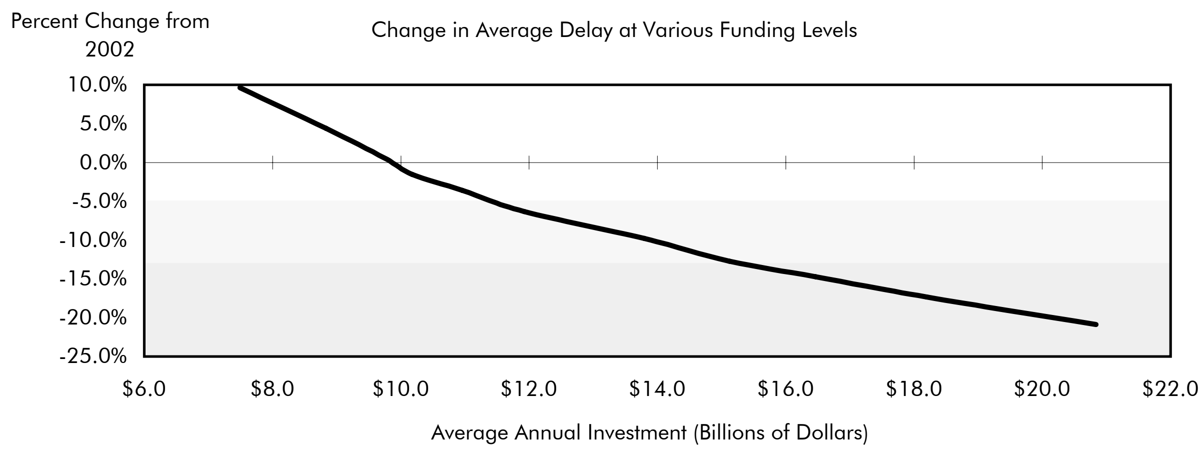

| Average Annual Highway Preservation + Expansion Investment (Urban Interstates) (Billions of 2002 Dollars) | Percent Change in Average IRI | Percent of VMT on Roads with IRI<95 | IRI<170 | Funding Level Description: Investment Required to... |
|---|---|---|---|---|
| **$7.46** | | **45.6%** | **90.0%** | 2002 Values |
| $20.84 | -18.1% | 72.7% | 93.7% | |
| $18.20 | -16.6% | 70.7% | 93.0% | |
| $16.47 | -14.5% | 68.9% | 92.2% | |
| $15.12 | -13.0% | 67.2% | 91.8% | |
| $13.80 | -10.5% | 64.5% | 91.1% | ...Maintain VMT with IRI<170 |
| $11.92 | -6.2% | 61.0% | 89.7% | |
| $10.96 | -3.2% | 57.5% | 89.0% | |
| $10.18 | -1.1% | 55.4% | 87.9% | ...Maintain Average IRI |
| $9.75 | 0.1% | 54.3% | 87.6% | |
| $8.83 | 4.0% | 51.6% | 86.1% | |
| $7.49 | 10.1% | 47.8% | 81.8% | |

*Source: Highway Economic Requirements System.*

If current funding levels were sustained, and the mix of highway preservation and widening investments recommended by HERS were implemented, then average IRI on urban Interstates would be expected to increase by 10.1 percent, and the percent of VMT on roads with acceptable ride quality would fall to 81.8 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 16-18 indicates that an average annual investment level in highway preservation and capacity expansion of between $9.75 and $10.18 billion would be needed to maintain average delay on urban Interstates. Total user costs would be maintained at investment levels up to $10.96 billion, and travel time costs on urban Interstates would be maintained at funding levels over $12 billion. These amounts are 30 to 70 percent higher than the comparable 2002 funding level of $7.5 billion. The results suggest that, if average annual funding were maintained (in constant dollars) at 2002 levels through 2022, average delay on urban Interstates would increase by 9.6 percent, total user costs would increase by 4.1 percent, and travel time costs would increase by 9.6 percent.

**Exhibit 16-18** *Projected Urban Interstate Conditions and Performance in 2022 for Different Possible Funding Levels*




| Average Annual Highway Preservation + Expansion Investment (Urban Interstates) (Billions of 2002 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... |
|---|---|---|---|---|
| $7.46 | | | | 2002 Values |
| $20.84 | -20.9% | -5.9% | -6.8% | |
| $18.20 | -17.3% | -5.0% | -5.3% | |
| $16.47 | -14.7% | -4.2% | -4.0% | |
| $15.12 | -12.7% | -3.6% | -2.9% | |
| $13.80 | -9.8% | -2.8% | -1.7% | ...Maintain Average Travel Time Costs |
| $11.92 | -6.3% | -1.4% | 0.5% | |
| $10.96 | -3.6% | -0.5% | 2.0% | ...Maintain Average User Costs |
| $10.18 | -1.5% | 0.3% | 3.2% | ...Maintain Average Delay |
| $9.75 | 0.6% | 0.7% | 4.0% | |
| $8.83 | 4.4% | 1.9% | 5.9% | |
| $7.49 | 9.6% | 4.1% | 9.6% | |

*Source: Highway Economic Requirements System.*

## *Bridge Preservation*

As described in Chapter 7, the National Bridge Investment Analysis System model identifies preservation investment requirements for all bridges, including those on Interstates. The current Interstate bridge preservation backlog is estimated at $14.2 billion.

*Exhibit 16-19* describes what the Interstate bridge backlog after 20 years would be at different funding levels. An average annual investment in bridge preservation of $2.13 billion is 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 $2.82 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 16-19** *Projected Interstate Bridge Investment Backlog in 2022 for Different Possible Funding Levels*

| (Billions of 2002 Dollars) | |
|---|---|
| **Average Annual Investment** | **2022 Interstate Bridge Backlog** |
| $2.82 | $0.0 |
| $2.65 | $3.9 |
| $2.50 | $6.7 |
| $2.27 | $11.2 |
| $2.13 | $14.2 |
| $1.96 | $17.7 |
| $1.65 | $24.2 |
| $1.38 | $31.1 |

*Source: National Bridge Investment Analysis System.*

Exhibit 16-13 indicates that bridge preservation expenditures on Interstates totaled $3.2 billion in 2002. Thus, if this level of funding were maintained in constant dollars over 20 years, NBIAS projects that the Interstate bridge backlog could be eliminated. However, Exhibit 16-14 shows that Interstate bridge preservation spending rose 93.7 percent from $1.6 billion to $3.2 billion between 2000 and 2002. If future spending reverts back to a level more in line with what was observed in 2000, then the Interstate bridge preservation backlog would increase significantly.

## *Current Spending Versus Investment Requirements*

Exhibits 16-15 through 16-19 indicate that 2002 levels of highway preservation 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 2002 level of rural and urban Interstate bridge preservation investment would be adequate to address the economic backlog of bridge deficiencies, if that level of investment could be sustained. However, as shown in Exhibit 16-14 and discussed previously, 2002 may represent an unusually high year for rural Interstate capital spending, especially for rural bridges.

On urban Interstates, significant increases in funding for preservation and expansion above current levels would be required to prevent both average physical conditions and operational performance from becoming degraded.

# CHAPTER 17

## National Highway System

# National Highway System

This chapter provides a snapshot of the physical conditions, operational performance, finance, and investment requirements of the National Highway System (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, 3, 4, 6, 7, 8, and 9.

## Background

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required Congress to establish an NHS by September 30, 1995. ISTEA authorized a NHS of up to 178,250 miles. The purpose of the NHS was to focus Federal resources on roads that are the most important to interstate travel and national defense, that connect with other modes of transportation, and that are essential for international commerce.

Although ISTEA required that certain key routes, such as the Interstate System, be included in the NHS, most of the NHS was not specified. The Federal Highway Administration (FHWA) worked with its State and local partners, public and private interest groups, and other agencies within the Department of Transportation to identify potential NHS routes. The National Highway System Designation Act of 1995, which became law on November 28, 1995, identified a 160,955-mile network. Additions to the NHS have been made since the initial authorization.

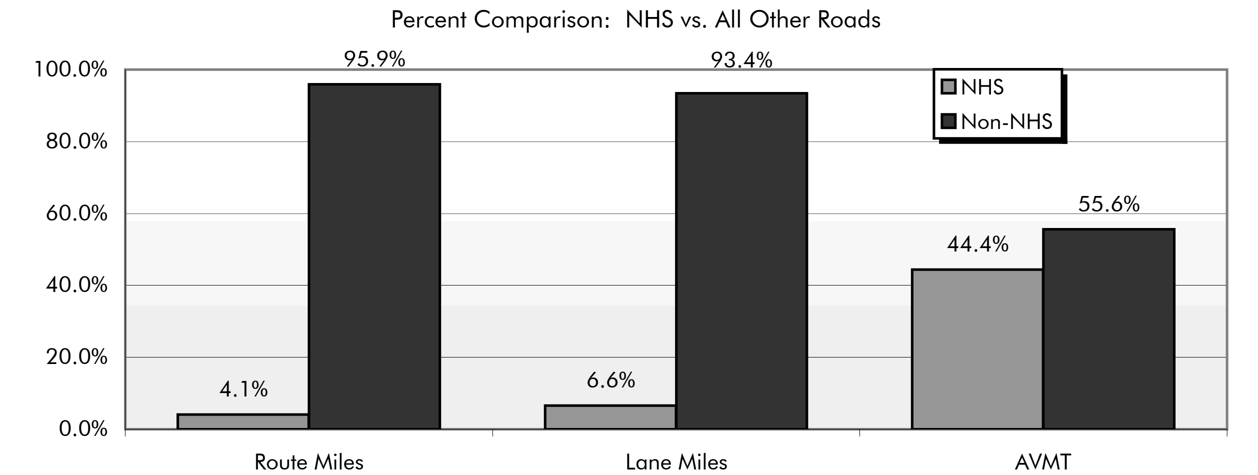
The NHS has five components. The Interstate System, described in Chapter 16, is the core of the NHS and includes the most-traveled routes. Many other rural and urban principal arterials, described in Chapter 2, are also included. The Strategic Highway Network (STRAHNET), described in Chapter 18, includes highways important to military mobilization. STRAHNET connectors, also described in Chapter 18, provide access between major military installations and routes that are part of STRAHNET. Intermodal connectors are highways that provide access between major intermodal passenger and freight facilities and the other four subsystems making up the NHS.

The NHS was designed to be a dynamic system able to change in response to future travel and trade demands. The Secretary of Transportation may approve modifications to the system 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 when proposing modifications.

## System and Use Characteristics: Highways

*Exhibit 17-1* summarizes NHS route miles, lane miles, and vehicle miles traveled (VMT), including all five NHS components listed above. The NHS is overwhelmingly concentrated on higher functional systems. All Interstates are part of the NHS, 84.0 percent of rural other principal arterials are part of the NHS, and 87.1 percent of urban other freeways and expressways and 35.7 percent of urban other principal arterials are

**Exhibit 17-1** *Highway Route Mileage, Lane Mileage, and Vehicle Miles Traveled on the National Highway System Compared to All Roads, by Functional System, 2002*

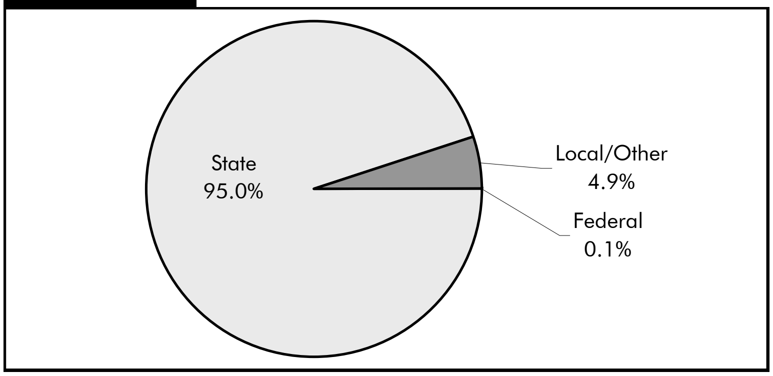



| | Route Miles | | Lane Miles | | Annual Vehicle-Miles Traveled (Millions) | |
|---|---|---|---|---|---|---|
| | Total on NHS | Percent of Functional System | Total on NHS | Percent of Functional System | Total on NHS | Percent of Functional System |
| **Rural NHS** | | | | | | |
| Interstate | 33,107 | 100.0% | 135,032 | 100.0% | 281,461 | 100.0% |
| Other Principal Arterials | 83,153 | 84.0% | 220,431 | 86.0% | 226,736 | 87.9% |
| Minor Arterial | 1,935 | 1.4% | 4,847 | 1.7% | 4,558 | 2.6% |
| Major Collector | 745 | 0.2% | 1,633 | 0.2% | 1,391 | 0.6% |
| Minor Collector | 24 | 0.0% | 48 | 0.0% | 26 | 0.0% |
| Local | 46 | 0.0% | 88 | 0.0% | 36 | 0.0% |
| **Subtotal Rural NHS** | **119,009** | **3.9%** | **362,078** | **5.7%** | **514,208** | **45.4%** |
| **Urban NHS** | | | | | | |
| Interstate | 13,640 | 100.0% | 75,864 | 100.0% | 412,481 | 100.0% |
| Other Freeway and Expres | 8,170 | 87.1% | 38,423 | 88.4% | 175,824 | 92.2% |
| Other Principal Arterial | 19,151 | 35.7% | 70,818 | 37.6% | 166,762 | 40.6% |
| Minor Arterial | 1,129 | 1.2% | 3,412 | 1.4% | 5,791 | 1.7% |
| Collector | 312 | 0.3% | 835 | 0.4% | 1,173 | 0.8% |
| Local | 127 | 0.0% | 299 | 0.0% | 238 | 0.1% |
| **Subtotal Urban NHS** | **42,529** | **4.7%** | **189,653** | **9.3%** | **762,269** | **43.8%** |
| **Total NHS** | **161,538** | **4.1%** | **551,731** | **6.6%** | **1,276,477** | **44.4%** |

*Source: Highway Performance Monitoring System.*

on the NHS. The share of minor arterials, collectors, and local roads on the NHS is relatively small. There are currently 161,538 route miles on the NHS, excluding some sections not yet open to traffic. While only 4.1 percent of the Nation's total road mileage is on the NHS, these roads carry 44.4 percent of VMT. This represents an increase since 1997, when 43.5 percent of total VMT were on the NHS. The 551,731 lane miles on the NHS in 2002 represented 6.6 percent of the national total, reflecting the fact that NHS routes are wider on average than non-NHS routes.

**Exhibit 17-2** *NHS Mileage by Owner, 2002*




*Source: Highway Performance Monitoring System.*

*Exhibit 17-2* describes the ownership of NHS mileage. Approximately 95.0 percent of route miles were State-owned in 2002. Only 4.9 percent were locally owned, and the remaining 0.1 percent were owned by the Federal government. By comparison, Exhibit 2-2 in Chapter 2 shows that 19.5 percent of all route miles in the United States were State-owned, 77.5 percent were locally owned, and 3.0 percent were owned by the Federal government. Since the NHS is concentrated on higher functional systems, the percentage of locally owned NHS routes is relatively small.

# Physical Conditions: Highways

The FHWA's 1998 National Strategic Plan introduced a new measure of pavement condition: "acceptable ride quality." This measure is described more comprehensively in Chapter 3. The National Strategic Plan stated that by 2008, 93 percent of NHS mileage should meet pavement standards for "acceptable ride quality." This goal was achieved in 1999 [*see Exhibit 17-3*].

The FHWA has adopted a new metric based on the percent of VMT on "acceptable" pavement, also described in Chapter 3. By adopting this metric, FHWA has broadened its emphasis to include the benefits of good surface quality to the user. In its FY 2005 Performance Plan, FHWA aimed to have 93.5 percent of VMT on NHS be on pavements rated "acceptable" or better by 2005. The VMT on NHS pavements with "acceptable ride quality" declined slightly between 2000 and 2002, as described in Exhibit 17-3.

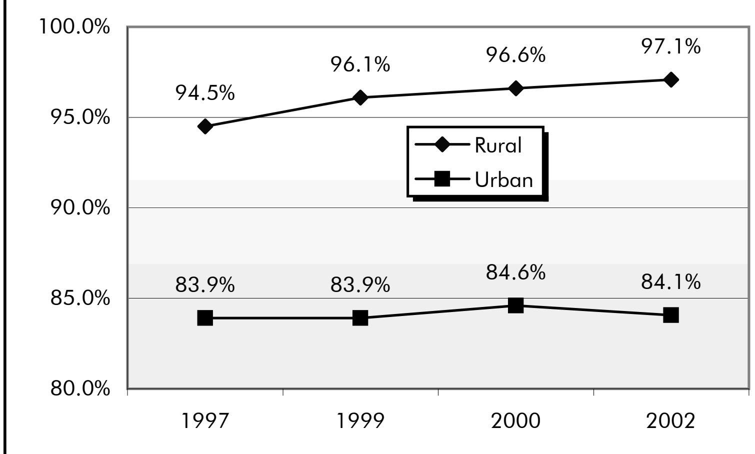
Routes on the NHS tend to have better overall pavement condition than the remainder of the highway system pavement. In 2002, the percent of NHS route miles with acceptable ride quality was 93.7 compared to 87.4 percent for the total highway system. With regard to VMT, 90.6 percent on the NHS was on pavement with acceptable or better ride quality compared with 85.3 percent for the total highway system.

**Exhibit 17-3** *Ride Quality on the National Highway System, 1995–2002*

| | 1995 | 1997 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|
| **Total VMT on NHS** | 2,773,938,956 | 3,033,588,343 | 3,241,907,944 | 3,312,712,815 | 3,475,416,799 |
| **Total VMT on NHS Acceptable Pavements** | 2,468,437,385 | 2,703,589,578 | 2,937,581,806 | 3,013,107,389 | 3,147,569,206 |
| **Total Miles of NHS** | 154,254 | 157,749 | 159,123 | 159,012 | 161,538 |
| **Total Miles of NHS with Acceptable Ride Quality** | 139,450 | 144,766 | 147,926 | 148,684 | 151,361 |
| **Percent VMT on NHS Acceptable Pavements** | 89.0% | 89.1% | 90.6% | 91.0% | 90.6% |
| **Percent Miles of NHS Pavement with Acceptable Ride Quality** | 90.4% | 91.8% | 93.0% | 93.5% | 93.7% |

Rural NHS routes tend to have better pavement conditions than urban NHS routes, which is consistent with the results reported for all roads in Chapter 3. As shown in *Exhibit 17-4,* in 2002 97.1 percent of rural NHS route miles had acceptable ride quality, compared to only 84.1 percent of urban NHS route miles. Rural NHS ride quality has risen more consistently since 1997 than has urban NHS ride quality.

**Exhibit 17-4** *Acceptable NHS Miles: Rural and Urban*




*Source: Highway Performance Monitoring System.*

**Q.** What is the condition of the intermodal connectors on the National Highway System?

**A.** A 2000 FHWA report to Congress on the condition and performance of intermodal connectors found that there were 517 freight-only terminals representing port (ocean and river), truck/rail, and pipeline/truck facilities. In addition to these freight-only terminals, 99 major freight airports (which handle both passenger and freight) were included in the list of freight intermodal terminals. The majority of mileage is in urban areas and is classified as arterials.

The report made several conclusions about physical deficiencies of these connectors. First, connectors to ports were found to have twice the percentage of mileage with pavement deficiencies when compared to non-Interstate NHS routes. Connectors to rail terminals had 50 percent more deficient mileage than non-Interstate NHS routes. Connectors to airport and pipeline terminals appeared to be in better condition with about the same percent of mileage with pavement deficiencies as those on non-Interstate NHS. This may be due to the high volume of passenger travel on airport roads.

Second, problems with shoulders, inadequate turning radii, and inadequate travel way width were most often cited as geometric and physical deficiencies with connectors. Data were not available to directly compare connectors and other NHS routes with regard to rail crossings, lane width, and other deficiencies. A general comparison of functional class attributes suggests that lane width, cross section, and design attributes are significantly more deficient when compared to non-Interstate NHS mainline routes. See chapter 25 of the 2002 edition of the C&P report for additional details.

# System and Use Characteristics: Bridges

Historically, bridge performance measures have been based almost exclusively on the number of bridges, with the number of deficient bridges giving an indication of the status of the inventory. However, this creates a situation in which the condition of a bridge on the Interstate System with average daily traffic (ADT) of 100,000 vehicles has the same weight as a bridge on a local road that carries 100 vehicles per day. While all bridges in the system are important; from a national perspective, the structure carrying 100,000 vehicles daily contributes more toward the overall mobility of the traveling public. As discussed in Chapter 3, bridge performance measures can be weighted by deck area and/or travel volume to give a more balanced perspective on the overall state of the Nation's bridges.

To guide management of the bridge inventory and improve the system by reducing the amount of deck area on deficient bridges, the performance goals in FHWA's annual performance plans have been subdivided into four categories to better reflect the relative importance of the bridges in improving user mobility. The four categories were developed based on ADT and NHS designation as follows:

High-Volume NHS Bridges – ADT greater than or equal to 50,000

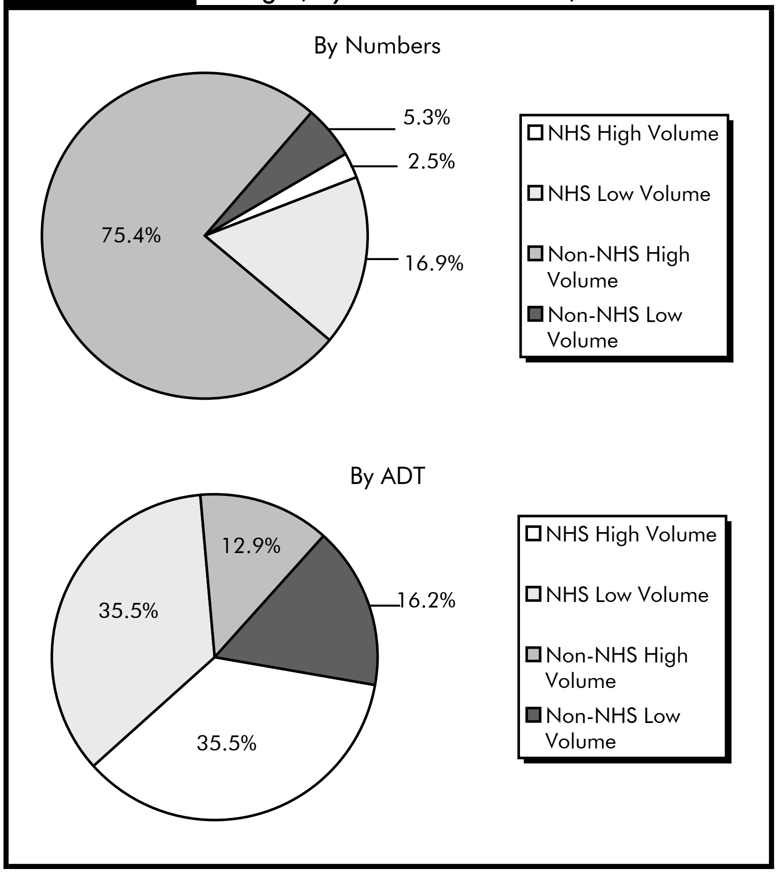
Low-Volume NHS Bridges – ADT less than 50,000

High-Volume Non-NHS Bridges – ADT greater than or equal to 10,000

Low-Volume Non-NHS Bridges – ADT less than 10,000

As shown in *Exhibit 17-5,* the 114,587 NHS structures constitute 19.4 percent of all bridges in terms of numbers, but carry 71.0 percent of the total daily traffic volume serviced by the bridge inventory. Among the NHS structures, 14,651 bridges carry 50,000 or more vehicles daily and are classified as "high-volume NHS bridges." These structures comprise 12.7% of the NHS bridges in terms of numbers, but carry half of the total daily traffic serviced by the NHS inventory. The remaining 99,936 NHS bridges carrying the other half of the daily traffic volume are classified as "low-volume NHS bridges."

**Exhibit 17-5** *High and Low Volume NHS and Non-NHS Bridges, by Numbers and ADT, 2002*

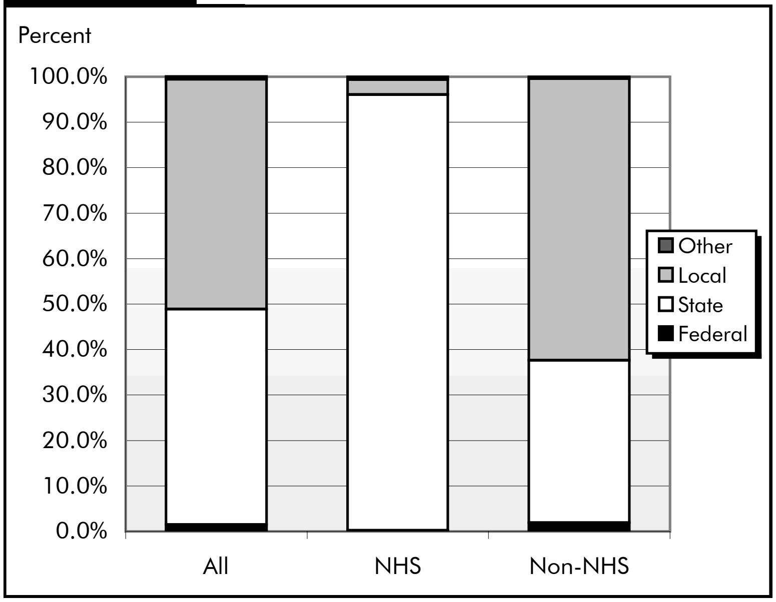



*Source: National Bridge Inventory*

The 477,053 non-NHS bridges comprise 80 percent of all bridges by numbers, but carry 30 percent of the total daily traffic volume serviced by the bridge inventory. There are 31,176 non-NHS bridges carrying 10,000 vehicles or more daily. These structures, classified as "high-volume non-NHS bridges" carry 55 percent of the total daily traffic serviced by non-NHS bridges in the inventory. The 445,877 "low-volume non-NHS bridges" (93% of all non-NHS bridges) carry 45% of the total ADT serviced by non-NHS bridges.

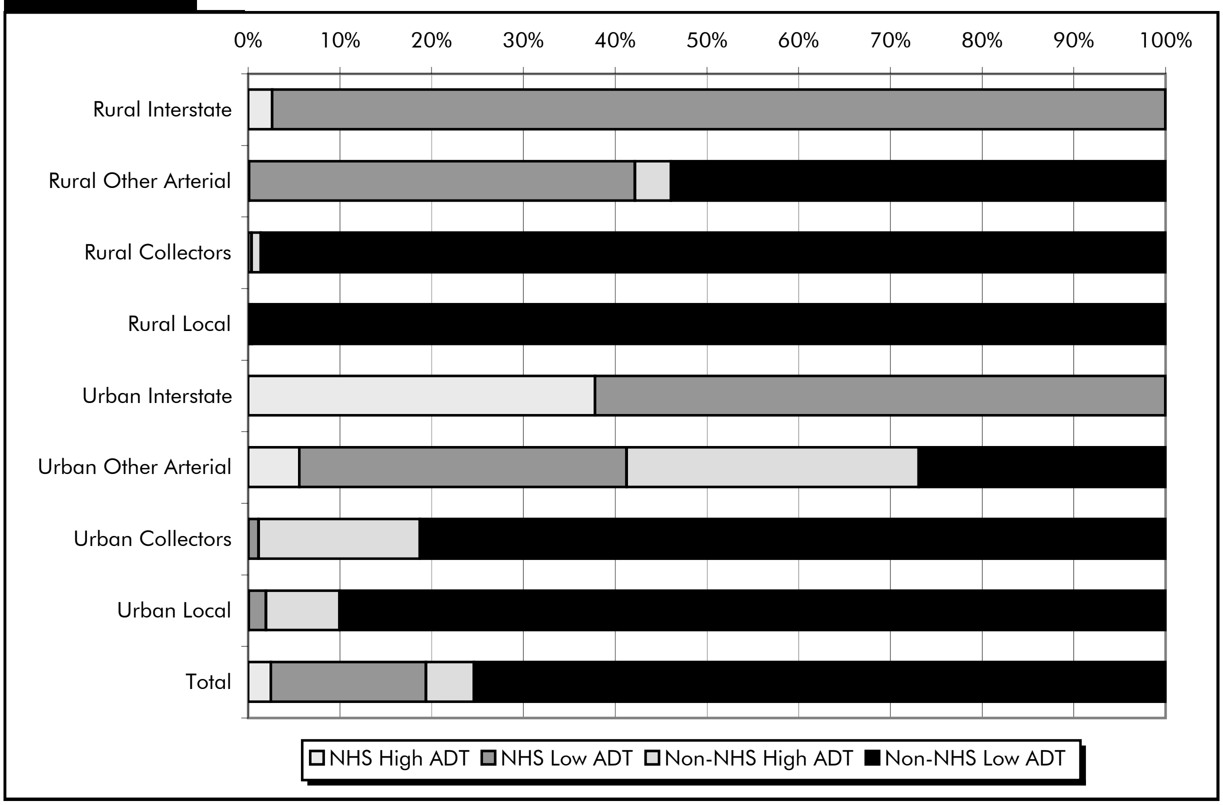
As shown in *Exhibit 17-6*, the vast majority of NHS structures (95.9 percent) are owned by State agencies, while the majority of non-NHS bridges (62.0 percent) are owned by local agencies. *Exhibit 17-7* shows NHS and non-NHS bridges by functional system and ADT level. Most NHS bridges are on higher-ordered functional systems with higher traffic volumes.

**Exhibit 17-6** *NHS and Non-NHS Bridges by Owner, 2002*




*Source: National Bridge Inventory*

**Exhibit 17-7** *High and Low Volume NHS and Non-NHS Bridges, by Functional System, 2002*




*Source: National Bridge Inventory.*

# Physical Conditions: Bridges

The percentages of structurally deficient and functionally obsolete bridges on the NHS compared with non-NHS system bridges are shown in *Exhibit 17-8* for high-and low-volume bridges in each of the established performance categories. To consider the traffic carried, percentages are shown where bridges are weighted by the ADT carried by the structures. To consider the size of the structure, bridges are weighted by the deck area. The impacts of considering these variables on the deficiency percentages may be determined by comparing the respective percentages to those determined by numbers where bridges are equally weighted. See Chapter 3 for a more detailed discussion of bridge conditions and the definitions of the terms "structurally deficient" and "functionally obsolete."

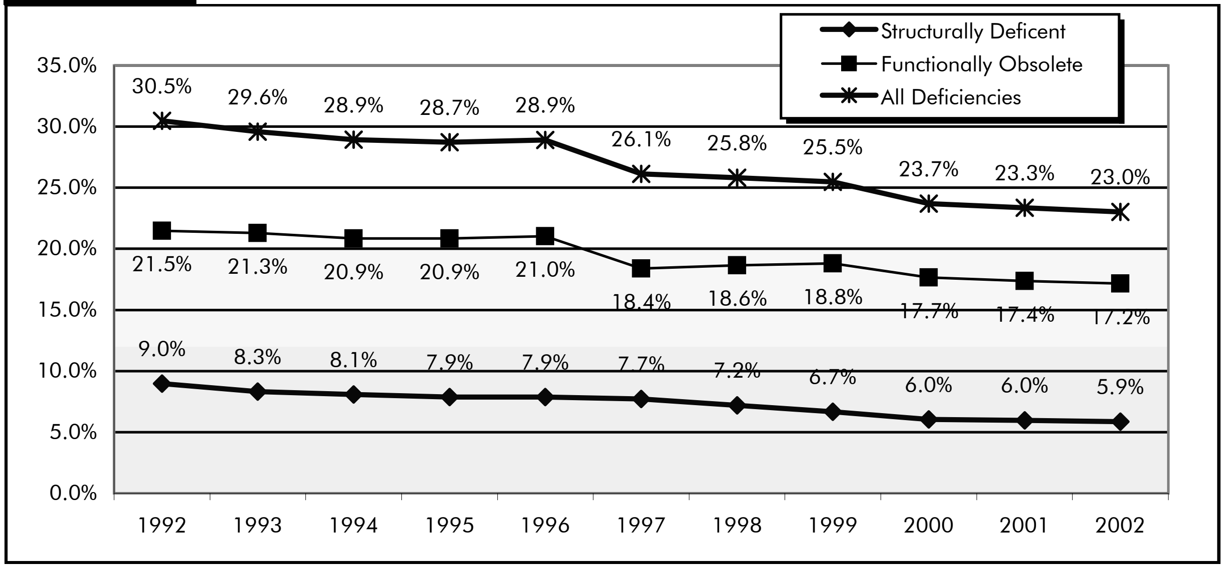
**Exhibit 17-8** *NHS and Non-NHS Bridge Deficiencies, by Number, ADT, and Deck Area, 2002*

| Category | Total | Structurally Deficient | Functionally Obsolete | Percent Structurally Deficient | Percent Functionally Obsolete |
|---|---|---|---|---|---|
| *Numbers of bridges shown for each category and used for percentages* | | | | | |
| NHS | | | | | |
| High Volume | 15,267 | 1,061 | 3,365 | 6.9% | 22.0% |
| Low Volume | 99,590 | 5,550 | 16,018 | 5.6% | 16.1% |
| NonNHS | | | | | |
| High Volume | 32,534 | 3,008 | 9,710 | 9.2% | 29.8% |
| Low Volume | 445,510 | 70,269 | 60,830 | 15.8% | 13.7% |
| *ADT in millions shown for each category and used for percentages* | | | | | |
| NHS | | | | | |
| High Volume | 1,490.6 | 112.4 | 318.6 | 7.5% | 21.4% |
| Low Volume | 1,428.2 | 85.6 | 260.4 | 6.0% | 18.2% |
| NonNHS | | | | | |
| High Volume | 673.6 | 59.2 | 207.1 | 8.8% | 30.7% |
| Low Volume | 525.1 | 55.1 | 115.0 | 10.5% | 21.9% |
| *Deck area (millions of square meters) shown for each category and used for percentages* | | | | | |
| NHS | | | | | |
| High Volume | 43.4 | 6.0 | 11.2 | 13.8% | 25.7% |
| Low Volume | 116.3 | 8.2 | 22.2 | 7.1% | 19.1% |
| NonNHS | | | | | |
| High Volume | 40.4 | 4.1 | 13.3 | 10.1% | 32.9% |
| Low Volume | 123.4 | 14.5 | 19.7 | 11.8% | 16.0% |

*Source: National Bridge Inventory.*

The overall condition of the bridges on the NHS has shown consistent improvement since 1992. In 1992, 30.5 percent of all NHS bridges were rated as deficient. This had declined to 23.0 percent in 2002. The percent of structurally deficient bridges declined from 9.0 percent to 5.9 percent, and the percent of functionally deficient bridges declined from 21.5 percent to 17.2 percent over the same time period [*see Exhibit 17-9*].

*Exhibit 17-9* *National Highway System Bridge Deficiencies*




*Source: National Bridge Inventory.*

# Operational Performance

Since 2000, use of the NHS has continued to increase more rapidly than its capacity has been expanded. The volume of traffic on the NHS has increased by 4.2 percent, while NHS lane miles grew by 1.3 percent. Daily vehicle miles traveled (DVMT) per lane mile grew by 3.0 percent on the rural NHS and 2.1 percent on the urban NHS. However, DVMT per lane mile on the NHS in urban areas is still almost three times larger than in rural areas.

Data for the three major performance indicators highlighted in Chapter 4, "Percent of Additional Travel Time," "Annual Hours of Delay," and "Percent of Travel Under Congested Conditions" are not available separately for the NHS. However, the NHS represents a major subset of the urban principal arterials, for which statistics are presented in that chapter. The operational performance of the Interstate component of the NHS is addressed in Chapter 16.

# Finance

*Exhibit 17-10* describes highway capital outlay on the NHS by functional system in 2002. Approximately $14.9 billion were spent on NHS rural arterials and collectors in 2002, and another $20.4 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 2002. It is not currently possible to identify spending by local government on these routes, which would mainly consist of intermodal connectors and STRAHNET connectors. STRAHNET is discussed in Chapter 18.

The $35.3 billion spent by all levels of government for capital improvements to the NHS in 2002 constituted 51.8 percent of the $68.2 billion identified in Chapter 6 as the total amount of highway capital investment on all roads. *Exhibit 17-11* categorizes this total by type of improvement. System preservation expenditures constituted 47.2 percent of this total, with system expansion constituting 44.7 percent and system enhancements 8.1 percent).

**Exhibit 17-10** *Highway Capital Outlay on the NHS by Functional System, 2002*

| Functional Class | Total ($Billions) |
|---|---|
| **Rural Arterials and Collectors** | |
| Interstate | $6.6 |
| Other Principal Arterial | $7.6 |
| Minor Arterial | $0.5 |
| Major Collector | $0.2 |
| Minor Collector | $0.0 |
| **Subtotal** | **$14.9** |
| **Urban Arterials and Collectors** | |
| Interstate | $10.5 |
| Other Freeway & Expressway | $4.5 |
| Other Principal Arterial | $5.1 |
| Minor Arterial | $0.2 |
| Collector | $0.0 |
| **Subtotal** | **$20.4** |
| **Subtotal, Rural and Urban** | **$35.3** |
| **Rural and Urban Local** | **$0.0** |
| **Total, All Systems** | **$35.3** |

*Source: Highway Statistics 2002 and unpublished FHWA data.*

**Exhibit 17-11** *NHS Capital Expenditures, 2002*

| | Total Invested (Billions of Dollars) | | | Percent of Total | NHS Percent of Total for all Highways | | |
|---|---|---|---|---|---|---|---|
| | Rural | Urban | Total | NHS | Rural | Urban | Total |
| **System Preservation** | | | | | | | |
| Highway Preservation | $5.4 | $5.7 | $11.1 | 31.5% | 22.0% | 23.4% | 45.3% |
| Bridge Preservation | $2.0 | $3.5 | $5.5 | 15.7% | 17.7% | 31.3% | 49.1% |
| **Subtotal** | **$7.4** | **$9.3** | **$16.7** | **47.2%** | **20.6%** | **25.9%** | **46.5%** |
| **System Expansion** | | | | | | | |
| Additions to Existing Roadways | $3.5 | $4.1 | $7.6 | 21.5% | 25.7% | 30.2% | 55.9% |
| New Routes | $2.8 | $4.7 | $7.5 | 21.4% | 24.0% | 40.0% | 64.0% |
| New Bridges | $0.2 | $0.4 | $0.6 | 1.8% | 19.1% | 38.5% | 57.6% |
| **Subtotal** | **$6.5** | **$9.2** | **$15.8** | **44.7%** | **24.7%** | **34.9%** | **59.6%** |
| **System Enhancements** | **$1.0** | **$1.9** | **$2.9** | **8.1%** | **17.0%** | **31.9%** | **49.0%** |
| **Total Investment** | **$14.9** | **$20.4** | **$35.3** | **100.0%** | **21.9%** | **29.9%** | **51.8%** |

*Sources: Highway Statistics 2002, Table SF-12A and unpublished FHWA data.*

# Capital Investment Requirements

This section mirrors the investment analysis in Chapter 16 for rural and urban Interstates, expanding it to include the non-Interstate sections of the NHS. *Exhibits 17-12* through *17-15* 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 2002 dollars.

**Q. 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?**

**A.** Yes. The values identified in this report for the Maiximum 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.

Exhibits 17-12 and 17-14 show the impact of different levels of combined highway preservation and expansion spending on rural and urban pavement condition, respectively, and Exhibits 17-13 and 17-15 show the impact of these same outlays on measures of rural and urban operational performance. Highway preservation and system expansion investment requirements are modeled by the Highway Economic Requirements System (HERS) (see Appendix A).

Expenditures on system enhancements (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 preservation investment requirements are discussed separately below.

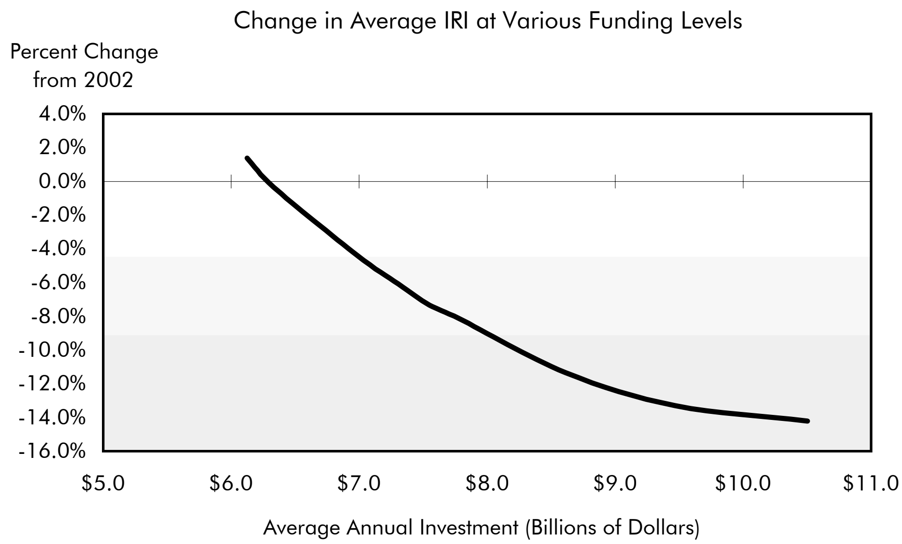
## *Rural NHS Routes*

Exhibit 17-12 shows projected values for the average International Roughness Index (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 2002 preservation and expansion investment level of $11.9 billion on rural NHS routes exceeded the maximum economic investment level of $10.5 billion estimated by HERS. As a result, significant improvements in pavement quality on the rural NHS would be expected if 2002 funding levels were maintained in constant dollars over 20 years. However, as pointed out in Chapter 16, the large increase in rural Interstate spending between 2000 and 2002 suggests that 2002 may simply have been an unusually high year for rural Interstate and rural NHS capital expenditure.

Average IRI and the percent of NHS travel on roads with "Acceptable" ride quality could be maintained at a funding level of $6.33 billion annually.

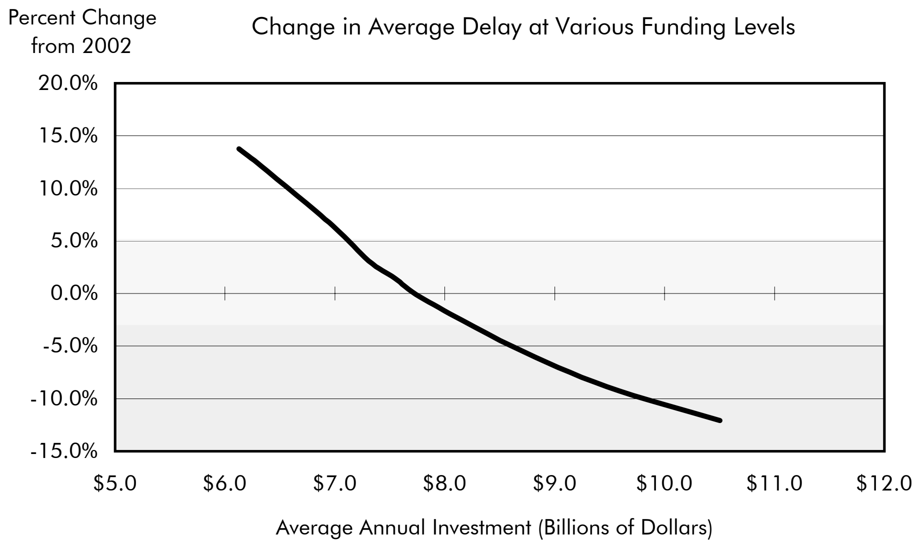
Exhibit 17-12 indicates that significant improvements in operational performance on the rural portion of the NHS would also result if the preservation and expansion investment levels for 2002 were continued in the future, with values for average delay per VMT (discussed in Chapter 9), total user costs, and travel time costs all declining. Average user costs on rural NHS routes would be maintained at an average annual investment level of $6.13 billion, while maintaining average travel time costs would require a funding level of $6.98 billion. Average delay on the rural NHS would be maintained at an investment level between $7.55 and $7.78 billion.

***Exhibit 17-12*** ***Projected Rural NHS Pavement Conditions in 2022 for Different Possible Funding Levels***




| Average Annual Highway Preservation + Expansion Investment (Rural NHS) (Billions of 2002 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... |
|---|---|---|---|---|
| **$11.92** | | **67.1%** | **96.7%** | 2002 Values |
| $10.50 | -14.2% | 84.3% | 99.5% | |
| $9.47 | -13.3% | 82.3% | 99.1% | |
| $8.61 | -11.4% | 79.4% | 98.7% | |
| $7.78 | -8.1% | 75.4% | 98.1% | |
| $7.55 | -7.3% | 74.1% | 97.9% | |
| $7.31 | -6.1% | 72.5% | 97.7% | |
| $6.98 | -4.4% | 70.3% | 97.4% | ...Maintain VMT with IRI<95 |
| $6.33 | -0.3% | 65.7% | 96.7% | ...Maintain Avg IRI and VMT with and <170 |
| $6.13 | 1.4% | 63.8% | 96.4% | |

**Exhibit 17-13** *Projected Rural NHS Condition and Performance in 2022 for Different Possible Funding Levels*

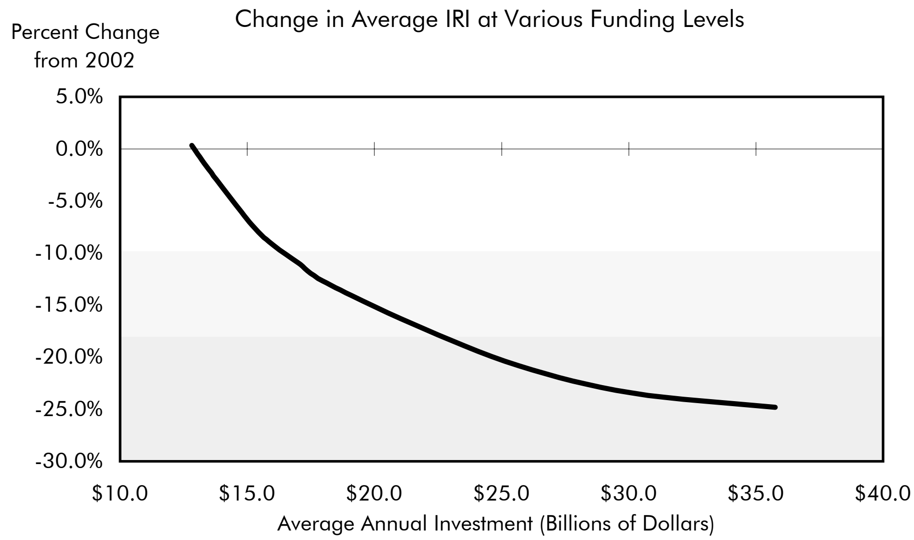



| Average Annual Highway Preservation + Expansion Investment (Rural NHS) (Billions of 2002 Dollars) | Percent Change in Average Total Delay | Percent Change in Total User Costs | Percent Change in Travel Time Costs | Funding Level Description: Investment Required to… |
|---|---|---|---|---|
| **$11.92** | | | | 2002 Values |
| $10.50 | -12.1% | -2.0% | -2.6% | |
| $9.47 | -8.9% | -1.9% | -2.2% | |
| $8.61 | -5.0% | -1.6% | -1.7% | |
| $7.78 | -0.4% | -1.2% | -1.0% | …Maintain Average Delay |
| $7.55 | 1.4% | -1.1% | -0.7% | |
| $7.31 | 3.1% | -1.0% | -0.5% | |
| $6.98 | 6.5% | -0.7% | -0.1% | …Maintain Average Travel Time Costs |
| $6.33 | 12.1% | -0.2% | 0.8% | |
| $6.13 | 13.8% | 0.0% | 1.1% | …Maintain Average User Costs |

## Urban NHS Routes

*Exhibits 17-14* and *17-15* show the impacts on the same measures of conditions and performance for different levels of capital spending on the urban portion of the NHS. Exhibit 17-14 shows that the current preservation and expansion investment level of $15.0 billion on urban NHS sections would be sufficient to improve average IRI on these sections by between 4.8 and 7.3 percent, assuming the mix of future preservation and capacity investments was consistent with those that HERS has identified. The percentages of travel on urban NHS pavements with “Good” and “Acceptable” ride quality would also increase significantly at this level of investment. Average IRI could be maintained at 2002 levels with an investment of between $12.82 and $13.42 billion annually.

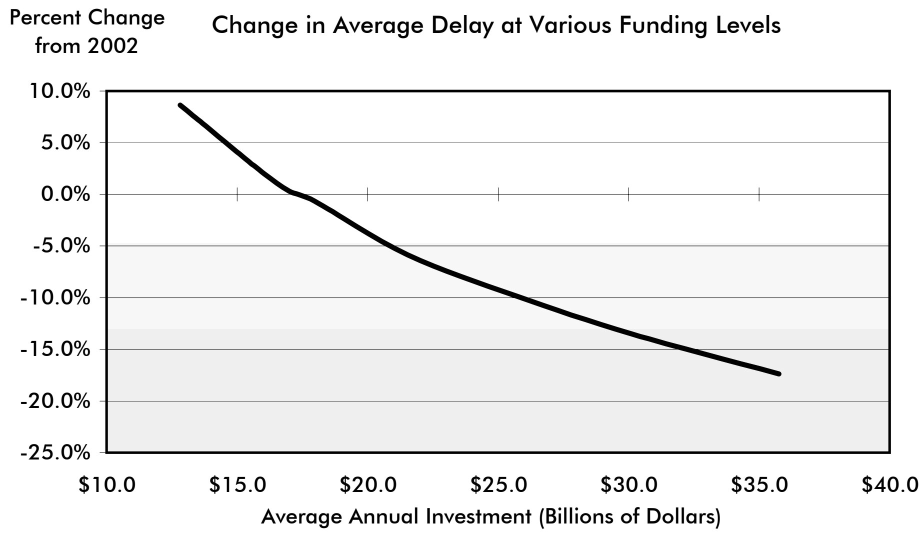
**Exhibit 17-14** *Projected Urban NHS Pavement Condition in 2022 for Different Possible Funding Levels*




| Average Annual Highway Preservation + Expansion Investment (Urban NHS) (Billions of 2002 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... |
|---|---|---|---|---|
| **$14.97** | | **40.2%** | **86.5%** | 2002 Values |
| $35.76 | -24.8% | 72.4% | 95.6% | |
| $30.12 | -23.4% | 71.6% | 95.8% | |
| $25.68 | -20.8% | 69.0% | 95.6% | |
| $21.54 | -16.8% | 65.1% | 95.2% | |
| $17.97 | -12.7% | 60.5% | 95.0% | |
| $17.00 | -10.9% | 59.0% | 95.0% | |
| $16.04 | -9.3% | 57.6% | 92.8% | |
| $15.17 | -7.3% | 55.4% | 92.5% | |
| $13.42 | -1.7% | 50.5% | 92.1% | ...Maintain Average IRI |
| $12.82 | 0.3% | 48.5% | 91.7% | |

*Exhibit 17-15* indicates that an average annual investment level in highway preservation and capacity expansion of between $17.0 and $18.0 billion would be needed to maintain average delay on urban NHS routes. Average total user costs would be maintained at a slightly lower level of $16.0 billion, while maintaining travel time costs alone on the NHS in urban areas would require between $18.0 and $21.5 billion annually. These amounts are $1 to $6 billion higher than the comparable 2002 funding level of $15.0 billion. Preservation 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 17-15** *Projected Urban NHS Conditions and Performance in 2022 for Different Possible Funding Levels*




| Average Annual Highway Preservation + Expansion Investment (Urban NHS) (Billions of 2002 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... |
|---|---|---|---|---|
| **$14.97** | | | | 2002 Values |
| $35.76 | -17.4% | -5.6% | -6.9% | |
| $30.12 | -13.5% | -4.6% | -5.2% | |
| $25.68 | -9.8% | -3.6% | -3.5% | |
| $21.54 | -5.8% | -2.3% | -1.4% | ...Maintain Average Travel Time Costs |
| $17.97 | -0.7% | -0.8% | 0.9% | ...Maintain Average Delay |
| $17.00 | 0.3% | -0.4% | 1.5% | |
| $16.04 | 2.0% | 0.0% | 2.2% | ...Maintain Average User Costs |
| $15.17 | 3.8% | 0.6% | 3.1% | |
| $13.42 | 7.4% | 2.0% | 5.2% | |
| $12.82 | 8.6% | 2.5% | 6.0% | |

## Bridge Preservation

As described in Chapter 7, the National Bridge Investment Analysis System (NBIAS) model identifies preservation investment requirements for all bridges, including those on the NHS. The current NHS bridge preservation backlog is estimated at $23.9 billion.

*Exhibit 17-16* describes what the NHS bridge backlog after 20 years would be at different funding levels. An average annual investment in bridge preservation of $3.79 billion is 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 $5.00 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 17-11 indicated that bridge preservation expenditures on the NHS totaled $5.5 billion in 2002. However, this represents a 77 percent increase over the comparable 2000 spending figure of $3.1 billion, driven largely by the increase in rural Interstate bridge spending noted in Chapter 16. If bridge preservation spending reverts to a level more consistent with that observed in 2000, then the investment backlog would tend to increase, rather than decrease.

**Exhibit 17-16** *Projected NHS Bridge Investment Backlog in 2022 for Different Possible Funding Levels*

| (Billions of 2002 Dollars ) | |
|---|---|
| Average Annual Investment | 2022 NHS Bridge Backlog |
| $5.00 | $0.0 |
| $4.68 | $6.6 |
| $4.42 | $11.5 |
| $4.01 | $19.2 |
| $3.79 | $23.9 |
| $3.52 | $29.4 |
| $3.03 | $39.6 |
| $2.51 | $51.8 |

*Source: National Bridge Investment Analysis System.*

## *Current Spending Versus Investment Requirements*

Exhibits 17-12 through 17-16 indicate that current levels of highway preservation 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 investment requirements identified in NBIAS. It should be noted, however, that this comparison is being made with a single year's funding, and that patterns of highway capital outlay between NHS and non-NHS routes (and between urban and rural areas) in 2002 are significantly different from those observed in 2000, and could easily shift back. On urban Interstates, current funding levels for preservation and expansion would be expected to result in improved pavement quality, but a decline in overall operational performance.

# CHAPTER 18

## Strategic Highway Network (STRAHNET)

# Strategic Highway Network (STRAHNET)

The Strategic Highway Network (STRAHNET) is critical to the Department of Defense's (DoD's) domestic operations. The STRAHNET is a 62,791-mile system of roads deemed necessary for emergency mobilization and peacetime movement of heavy armor, fuel, ammunition, repair parts, food, and other commodities to support U.S. military operations. Even though DoD primarily deploys heavy equipment by rail, highways play a critical role.

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 Federal Highway Administration (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.

## System Characteristics

*Exhibit 18-1* shows the extent of STRAHNET. Most of the STRAHNET miles in 2002 were on Interstate highway routes. STRAHNET Connectors (about 1,700 miles) are additional highway routes linking over 200 important military installations and ports to STRAHNET. These routes are typically used when moving personnel and equipment during a mobilization or deployment. Additionally, there were 79,852 bridges on STRAHNET in 2002.

**Exhibit 18-1** *STRAHNET Mileage, 2002*

| | |
|---|---|
| Interstate | 46,749 |
| Non-Interstate | 16,042 |
| Total | 62,791 |

*Source: Highway Performance Monitoring System*

**Q.** Why is the number of bridges shown on the STRANET system in the 2002 report different than the number in the current report?

**A.** Some of the bridges identified as being on STRAHNET in the last report based on year 2000 data were actually on a broader "Defense Highway Network" that is no longer in existence. Starting with the 2001 National Bridge Inventory data, a major effort was made by States to recode this information to line up better with STRAHNET as it is currently designated.

*Exhibit 18-2* identifies lane miles and daily vehicle miles traveled on STRAHNET in 2002 by functional class.

**Exhibit 18-2** *STRAHNET Lane Mileage and DVMT by Functional Class, 2002*

| Functional Class | Lane Miles | DVMT (millions of miles) |
|---|---|---|
| Rural Areas (Under 5,000 in Population) | | |
| Interstate | 134,945 | 772.14 |
| Other Principal Arterial | 35,583 | 130.14 |
| Minor Arterial | 2,212 | 4.25 |
| Major Collector | 606 | 1.40 |
| Minor Collector | 21 | 0.04 |
| Local | 28 | 0.03 |
| **Subtotal Rural** | **173,395** | **908.00** |
| Urban Areas (5,000 or more in population) | | |
| Interstate | 75,714 | 1,129.49 |
| Other Freeway and Expressway | 7,476 | 114.41 |
| Other Principal Arterial | 6,621 | 41.79 |
| Minor Arterial | 503 | 2.48 |
| Collector | 43 | 0.21 |
| Local | 14 | 0.02 |
| **Subtotal Urban** | **90,372** | **1,288.39** |
| **Total Rural and Urban** | **263,767** | **2,196.39** |

*Source: Highway Performance Monitoring System*

# Physical Conditions: Pavements

*Exhibit 18-3* shows the condition of STRAHNET. In 2002, 96.1 percent of all mileage in STRAHNET had a measured pavement roughness (using the International Roughness Index [IRI]) less than or equal to 170 inches per mile. As discussed in Chapters 3 and 17, National Highway System (NHS) pavement with an IRI less than or equal to 170 is classified as "acceptable" in the annual FHWA Performance Plans.

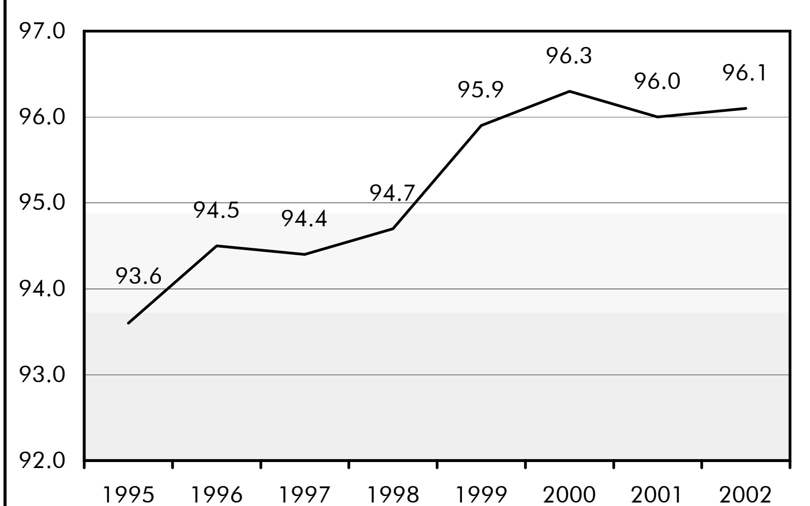
**Exhibit 18-3** *STRAHNET Condition, 2002*

| | Percent STRAHNET Miles with IRI <=170 |
|---|---|
| Interstate | 96.2 |
| Non-Interstate | 95.6 |
| Total | 96.1 |

*Source: Highway Performance Monitoring System.*

The percent of STRAHNET miles with acceptable ride quality has shown a general increase since 1995. This trend is shown by *Exhibit 18-4.*

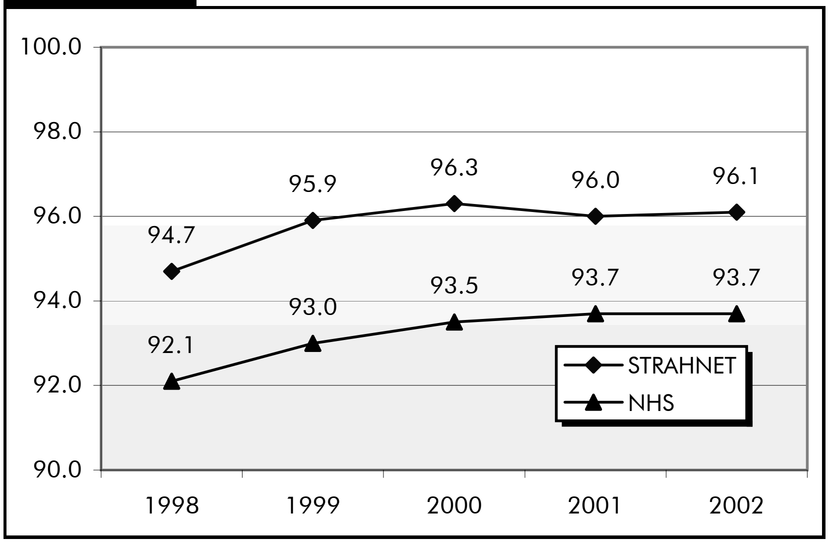
**Exhibit 18-4** *Percent of STRAHNET Mileage Rated Acceptable*




*Source: Highway Performance Monitoring System.*

When compared with the NHS, the overall STRAHNET system has consistently been maintained at a higher level of ride acceptability. In 2002, 96.1 percent of the STRAHNET miles were rated at an IRI value of 170 or less, compared with 93.7 percent of the NHS miles rated at an IRI of 170 or less. *Exhibit 18-5* compares the percent of miles with IRI in the acceptable range on STRAHNET with that on the NHS from 1998 through 2002.

**Exhibit 18-5** *Percent Miles IRI <= 170 STRAHNET Versus NHS*




*Source: Highway Performance Monitoring System.*

*Exhibit 18-6* compares the percentage of vehicle miles traveled on STRAHNET that occurs on pavements with acceptable ride quality with the percentage of total travel on pavements with acceptable ride quality for selected functional classes. For rural principal arterials, STRAHNET routes have a lower percentage of pavements with acceptable ride quality than do non-STRAHNET routes. However, for the remaining functional classes, pavements on STRAHNET appear to be in the same or better condition than those on non-STRAHNET routes.

**Exhibit 18-6** *Percent of Travel on Pavements with IRI <= 170, for STRAHNET and Total System for Selected Functional Classes, 2002*

| | STRAHNET | Total System |
|---|---|---|
| Rural Interstate | 97.3% | 97.3% |
| Rural Other Principal Arterial | 95.4% | 96.2% |
| Rural Minor Arterial | 98.1% | 93.8% |
| Rural Major Collector | 94.3% | 87.6% |
| Urban Interstate | 89.6% | 89.6% |
| Urban Other Freeway and Expressway | 89.6% | 87.8% |
| Urban Other Principal Arterial | 89.1% | 71.0% |
| Urban Minor Arterial | 85.0% | 76.3% |

*Source: Highway Performance Monitoring System.*

# Physical Conditions: Bridges

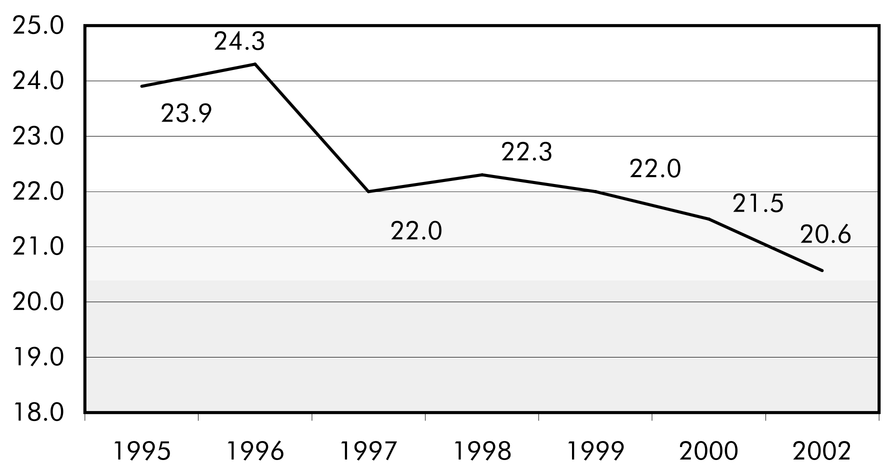
*Exhibit 18-7* shows the condition of STRAHNET by the percent of deficient bridges on STRAHNET routes. About 20.6 percent of STRAHNET bridges were deficient in 2002. Approximately 5.2 percent were structurally deficient, and 15.3 percent were functionally obsolete. By comparison, about 27.5 percent of all bridges nationwide were deficient in 2002, while roughly 13.7 percent were structurally deficient and 13.8 percent were functionally obsolete. *Exhibit 18-8* shows how the percent of deficient STRAHNET bridges has declined since 1995.

**Exhibit 18-7** *Number and Percent of Deficient STRAHNET Bridges, 2002*

| | Deficient Bridges | |
|---|---|---|
| | Number | Percent |
| STRAHNET Bridges | 79,852 | |
| Deficient Bridges | 16,426 | 20.6% |
| Structurally Deficient Bridges | 4,186 | 5.2% |
| Functionally Obsolete Bridges | 12,240 | 15.3% |

*Source: National Bridge Inventory.*

**Exhibit 18-8** *Percent of STRAHNET Bridges Rated Deficient, 1995 – 2002*




*Source: National Bridge Inventory.*

*Exhibit 18-9* shows the percent of deficient deck area for STRAHNET bridges. In 2002, 25.7 percent of the deck area on STRAHNET bridges was deficient. By comparison, about 27.5 percent of bridge deck area nationwide was considered deficient.

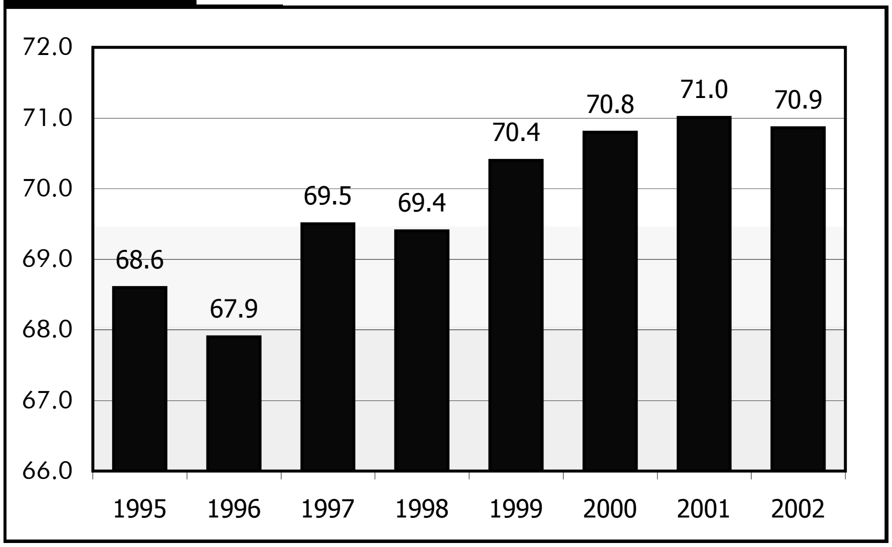
**Exhibit 18-9** *Percentage of Deficient Deck Area on STRAHNET Bridges, 2002*

| | |
|---|---|
| All STRAHNET Bridges | 25.7% |
| Structurally Deficient Bridges | 7.9% |
| Functionally Obsolete Bridges | 17.8% |

*Source: National Bridge Inventory.*

Exhibit *18-10* shows the percent of STRAHNET routes under bridges with vertical clearances greater than 16 feet. In 2002, about 70.9 percent of STRAHNET routes under bridges met this threshold. This indicator has a generally steady improvement since 1995. This is an important measure because military convoys and emergency response vehicles need to be able to clear structures on the STRAHNET system.

**Exhibit 18-10** *Percent of STRAHNET Routes Under Bridges with Clearances Greater Than 16 Feet, 1995 – 2002*




*Source: National Bridge Inventory.*

# CHAPTER 19

## Highway-Rail Grade Crossings

# Highway-Rail Grade Crossings

## Introduction

In 2004, growth in rail and truck traffic continues to test infrastructure capacity limits along many of the Nation's freight corridors, establishing a trend expected to continue for the foreseeable future. Freight rail traffic tonnage is expected to grow by at least 67 percent over the next 20 years, led by the growth of intermodal rail traffic, while freight truck tonnage is expected to double over the same period. Intermodal rail shipments increased by 10.4 percent in 2004 over the previous year. Some of the recent growth in rail traffic can be attributed to diversions of intermodal traffic from truck to rail. Such diversions are expected to continue in response to increased domestic and international trade and fluctuations in the price of fuel. Double track crossings currently serve as many as 140 trains per day, and the number of crossings serving more than 100 trains per day is expected to more than double over the next 20 years. Crossings near intermodal facilities, major ports, rail yards, and classification and switching areas will continue to experience significant increases in rail and truck traffic. Highly congested rail lines already extend from Chicago to the Pacific Northwest and from Los Angeles to all destinations.

**Q. What is a highway-rail grade crossing?**

**A.** A highway-rail grade crossing is the intersection of highway lanes and railroad track. The Federal Railroad Administration has identified over 260,000 public and private grade crossings in the United States. Passive warning devices protect over 78 percent of the grade crossings. Flashing lights, automated gates, and other train-activated warning devices protect the remaining grade crossings. State and local governments have the responsibility of enforcing traffic laws at highway-rail grade crossings.

**Q. Does this analysis cover highway-rail grade crossing safety?**

**A.** Traditionally, grade crossings have been viewed as a safety concern. This analysis focuses on delay-related highway user costs and includes safety. For more information on grade crossing safety, see Chapter 11.

Railroads have improved productivity by running longer trains. More and longer trains increase the amount of time grade crossings are blocked to highway traffic. As a result, delay to motorists, truckers, and pedestrians could reach unacceptable levels in many communities, blocking emergency vehicles, disrupting local commerce, inconveniencing residents, and creating societal divisions.

The Federal Railroad Administration (FRA) has analyzed grade crossings located on the Federal-aid highway system in metropolitan and surrounding areas. These crossings serve high volumes of rail traffic and are closed for large portions of the day, causing significant delay to both passenger vehicles and trucks.

The FRA analysis suggests that, during the first 10 years of the 20-year analysis period, total hours of delay for trucks, autos, and buses could increase by 8 percent annually at the Nation's busiest crossings. The annual increases could reach 18 percent during the last 10 years of the analysis period, depending on whether trains travel through the crossings when highway traffic volume is at its highest. The large annual increase in delay in the latter portion of the analysis period is attributed to the congested highway conditions compounded by the increased number of gate closures due to higher rail traffic volumes. Annual hours of delay for autos could increase from 2004 levels by between 64.4 million and 86.6 million hours by 2024, and trucks could spend between 9.9 million and 10.7 million more hours annually behind closed gates by 2024 than at present, depending on how frequently trains arrive at the gates during daily highway traffic peaks. The cost to highway users in lost time at the most heavily traveled crossings on the Federal-aid system would increase to between $9 billion and $10 billion over the 20-year analysis period.

## Grade Separation Improvements

When traffic volumes reach the levels noted above, the most effective solution may be to separate highway and rail traffic by building a bridge. The analysis of the costs and benefits of grade separation investment presented here focuses on the length of time highway vehicles spend queued up waiting for a train to pass. Most important is to determine how many highway vehicles are affected each time a train arrives at the crossings. This analysis was limited to grade crossings on the Federal-aid highway system.

*Exhibit 19-1* shows the projected changes in different types of highway user and emissions costs in 2024 (compared with 2004 levels) at different annual levels of investment in grade separation improvements. This analysis indicates the following:

- An average annual investment in highway-rail grade separation improvements of $250 million would be sufficient to maintain highway user costs at these crossings at 2004 levels. This investment level is comparable to the "Maintain User Costs" scenario for highways discussed in Chapter 7. Under this investment scenario, grade crossing-related user costs would be held constant at 2004 levels.

- Increasing average annual investment to $400 million would be sufficient to undertake all cost beneficial separation projects on the Federal-aid system. This level is comparable to the "Maximum Economic Investment" scenario for highways discussed in Chapter 7. Under this investment scenario, all grade crossing separation projects that have estimated benefits in excess of their estimated costs would be undertaken. Grade crossing-related user costs would decline below 2004 levels under this scenario.

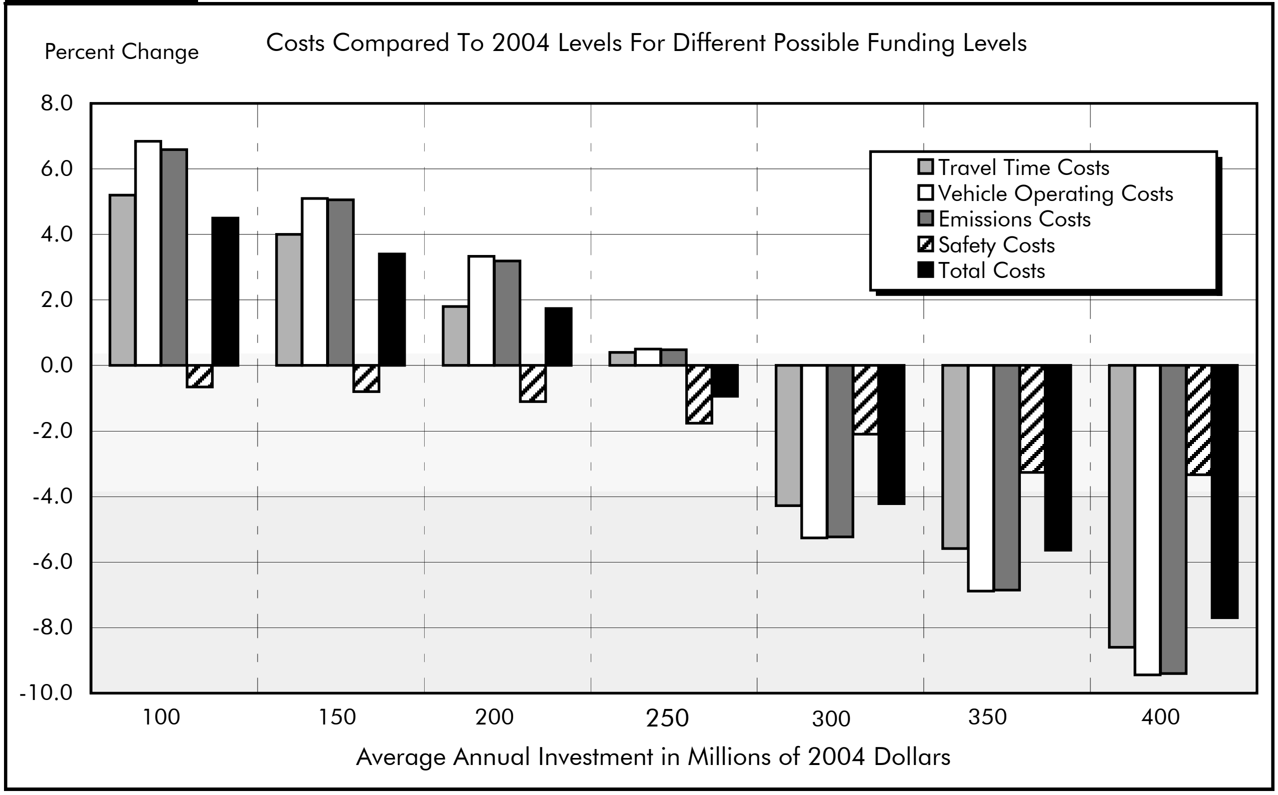
- Grade separation improvements are at least partially captured in the external adjustments made in Chapter 7 to account for nonmodeled capital investments (particularly safety enhancements). The FRA analysis, however, also captures separation improvements motivated by

**Q.** How do the highway-rail grade separation investment requirement estimates presented in this chapter compare with current spending on such activities?

**A.** The State and local highway financial reporting that forms the basis of the analysis of highway spending presented in Chapter 6 of this report is not sufficiently detailed to determine the amount of current spending that is used specifically for this purpose. Consequently, it is not possible to make a direct comparison of these investment requirement estimates with current spending by all levels of government for the types of improvements that are modeled.

At the Federal level, of the total amount apportioned to States for the Surface Transportation Program (STP), 10 percent is set-aside for safety programs. Of this amount, States are required to reserve an amount each year for the elimination of hazards at highway-rail crossings that is not less than the amount that was apportioned to States for this purpose in 1991, which was $155 million. (States have the option of devoting a larger portion of their STP Safety set-aside funds for this purpose, as long as they reserve another amount each year equal to their apportionments in 1991 for the Hazard Elimination program.) Note that only a portion of the amount reserved for the elimination of hazards at highway-rail crossings are available to be spent for grade separations; at least one-half of these funds are required to be spent for the installation of protective devices. Other types of improvements to eliminate hazards at grade crossings are also eligible for funding.

**Exhibit 19-1** *Projected Change in 2024 Highway User Costs*




**Q. What assumptions were made about highway and rail traffic to estimate the change in highway user costs resulting from these funding levels?**

**A.** The highway user costs used in Exhibit 19-1 are the average of the two traffic scenarios, uniform and peak, established in this analysis. All highway user cost estimates depend on the amount of highway traffic affected when trains arrive at grade crossings.

highway user delay caused by increasing highway and railroad traffic, which likely are not fully reflected in the two highway investment scenarios.

As did the highway and bridge analysis presented in Chapter 7, the FRA analysis finds a significant backlog of grade separation improvements that could be immediately justified. The backlog of such improvements in 2004 totals $2.2 billion.

In practice, grade crossing separations are planned in conjunction with the closing of adjacent grade crossings. Highway traffic is rerouted from the closed to the grade separated crossing. As a result, the grade separation eliminates wait time at both the closed and separated crossings. While a more thorough analysis would consider the benefits associated with the redirected traffic (as well as the residual value of capital investments in grade separation), they are not included in this analysis.

Grade separation improvements require extensive planning and costly construction. While this analysis focuses on local impacts of these types of improvements, there may be broader regional considerations that are not captured. For example, a sudden increase in train traffic due to rail line consolidation could significantly increase the highway delay experienced by a local community, though it would receive only a small portion of the economic benefits of the increased rail traffic. While issues of cost responsibility go beyond the scope of this report, it is important to recognize that the distribution of benefits in situations such as these may influence decisions concerning how specific grade separation improvements might be financed.

# Grade Crossing Traffic Distribution Scenarios

Delays at grade crossings occur when highway and rail traffic arrive at the gate simultaneously. The analysis of such delay thus depends on assumptions about the distribution of highway and rail traffic among different time periods. In the FRA analysis, two traffic distributions were analyzed: peak traffic and uniform traffic.

## *Peak Traffic*

**Q.** Does this analysis cover issues relating to truck–to-rail diversion?

**A.** The models used in this report are mode-specific and do not directly reflect the impacts that investments in one mode could have on other transportation modes in that area. Research is underway to identify approaches for tying the individual models more closely together (see Part V).

As shown in *Exhibit 19-2*, allowing both highway and train traffic to peak at grade crossings could result in automobile delay increasing by 86.5 million hours annually by 2024 at the 50 percent confidence interval. Similarly, trucks would likely experience an additional 10.7 million hours of delay annually in 20 years and bus delay could increase by an average 8.9 million hours of delay at the 50 percent confidence interval. The present value of delay for all vehicles for the 20-year period is valued at $8.8 billion at the 50 percent confidence interval. In other words, under these assumptions, one can be 50 percent certain that the hours of delay would equal or exceed the values stated above. At the 50 percent confidence interval, annual carbon monoxide emissions would increase by 40,000 metric tons, annual hydrocarbon emissions would increase by 2,500 metric tons, and annual nitrogen oxide emissions would increase by 900 metric tons. The present value of total emission costs for the 20-year analysis period is $34 million at the 50 percent confidence interval. Similarly, the annual fuel burned idling at grade crossings would increase by 72 million gallons of gasoline, 15 million gallons of diesel fuel, and 6 million gallons of lubricating oil. Vehicle operating costs are the sum of the costs

**Exhibit 19-2** *Annual Increase in Delay and Associated Costs for Sample Crossings in 2024 Compared with 2004 Level, Peak Delay Scenario*

| Confidence Interval | 50% | 80% | 20% |
|---|---|---|---|
| | **Average** | **Minimum** | **Maximum** |
| **Transportation Mode** | Delay, hours | | |
| Auto | 86,573,550 | 30,547,530 | 246,871,600 |
| Truck | 10,727,495 | 4,132,080 | 30,362,520 |
| Bus | 8,939,580 | 3,443,400 | 25,302,100 |
| **Pollutant Type** | Emissions, metric tons | | |
| CO | 39,853 | 12,903 | 114,149 |
| HC | 2,484 | 804 | 7,114 |
| NOx | 886 | 291 | 2,535 |
| **Fuel Type** | Consumption, gallons | | |
| Gasoline | 71,614,900 | 22,955,870 | 205,260,500 |
| Diesel | 15,277,460 | 5,395,000 | 43,492,040 |
| Lubricating Oil | 5,613,480 | 1,831,542 | 16,070,080 |
| **Present Value of All Costs for the Entire 2005–2024 Analysis Period** | Cost, $Thousands | | |
| Safety | $699,674 | $561,230 | $965,651 |
| Delay | $8,783,935 | $4,430,055 | $17,392,695 |
| Emissions | $34,065 | $13,548 | $92,880 |
| Vehicle Operating Costs | $477,842 | $266,363 | $1,031,463 |
| **Total Cost** | **$9,995,517** | **$5,271,196** | **$19,482,689** |

of additional fuel and lubricating oil burned while idling at grade crossings, and these combined costs add $480 million (in present value) to the total user costs of highway-rail grade crossings. All categories of accidents (fatal, injury, and property damage only) combined add another $700 million in present-value costs to the total.

On average, the total increase in costs for all years and all categories over the 20-year analysis period is valued at nearly $10 billion in present-value dollars. Thirty-five percent of the deviation from the mean is attributed to variations in train length, and 15 percent is attributed to variations in the number of passenger trains.

## Uniform Traffic

*Exhibit 19-3* shows that, when highway and rail traffic is uniformly distributed, it is estimated that the automobile traffic delay would increase over 64 million hours by 2024, trucks would spend an additional 9.9 million hours queued up behind closed gates, and bus delay would increase by 8.2 million hours at the 50 percent confidence interval. The total value of time lost for all vehicle types over the 20-year period amounts to $7.8 billion in present value. Idling vehicles would emit an additional 29,000 metric tons of carbon monoxide, 1,800 metric tons of hydrocarbons, and 700 metric tons of nitrogen oxides annually than in 2004. The changes in emissions over the analysis period convert to over $28 million in present value dollars. An additional 51 million gallons of gasoline, 13 million gallons of diesel fuel, and 4 million gallons of lubricating oil would be burned at the closed grade crossings than in the first year of the analysis period and would add a total of $400 million in present-value dollars to the national fuel bill. Safety costs of all predicted categories would be valued at $712 million in present-value dollars. The total present-value costs of increased delay, fuel consumption, and accident risk at high-volume crossings on the Federal-aid highway system would exceed $8.9 billion at the 50 percent confidence interval if all highway and rail traffic were uniformly distributed.

**Exhibit 19-3** *Annual Increase in Delay and Associated Costs for Sample Crossings in 2024 Compared with 2004 Level, Uniform Delay Scenario*

| **Confidence Interval** | **50%** | **80%** | **20%** |
|---|---|---|---|
| | **Average** | **Minimum** | **Maximum** |
| Transportation Mode | Delay, hours | | |
| Auto | 64,390,600 | 27,125,205 | 180,965,250 |
| Truck | 9,906,245 | 4,173,110 | 27,840,810 |
| Bus | 8,255,205 | 3,477,591 | 23,200,675 |
| Pollutant Type | Emissions, metric tons | | |
| CO | 29,084 | 11,681 | 82,107 |
| HC | 1,812 | 728 | 5,117 |
| NOx | 667 | 268 | 1,883 |
| Fuel Type | Consumption, gallons | | |
| Gasoline | 51,067,200 | 20,511,065 | 144,169,400 |
| Diesel | 13,476,225 | 5,412,705 | 38,045,145 |
| Lubricating Oil | 4,169,678 | 1,674,745 | 11,771,545 |
| Present Value of All Costs for the Entire 2005–2024 Analysis Period | Costs, $Thousands | | |
| Safety | $711,564 | $570,890 | $981,413 |
| Delay | $7,841,520 | $4,165,215 | $15,250,575 |
| Emissions | $28,125 | $12,380 | $74,682 |
| Vehicle Operating Costs | $398,425 | $244,175 | $835,014 |
| **Total Cost** | **$8,979,634** | **$4,992,660** | **$17,141,683** |

In the uniformly distributed traffic scenario, 40 percent of the deviation from the mean is attributed to variations in train length and 8 percent is attributed to variations in volume of passenger trains. This is expected because all traffic is uniformly distributed under this scenario; thus, the additional passenger trains would not be adding to congested conditions during peak traffic periods.

**Q. How was this analysis conducted?**

**A.** The FRA relied on its GradeDec 2000 software to conduct a Monte Carlo simulation to provide a range of values for all benefit categories at the 20, 50, and 80 percent confidence intervals for each scenario. Train length was allowed to vary from 30 to 90 cars, and the number of passenger rail trains varied between zero and four. All other variables were held constant.

Two scenarios, uniform and peak, were established to evaluate a reasonable range of highway traffic volumes affected by grade crossing closures. In the uniform scenario, parameters were set so that highway and rail traffic are evenly distributed across each hour of the day. The peak scenario sets parameters to adjust daily traffic volumes so that 48 percent of daily highway traffic is allowed to peak at an increasing rate over 6 hours of the day to a maximum peak of 0.08 percent of daily traffic. All highway traffic above 900 vehicles per lane per hour is redirected away from the crossing. The costs and benefits of redirecting traffic are not included in this analysis. Thirty-seven percent of daily traffic is distributed evenly over the next 12 hours, and the remaining 15 percent is distributed evenly for the remaining 6 hours. Train traffic is allowed to cluster at any time, including the 6-hour peak period for highway traffic.

# CHAPTER 20

## Transit on Federal Lands

# Transit on Federal Lands

Federal lands, which are composed of the U.S. Forest Service, the National Park Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service, account for about 27 percent of the land area of the United States, principally in the western part of the country. A brief description of each Federal land area is provided below, and where available, the number of visitors to each and the level and type of transit services in each area. As the number of visits to these sites increases, transit services will need to be put into place to preserve their scenic beauty and natural endowments. This chapter examines these transit investment needs. These investment requirements have been estimated outside the TERM framework and are not explicitly included in the investment needs reported in Chapter 7.

*This chapter updates the material on transit capital investment requirements on Federal lands provided in the 2002 C&P report with information from a joint Federal Transit Administration (FTA) and Federal Highway Administration (FHWA) study, Federal Lands Alternative Transportation Systems (ATS) Study, Summary of Forest Service ATS Needs, completed in January 2004. Alternative Transit Systems (ATS) are composed of transit and transit enhancements. This second study of ATS needs on Federal lands was undertaken in association with the U.S. Forest Service (USFS), which is part of the U.S. Department of Agriculture (USDA). The 2002 C&P report focused on the investment requirements of Federal lands managed by the US Department of the Interior (DOI), based on information from a joint FTA and FHWA study, Federal Lands Alternative Transportation Systems (ATS), August 2001. This first study of Federal land ATS needs was undertaken in association with the National Park Service (NPS), the Bureau of Land Management (BLM), and the U.S. Fish and Wildlife Service (USFWS), all part of the DOI. It was initiated in response to concerns that some of the natural, cultural, and historic sites located on these DOI areas were being damaged or were in danger of being damaged by automobile traffic. A number of the site reports developed for the first ATS study noted the close proximity between DOI lands and USDA lands and came to the conclusion that DOI and USDA would have to work closely and cooperatively together in order to devise and implement ATS on all Federal lands successfully. This realization led to the commissioning of the second ATS study requirements on USDA, USFS lands.*

- **U.S. Forest Service:** The USFS (part of USDA) manages 151 national forests and 20 grasslands in 42 States, Puerto Rico, and the Virgin Islands. Forest service lands have a combined area of 192 million acres *(Exhibit 20-1)*. The USFS was established to provide quality water and timber for the Nation's benefit, although parts of USFS areas are open for recreational use. Buses currently provide most of the transit services on Forest Service lands and are expected to continue to do so in the future.

- **National Park Service:** The NPS (part of DOI) currently manages 379 parks covering more than 81 million acres. More than 285 million people visit National Parks each year. In 2002, approximately 100 ATS were in operation in 90 NPS parks. These ATS include trolleys, rail systems, canal boats, ferries, tour boats, cable cars, snow coaches, trams, buses, and vans. Ten national parks are served by local public transit systems, and eight national parks own and operate their own public transit systems. Private operators manage the remaining transit services under contract to the NPS. In 2002, the NPS owned and operated about 600 vehicles used to provide transit services. Recent ATS projects on NPS lands include the introduction of a shuttle bus service to the most visited sites of Zion National Park in 2000 and the introduction of historic touring buses in Glacier National

**Exhibit 20-1** *Federal Lands Holdings*

| | Millions of Acres | Percent of Acreage: Total U.S. | Percent of Acreage: Lower 48 States |
|---|---|---|---|
| U.S. Forest Service | 192 | 8.3% | 10.1% |
| National Park Service | 81 | 3.5% | 4.3% |
| Bureau of Land Management | 262 | 11.4% | 13.8% |
| U.S. Fish and Wildlife Service | 95 | 4.1% | 5.0% |
| Total | 630 | 27.4% | 33.2% |

*Sources: U.S. Department of the Interior and U.S. Department of Agriculture.*

Park in 2001. In FY 2002, the NPS and the FHWA set aside $11.7 million from the Federal Lands Highway Program (FLHP) for transit projects. Of the amount, $6.0 million went toward 23 planning projects and $5.7 million funded 12 implementation projects. In FY 2003, $14.1 million was set aside; $5.0 million went toward 17 planning projects and $9.10 million to 11 implementation projects.

- **Bureau of Land Management:** BLM (part of the DOI) holds 262 million acres located primarily in the western states and constituting one-eighth of the total U.S. land area. There are over 4,500 miles of National Historic, Scenic, or Recreational Trails, in addition to multiuse trails, through BLM lands. Visits to BLM sites are increasing as a result of the rapidly growing population in the west. Nearly two-thirds of the BLM-managed lands, located in the lower 48 states, can be reached by driving 1 hour or less from an urban area. In 2001, more than 62 million visits were made to BLM sites, 38 percent more visits than in 1991. Some BLM sites are experiencing traffic congestion and parking shortages at levels experienced by some major NPS sites. Particularly, the La Posa Long-Term Visitor Area along the Arizona-California border and its gateway community of Quartzite are severely congested as a result of the influx of northern retirees who visit these areas during the winter.

- **U.S. Fish and Wildlife Service:** The USFWS (part of DOI) manages approximately 95 million acres nationwide. This area is composed of over 570 national wildlife refuge and wetland management districts in the 50 states and territories. Most USFWS sites receive relatively few visitors, although the number of visits is increasing. There were 39 million visits to USFWS lands in 2001, compared with 27 million in 1995. In 2002, six transit systems and two ferry boats operated on USFWS lands. Some of the most heavily visited USFWS sites include the National Wildlife Refuge at Sanibel Island, Florida, and Santa Anna National Wildlife Refuge, Texas. Both of these sites offer transit services to improve accessibility and to reduce the negative environmental effects caused by excessive private vehicle travel.

# Transit Requirements for USFS Lands

Transit services are needed in USFS lands because of increasing recreational demand and limited possibilities of expanding roadways and parking lots at a reasonable cost and without causing environmental degradation. USFS lands often surround National Parks and frequently surround or are adjacent to urban areas. This proximity offers the opportunities for transit services on USFS lands to connect with existing transit systems on other Federal lands or to be serviced by extending transit services from nearby urban areas. While transit systems on USFS lands could take advantage of the fact that urban transit systems require more vehicles during the week and USFS recreational areas require more vehicles during the weekend, vehicles used in urban areas are frequently unsuitable for use on USFS lands. Given the seasonal nature of transit service needs on USFS lands, the ATS study found that contracting these services from private providers was likely to be a cost-effective strategy. The ATS study concluded that the implementation of transit on USFS lands would

- Relieve traffic congestion and parking shortages;
- Enhance visitor mobility, accessibility, and safety;
- Enhance mobility and safety for local residents;
- Conserve sensitive natural, cultural, and historic resources;
- Provide improved interpretation, education, and visitor information services;
- Reduce pollution; and
- Diversify economics and help to improve economic development opportunities for gateway communities.

Transit investment needs include purchasing bus vehicles, trolley cars, tram vehicles, and waterborne vessels. They also include investment in maintenance facilities and ferry piers. Needed transit enhancements include parking facilities, connections with non-motorized trails, shelters and signage, and information services.

Thirty USFS sites were identified by the ATS study that would benefit from new or supplemental transit or transit enhancement investment. Six of these sites are located in Alaska, five are located in California, and two each are located in both California and Nevada. Three sites are located in the state of Washington, and one site was identified in each of the following states—Arizona, Colorado, Florida, Idaho, Illinois, Michigan, Montana, Nevada, New Hampshire, New Mexico, Oregon, Puerto Rico, and Wyoming. One site straddles Tennessee and Kentucky.

The ATS study estimated that, in 2003 dollars, a total of approximately $698 million ($687 million in 2002 dollars) is needed for the development of ATS in USFS lands between 2003 and 2022 *(Exhibit 20-2)*. Of this amount, $522 million ($514 million in 2002 dollars) is estimated to be for surface transportation systems, $122 million ($120 million in 2002 dollars) for water transportation, and $54 million ($53 million in 2002 dollars) for transit enhancements, principally nonmotorized trails *(Exhibit 20-3).*

Estimated costs are $52 million ($51 million in 2002 dollars) for project development, $189 million ($186 million in 2002 dollars) for vehicle capital costs, $131 million ($129 million in 2002 dollars) for other capital costs, and $326 million ($321 million in 2002 dollars or $26.7 million annually) for operations and maintenance costs. *Exhibit 20-4* shows these amounts broken down by time frame. Sixty-seven percent of this investment ($469 million) is estimated to be needed between 2003 and 2012, and 33 percent ($229 million) is estimated to be needed between 2013 and 2022.

*Exhibit 20-5* shows these future ATS investment needs allocated between existing and new systems. Twenty-six percent ($185 million) is estimated for existing systems and 74 percent ($513 million) for new systems.

**Exhibit 20-2** *U.S. National Forest Service ATS Investment Needs, 2003–2022*

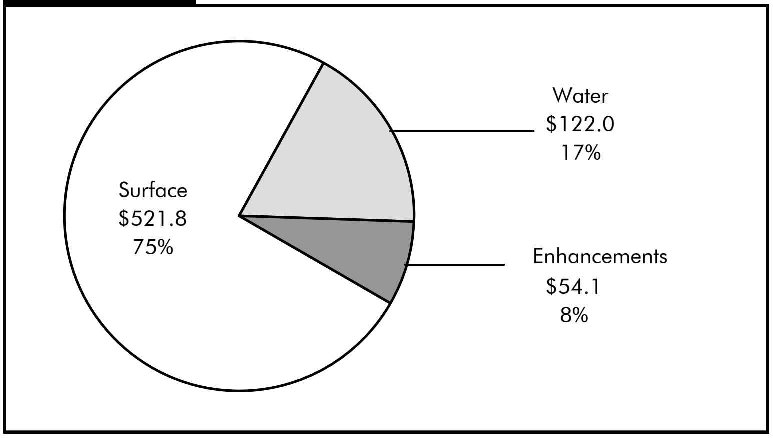
| (Millions of 2003 dollars) | Short-term Costs | Long-term Costs | Total Costs |
|---|---|---|---|
| **Surface Transit** | **$320.0** | **$201.8** | **$521.8** |
| Project Development | 21.6 | 6.1 | 27.7 |
| Vehicle Capital Costs | 95.6 | 40.6 | 136.2 |
| Other Capital Costs | 47.9 | | 47.9 |
| Operations & Maintenance | 154.9 | 155.1 | 310.0 |
| **Water Transit**[1] | **102.9** | **19.1** | **122.0** |
| Project Development | 13.4 | 5.9 | 19.3 |
| Vehicle Capital Costs | 39.3 | 13.2 | 52.5 |
| Other Capital Costs | 50.2 | | 50.2 |
| Operations & Maintenance | | | |
| **Transit Enhancements** | **46.0** | **8.1** | **54.1** |
| Project Development | 4.9 | | 4.9 |
| Vehicle Capital Costs | | | |
| Other Capital Costs | 33.0 | | 33.0 |
| Operations & Maintenance | 8.1 | 8.1 | 16.2 |
| **Total** | **468.9** | **229.1** | **698.0** |
| *Project Development* | ***39.9*** | ***12.0*** | ***51.9*** |
| Existing Systems | 14.5 | 6.9 | 21.4 |
| New Systems | 25.4 | 5.1 | 30.5 |
| *Vehicle Capital Costs* | ***134.8*** | ***53.8*** | ***188.7*** |
| Existing Systems | 45.7 | 19.6 | 65.3 |
| New Systems | 89.1 | 34.2 | 123.3 |
| *Other Capital Costs* | ***131.1*** | | ***131.1*** |
| Existing Systems | 50.9 | | 50.9 |
| New Systems | 80.2 | | 80.2 |
| *Operations & Maintenance* | ***163.1*** | ***163.3*** | ***326.4*** |
| Existing Systems | 23.6 | 23.6 | 47.2 |
| New Systems | 139.5 | 139.7 | 279.2 |

*Source: Federal Lands Alternative Transportation Systems Study, FHWA, FTA, January 2004.*

[1] Southeast Alaska Intermodal Ferry Project

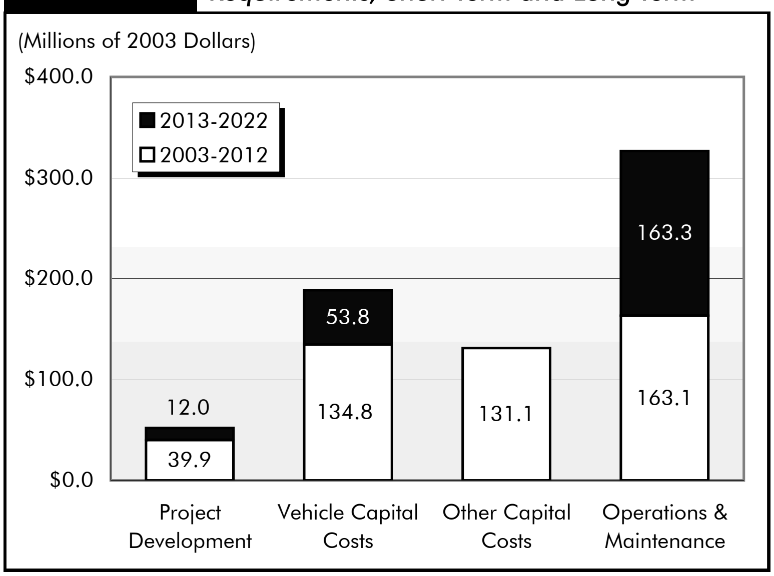
Note: Numbers may not add due to rounding.

**Exhibit 20-3** *U.S. Forest Service ATS Requirements by ATS Type, 2003–2022 (Millions of 2003 Dollars)*



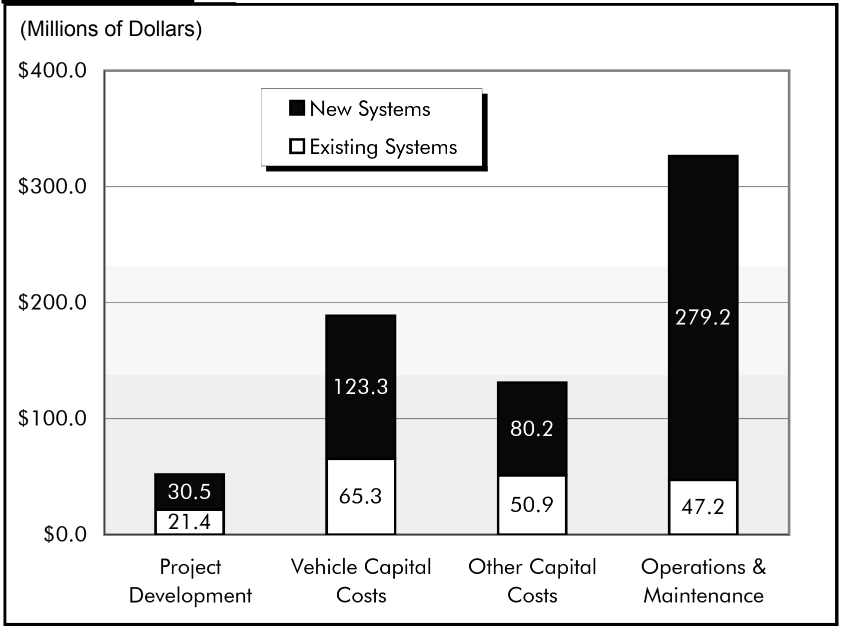

*Source: Federal Lands Alternative Transportation Systems (ATS) Study, Summary of Forest Service ATS Needs, FHWA, FTA, January 2004.*

**Exhibit 20-4** *U.S. Forest Service ATS Investment Requirements, Short-Term and Long-Term*




*Source: Federal Lands Alternative Transportation Systems (ATS) Study, Summary of Forest Service ATS Needs, FHWA, FTA, January 2004.*

**Exhibit 20-5** *U.S. Forest Service ATS Investment Requirements, Existing Systems and New Systems, 2003–2022*




*Source: Federal Lands Alternative Transportation Systems (ATS) Study, Summary of Forest Service ATS Needs, FHWA, FTA, January 2004.*

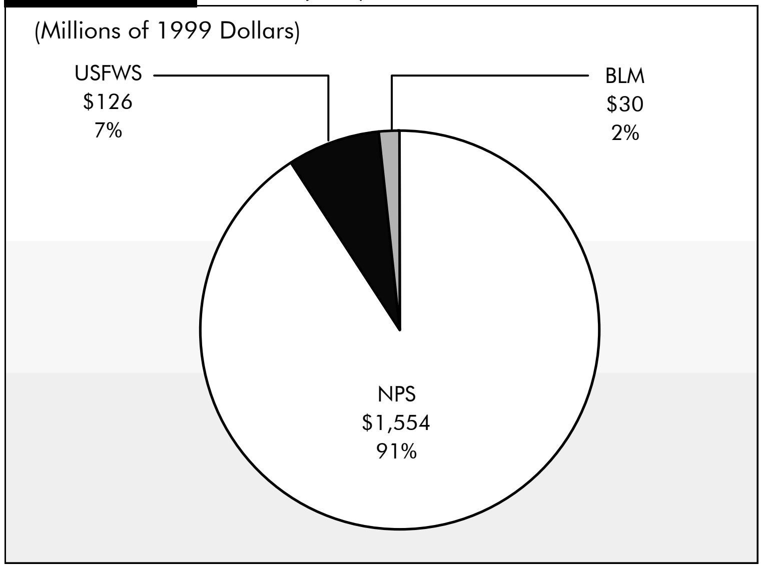
# Transit Requirements for DOI Lands

As reported in the 2002 edition of this report, 136 of the 207 DOI sites visited for the first ATS study were identified as having transit investment needs. These were composed of 118 NPS sites, five BLM sites, and 13 USFWS sites. Transit needs include improving or expanding existing transit services and implementing new services. In most cases, transit needs were found to be modest and able to be served by a small number of vehicles operating on a seasonal basis.

These 136 DOI sites were estimated to have 20-year transit investment requirements of $1.71 billion in 1999 dollars ($1.82 billion in 2002 dollars). NPS will require the largest transit investment, estimated at just under $1,554 million ($1,586 million in 2002 dollars), followed by USFWS with estimated needs of $126 million ($134 million in 2002 dollars), and BLM with $30 million ($32 million in 2002 dollars) *(Exhibit 20-6).* Of this amount, $1,337 million was estimated for investment in buses and rail/guideway (a very small percentage for rail/guideway), and 217 million for water transit services. While bus transit is, and will continue to be, the most common form of transit service on Federal lands, future water transportation needs also are expected to be significant. The majority of BLM transit needs, for example, are for waterborne systems. Chapter 27 of the 2002 C&P Report provides a more detailed summary of estimated ATS investment requirements on DOI sites. (Note: 1999 and 2003 dollars have been converted to 2002 dollars with the Gross Domestic Product chained price index reported in the Budget of the United States, FY 2005.)

## Funding Sources

**Exhibit 20-6** *Summary of Transit Needs on Department of Interior (DOI) Lands, 2001–2020*




*Source: Federal Lands Alternative Transportation Study, Congressional Report, August 2001.*

The majority of funding for transit services on Federal lands is allocated through State and local transportation authorities, but is not specifically targeted for transit programs on Federal lands. Transit programs on Federal lands are required to compete with other transit projects in the same State or local jurisdiction for Federal funds. A smaller percentage of funds is allocated to transit projects on Federal lands through the Federal Lands Highway Program (FLHP), which distributes funds exclusively to Federal Lands Management Agencies (FLMA). In the past, the bulk of FLHP funds has been used for future roadway and bridge projects and not for transit. As the funds needed to maintain roadways and bridges on Federal lands are likely to continue to exceed available FLHP funds, a limited amount of funding for transit programs is expected to come from this source in the future.

The ATS studies have identified a number of additional potential revenue sources for transit services on Federal lands. These include user fees, special use permits, private sponsorships, advertising, fund raising and contributions, and loans from State Infrastructure Banks.

# Afterword: A View to the Future

# Part V

# 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, operational performance, and investment requirements for our Nation's surface transportation 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.

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 by State and local government entities to the Federal government, issues relating to intergovernmental relationships and 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.

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 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 Department, 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 and the FHWA Office of Freight Management and Operations 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 will always be uncertain. At the same time, it is helpful to describe the ideal in order to ensure that future development work will bring us closer to that goal.

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. The models currently being used, while recently updated (see Appendix A), 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 great leaps forward 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

> **Q. What research projects do FHWA and FTA currently have underway to improve the modeling of conditions and performance?**
>
> **A.** Current FHWA research projects on conditions and performance include:
>
> - **Pavement model improvements.** This multiyear effort is assessing the current methods used to model pavement deterioration in both HERS and 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 pavement modeling procedures in the Highway Economics Requirements System (HERS) in time to be used for the 2008 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.
>
> Current FTA research on conditions and performance includes:
>
> - **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 and related maintenance facilities. Condition assessment research is currently underway for stations while analysis of guideway, track, and systems conditions is pending.

the need for capital improvements to address pavement condition deficiencies. To the extent possible, the investment models should include such impacts when modeling pavement deterioration. 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 preservation 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 collect the element data directly and use them directly.

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) that are not currently being modeled or measured directly. Questions of how such measurement should be done and the extent to which other measures might pick up such factors are part of the research agendas of the FHWA Offices of Policy, Infrastructure, and Research and Development.

Another bridge condition modeling issue relates to concerns about our aging infrastructure. As discussed in Chapter 15, 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 age and load ultimately require 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. How should such potential user impacts be incorporated into our estimates of the cost savings associated with pavement and bridge preservation improvements?

## 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 to estimate transit asset conditions and the investment required to maintain and improve these conditions. TERM is comprised of a database of transit assets and deterioration schedules that express asset conditions as a function of an asset's utilization rate and maintenance history. The deterioration schedules used by TERM were initially estimated using 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. A detailed description of these deterioration schedules is provided in a January 1996 FTA report, "The Estimation of Transit Asset Condition Ratings." The deterioration curves developed from the Chicago data continue to be used in TERM, with the exception of those for bus and rail vehicles, maintenance facilities, and stations, which have been re-estimated based on information collected from nationwide on-site engineering sample surveys.

Each year FTA conducts physical surveys of a type of transit asset to improve the deterioration schedules used by TERM. Before the surveys can be conducted, a methodology must be developed for the asset inspections. In most cases, the assets modeled are comprised of a more detailed set of assets, each of which are examined and rated in the surveys. The final asset condition rating is an average of its subcomponents. FTA's estimates of conditions and estimates of the amount required to maintain and improve conditions, continue to improve as the deterioration schedules based on the Chicago data are replaced with estimates based on data from surveys at a statically representative number of transit systems. This work will continue into the future commensurate with available funding levels. Initial surveys of rail transit train control equipment and communications and electrification systems are planned for 2005. The feasibility of collecting condition information on guideways from transit systems will also be explored.

## *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. Some of the highway performance indicators commonly used (such as daily vehicle miles traveled per lane mile or the percent of travel occurring at high volume/capacity ratios) simply reflect the prevalence of the conditions under which travel delay is likely to occur. Other indicators (such as percent travel under congested conditions), while directly addressing the delay experienced by users, 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 12). One product of this effort is a new performance indicator, the buffer time index, discussed in Chapter 4.

According to studies sponsored by the American Highway Users Alliance, a significant portion of the delay experienced by travelers in the United States occurs at bottlenecks, where capacity and throughput are restricted relative to the adjacent roadways feeding into the bottleneck. This primarily occurs at major intersections and interchanges and at "lane drop" locations where the number of through lanes is reduced. Addressing these chokepoints is one of the most difficult challenges faced by transportation planners. However, current methods for modeling performance do not expressly take into account the operational characteristics associated with bottlenecks, and there is a great need for research into the data and methodologies that could be used to further our understanding in this area.

Among the most common locations for bottlenecks are major bridges, especially those over rivers in major metropolitan areas. Expanding the capacity of bridges is very expensive relative to adding lanes to roadways in the immediate vicinity. As a result, bridge structures often will have fewer lanes than immediately adjacent roadways, thus creating 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 Highway Performance Monitoring System (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 has recently been updated to consider work zone delay in its benefit calculations (see Appendix A). 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 new buffer time index (BTI) is 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 BTI 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 such operations.

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. Investment requirements 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 uses 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.

## *Safety*

As discussed in Chapters 5 and 11, the safety of our Nation's transportation system is one of the highest priorities of the U.S. Department of Transportation (DOT). Safety is also one of the key indicators of system performance that Federal involvement is intended to address, and Chapter 5 also presents some of this information. However, in the context of surface transportation infrastructure investment, there are many areas needed to improve our understanding of the safety impacts of that investment.

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.

One type of additional information that would be particularly useful is improved locational data on motor vehicle crashes. 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 stated, 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 accident data at this level of detail, a change that would entail a significant increase to current National Transit Database (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 requirements 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 negative effects on non-users of the system. These effects, referred to as negative externalities, can represent significant disbenefits to society resulting from transportation. 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 (and perhaps most significant) environmental externalities associated with highway use, namely the damaging effects of vehicle emissions. 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 *Conditions and Performance Report* for a more thorough discussion). However, translating emissions levels into emissions costs is a more challenging step because 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 a significant externality, other impacts could potentially be similarly modeled, such as the noise caused by highway and rail traffic. Two barriers would need to be overcome to incorporate such estimates into the HERS methodology. One 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, unlike vehicle emissions, 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 areas (i.e., regions that do 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. The effect of such requirements may be to limit the type of projects that may be implemented in a given time period. As a result, 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 requirement 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.

**Q.** What research projects does FHWA currently have underway to improve the modeling of transportation capacity investments?

**A.** FHWA has recently funded the following research projects:

- **Interchange needs.** This project consists of a feasibility study to assess how interchange investment needs might best be captured within the C&P report. Options to be evaluated include both improvements to existing models and/or the creation of a new analytical tool to handle these types of investments. Current and potential data sources are also being considered in the study.
- **High cost capacity improvements.** This project is intended to improve the analysis of high cost capacity improvements in HERS. The project is aimed both at providing better estimates of the typical costs of such improvements, and a better understanding of the factors that might trigger the consideration of such extraordinary measures to remedy capacity deficiencies.

## *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 requirements 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, it could potentially be used to improve our modeling of such improvements.

Another class of highway capacity improvements includes those aimed at addressing bottlenecks in the system. 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. They are frequently associated with major intersections, interchanges, bridges, or tunnels in large urbanized areas.

Untangling these bottlenecks can be quite complicated from a traffic engineering viewpoint and require extremely costly investments. The solution may also involve operations enhancements in addition to construction. Further, the data collected in HPMS that might help identify and characterize bottlenecks are very limited. Presently, a bottleneck section would be identified simply on the basis of a lower capacity level coded by the State than would be projected based on other characteristics of the section (this is different from a section that simply has a high volume/capacity ratio). The lower coded capacity value would essentially reflect functional issues not captured in the other data items. Improving our understanding of traffic bottlenecks (and the types and impacts of investments aimed at addressing them) would thus require significantly more data than are currently available. In particular, more data would be needed on the location and operational characteristics of interchanges and intersections.

Another limitation of the current approach to modeling highway capacity improvements is that investment requirements 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.

## *Operations*

As described in Appendix A and elsewhere in this report, the HERS model has recently been modified to consider the impact of operations strategies and ITS deployment on highway system performance and investment requirements. The new procedure is implemented in the form of two 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.

The final 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.

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 estimated investment requirements for both highways and transit. Improving the precision of this portion of the analysis would require improvements in both the forecasts of future travel growth used in the models and in 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, it is difficult to make precise forecasts for 20-year time horizons, and it is open to question as to whether one could improve on forecasts that are done at the metropolitan planning organization (MPO) and State levels.

### 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 (and the future year of those forecasts) 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 level of service. 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.

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. As noted in Chapter 10, 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. Alternative estimates of truck volume growth are available through FHWA's Freight Analysis Framework and were used in the Chapter 10 sensitivity analysis. However, there are issues with the timeliness of these forecasts, which may limit their use on a regular basis (see Appendix A). More significantly, 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 76 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 were used in lieu of projected PMT when the latter was unavailable. Transit travel growth rates for the 370 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. These forecasts have improved with the newly available forecasts for the New York City region.

A minor coverage issue concerning the forecasts is that the regions covered by the 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.

Another issue is the fact that forecasts may 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.

Finally, the nature of the planning process that produces the forecasts is both a strength and a weakness. The forecasts themselves have the advantage of coming from a rigorous, documented process. However, 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 requirements analysis) and thus might forecast less travel growth than they would otherwise.

**Q.** What research projects does FHWA currently have underway to improve the modeling of transportation demand and address pricing issues?

**A.** 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. Current projects in this area include:

- **Time-of-day demand disaggregation.** 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. Research is currently underway to determine how to best model this disaggregation within the HERS travel demand analytical framework.
- **HERS revenue options.** This project will modify HERS to greatly expand the number of policy levers available for modeling the impact of different user fee strategies and options. The revenue-related aspects of this project are furthered described in a Q&A below.
- **Optimal congestion pricing.** This effort, building on the previous two listed here, is planned for inclusion in the 2006 C&P report analysis. The goal is to estimate the optimal congestion pricing charge on each highway segment where it is appropriate and to determine the impact of such a useful (but theoretical) policy on the maximum efficient level of highway investment. The intent of this analysis will be to establish an upper bound on the impact that a more efficient road pricing system could have on estimated highway investment requirements. Future extensions of this analysis, planned for subsequent C&P reports, would expand the number of pricing and tolling options included in the 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.

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 analytical procedures could be required in order to keep the problem 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.

### Pricing Effects

There is great interest in analyzing the impacts of alternative pricing mechanisms.  Disaggregating travel demand in HERS would help to make such analysis possible. Time-of-day demand segmentation would allow for the analysis of optimal congestion pricing in a meaningful way and be able to capture the effects of peak shifting in response to such time-varying tolls. Disaggregation between trucks and passenger vehicles would allow some analysis of differential cost allocation schemes, although such analysis has not traditionally been part of the C&P analysis.  Pricing is also discussed in the "Finance" section below and more extensively 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 attempts to provide quantitative estimates of some of the impact that widespread pricing could have on travel,congestion, and investment.

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.

## *Finance*

While this report compares the estimates of future investment requirements with current spending levels (see Chapter 8), no direct link is made to the funding sources that would (or could) be used to pay for those improvements. In the case of expenditures by different levels of government, this is appropriate because the question of jurisdictional responsibility for those investment needs is outside the scope of this report. However, this is not the case regarding different types of financing mechanisms, for two reasons. First, if a higher level of expenditures were financed through increases in road user charges, this would affect the demand for transportation, which in turn could affect congestion levels and thus future highway performance and investment needs. Different types of user charge regimes could also have varying impacts on demand (such as fuel taxes versus time-of-day tolls), which would need to be accounted for. Second, most public revenue sources for transportation come from taxation, which have a distortionary impact on the economy and thus a cost (sometimes referred to as the social cost of public funds). The extent of this distortion varies for different types of taxes (such as property, sales, or fuel taxes). If higher investment levels were funded through increases in taxes, then the effective cost of the increased spending level would also be increased, which would have an impact on the maximum economic efficiency level of investment. 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.

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.

> **Q.** What research projects does FHWA currently have underway to improve the analysis of highway and transit finance?
>
> **A.** FHWA has two projects underway that will address issues of highway finance:
>
> - **HERS revenue options.** This project is aimed at linking highway investment levels with the revenue streams that would be used to pay for that investment. The project will modify HERS to calculate the highway user revenues generated by the levels of highway travel estimated within the model, using a variety of financing options. Preliminary results from this effort are expected for the 2006 C&P report. Longer term, the goal of this research is to allow for a "balanced budget constraint" to be imposed within the HERS investment analysis.
> - **State highway funding model.** This project is intended to update FHWA's procedures for making short-term estimates of State and local highway funding. The results would be used in future reports for comparisons of estimated investment requirements and projected highway capital funding.

Another funding issue related to the C&P analysis is projections of Federal, State, and local funding for highways and transit. The 1999 and 2002 editions of the report used such projections of anticipated increases in funding under TEA-21 in the Chapter 8 comparisons of investment requirements and current spending. This type of analysis requires a means of forecasting expenditures by different levels of government over a multiyear period. In theory, such forecasts could be made for the entire period covered by the investment requirements analysis, but this could be problematic in practice. For Federal expenditures, forecasts of Highway Trust Fund revenues are available, but Federal funding also depends significantly on the program financing structure authorized by Congress. For this reason, making such projections beyond a reauthorization cycle can be problematic, which is why such analysis is not included in this edition of the report. Forecasting State and local expenditures requires some modeling technique for making such projections. While such models might be reasonably reliable for near-term projections, any long-range (i.e., 20-year) forecasts would be more speculative. For these reasons, this type of comparative analysis is likely to remain an occasional feature focused on the periods covered by recent legislation.

Finally, implicit in all estimates of highway and transit investment and performance is 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 investment analytical procedures themselves and the scope of the investments covered in the analysis. These issues include security and infrastructure investment analysis, addressing 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*

The relationship between transportation infrastructure and national security 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 defining investment requirements sufficient when considering investment 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.

## *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, such methods may 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 constantly looking for opportunities for improvement. The Travel Model Improvement Program, sponsored by the two agencies (and described in the 2002 C&P report), is also 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.

**Q. What research projects do FHWA and FTA currently have underway aimed at addressing some of these analytical issues?**

**A.** 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. The first phase of this research will consist of reviews of each of the three analytical tools used in the C&P report, focusing on the benefit-cost analysis procedures and recommending ways that these could be improved and harmonized with each other. The second phase will bring together a wide array of researchers and stakeholders to assess the possibilities for improving multimodal analysis in the C&P report and charting a course for future research efforts toward this goal.

## *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 a mechanical one, based solely on whether the pavement condition is above or below a threshold reconstruction level. Ideally, such a decision would be made based on a trade-off analysis between the less aggressive resurfacing option and the more expensive (but longer-lasting) reconstruction.

## *New Technologies and Techniques*

The investment estimates reported in the C&P report are intended to reflect existing technologies and techniques, and FHWA and FTA devote considerable resources to keep the models and methodologies used in the C&P analysis current with transportation industry research and practice. However, it is entirely possible that new technologies and methods might be developed over the course of the 20-year horizon analyzed in the report that could affect the performance of the transportation system and the cost of transportation infrastructure improvements. Such developments might come in several areas, including construction methods and materials, operations strategies and ITS technologies, and transit vehicle technologies.

FHWA continues to devote a significant portion of its 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, thus increasing the future costs of capital improvement needs (while still providing benefits to users of the transportation system).

Highway operations strategies and ITS technology are other obvious candidates for continuing improvement over time. The aggressive deployment scenario analyzed in Chapter 10 assumes 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 investment requirements) 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 analyses may thus not be strictly compatible with one another. It also means that the combined total investment requirements 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 requirements, the models vary widely in how that application is performed. 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 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.

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, imposing some constraint on the final improvement selection process. 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 inclusion in the others.

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 for this report (see Appendix B) 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 procedures that are not closely related to one another.

One of the prime challenges in BCA for bridge preservation is adequately capturing 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 preservation 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 that limitations of the TERM and NBIAS BCAs described here are largely owing 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 the maximum economically efficient level of investment. For TERM and NBIAS, a limited BCA filter is applied to the overall results, but not to the scenario itself. Thus, the Cost to Improve scenarios for these two models cannot be described in economic terms at the present time; instead, they are described in terms of 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. It is hoped that recent updates to the model will allow the calculation and prediction of such condition measures with a sufficient degree of confidence as to allow the NBIAS scenarios to be redefined based on broader performance outcomes in time for the 2006 edition of the C&P report.

Finally, it should also be noted that there is an important distinction between how the system condition measures are calculated in HERS and TERM 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, the average asset condition measures under the transit Maintain Conditions and Performance investment scenarios will in fact be increasing marginally over time.

## *Network and Multimodal Trade-Off Analysis*

In addition to analytical comparability, significant multimodal issues exist with the C&P analysis concerning the independence of the investment results produced by the 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; 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 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 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. Also, 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 inter-segment 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 requirements, a worthy goal for the C&P reporting process. If such an end could be accomplished, then the combined total investment requirements 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 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.

Since driving or using 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 requirements 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 requirements.

An example of a complementary transportation investment type that is not currently modeled, but that would affect both highways and transit operations, is high occupancy vehicle (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 tradeoff 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. Such analyses, however, would 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 exist, the current methodology may understate transportation investment benefits by failing to account for this positive externality. At the present time, however, there is some debate within the transportation research community on this subject.

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.

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.

Additional research is focused on developing an analytical model to estimate the links among highway performance, truck freight rates, and shippers' demand for highway freight transportation. The model is intended to quantify the first-order and second-order benefits detailed above. Preliminary research has found a relationship between highway performance and freight costs, but additional research is needed to clarify these results and their implications for BCA.

More information on this line of research is available at http://ops.fhwa.dot.gov/freight/freight_analysis/econ_methods.htm.

## *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, investment requirements on these functional classes must be estimated, rather than being directly 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 are required to report to the NTD. This requirement thus excludes transit operators in nonurbanized areas and some providers in urbanized areas (though some nonrecipients do report). Again, this lack of data consistent with that in urbanized areas results in an alternative procedure for estimating investment needs in these areas, based on alternative, occasional data surveys (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*

The legislative language concerning the C&P report requires estimates of future capital investment requirements at the national level. While some disaggregate data and analyses are provided for different functional or population classes or improvement types, even these analyses are national in scope. The Part I historical data and Part II investment estimates themselves, however, are based on input data that are also disaggregated and stratified geographically within the United States. Thus, it would be conceptually feasible to provide data and analysis with a finer level of geographic detail than is currently presented in the report. However, doing so would raise a whole host of questions. Would such detail enhance the usefulness of the report to policymakers, or would it simply obscure the traditional focus of the report on the Nation as a whole? Is there some intermediate level of aggregation (above the State and operator level) that would be meaningful and useful, while avoiding issues involved with singling out individual agencies? Also, since the investment tools and data collection procedures have been developed around the national-level analysis concept, would they require additional refinements to make them suitable for more disaggregate analysis?

Another scope issue concerns noncapital transportation expenditures. While the Part I chapters 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 requirements estimates reflect such possibilities?

Other issues relating to the scope of the C&P report concern its potential role in legislative and policy development. As emphasized in Chapter 7 and elsewhere in the report, the investment requirements estimates are intended to be informative about the current and future state of the surface transportation system, but they are not intended to be prescriptive. However, the estimates reported in the 2002 edition of the report have been described in such terms and used to compute funding levels for legislative proposals (though not by the DOT itself). Such uses require significant assumptions about inflation, the desirable level of system performance, and the proper distribution of responsibility for future investment among different levels of government. Such considerations are well beyond the current scope of the report, but should the report provide technical guidance as to how such analyses might legitimately be performed?

A final scope issue is the particular modes that are included in the report analyses. The legislative requirements for highway and transit conditions and performance reports are found in separate parts of the United States Code, and the reports series were originally prepared separately. Since 1993, these analyses have been combined into a single report. 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, though investments in these modes could affect both highways and transit. Past analyses (such as the 1995) 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 significant consultation with policymakers and stakeholders before implementation. More generally, the issues listed above, and many of the topics discussed elsewhere in this Afterword, 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 requirements reporting? Do the special topics and analyses that have been added to 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 it 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.

Another extension of C&P research would be to extend the use of the analytical tools to other stakeholders outside of the DOT. In particular, could State and local agencies make use of these tools? The FHWA is exploring this avenue by developing a version of HERS for use by State highway agencies, known as HERS-ST, initially released in 2002. The agency is actively promoting HERS-ST as an asset management tool, providing training and support in addition to software. 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.

# Appendices

# Part VI

# Introduction

Appendices A, B, and C describe the modeling techniques used to generate the estimates of future investment requirements 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 generate estimates of investment requirements for highway preservation and highway and bridge capacity expansion. Significant changes to HERS include the updated pavement deterioration equations; a new improvement costs input matrix; revised capacity calculations; the consideration of work zone delay; changes to the evaluation of widening options; and capturing the effects of current and future operations strategies and ITS deployments.

The **National Bridge Investment Analysis System (NBIAS)** is the primary tool for estimating bridge preservation investment requirements. The model, which is described in **Appendix B**, includes routines for estimating investment for both bridge replacement and bridge repair and rehabilitation. For this report, the model has been revised to analyze repair and rehabilitation improvements on a bridge-by-bridge basis, and allow the prediction of additional bridge condition measures.

**Appendix C** presents the **Transit Economic Requirements Model (TERM)**, which is used to estimate transit investment requirements 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 new data on asset inventories; revised vehicle replacement cost estimates; newly estimated deterioration curves for commuter rail vehicles; and changes to the benefit cost analysis procedures.

# Appendix A

# Changes in Highway Investment Requirements Methodology

# Changes in Highway Investment Requirements Methodology

Investment requirements for highway preservation and highway and bridge capacity expansion are modeled by the Highway Economic Requirements System (HERS), which was introduced in 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 high cost improvements, 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 2002 C&P report, including changes in the pavement deterioration equations, improvement costs matrix, capacity calculations, delay equations, and the evaluation of widening options. The HERS model has been modified to import section-specific data concerning current and future operations strategies and ITS deployments, as well as freight forecasts; this appendix provides a summary of how these data were developed and utilized in the HERS analysis.

## Highway Economic Requirements System

The HERS model initiates the investment requirement 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: reconstruction with more lanes, reconstruction to wider lanes, pavement reconstruction, major widening, minor widening, resurfacing with shoulder improvements, and resurfacing. For each of these seven kinds of improvements, HERS evaluates four alignment alternatives: improved curves and grades, improved curves only, improved grades only, or no change. Thus, HERS has 28 distinct types of improvements to choose from. When analyzing a particular section, HERS actively considers no more than six alternative improvement types at a time: one or two aggressive improvements that would address all of the section's deficiencies and three or four less-aggressive improvements that would address only some of the section's deficiencies.

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 and the residual (salvage) value of the projects. 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) would be factored into the analysis as a "disbenefit."

**Q. Where can I find more detailed technical information concerning the HERS model?**

**A.** The FHWA periodically develops a Highway Economic Requirements System: Technical Report. The most recent printed edition is dated December 2000 and 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 in a number of customized features to facilitate analysis on a section-by-section basis. HERS-ST version 2.0 is based on HERS version 3.54, which was utilized in developing the 2002 edition of the C&P Report. The Highway Economic Requirements System–State Version: Technical Report is available at http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersdoc.htm.

The HERS-ST model will be updated to take advantage of the upgrade analytical procedures described later in this appendix, which will be reflected in future editions of the Technical Report.

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. This was one of the limitations of the model cited in a June 2000 report by the United States Government Accountability Office (GAO), *FHWA's Model for Estimating Highway Needs is Generally Reasonable, Despite Limitations*. 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.

## *Allocating HERS and NBIAS Results Among Improvement Types*

Highway capital expenditures can be divided among three types of improvements: system preservation, 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 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 requirements projected by the National Bridge Investment Analysis System (NBIAS) are classified as preservation only, since new bridge and bridge capacity expansion investments are implicitly modeled by HERS. The HERS model does not currently identify investment requirements for system enhancements.

### *Highway Investment Backlog*

To calculate this value, HERS has been modified to evaluate 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, would be 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.

**Q. What are some examples of the types of behavior that the travel demand elasticity features in the HERS represent?**

**A.** If highway congestion worsens in an area, this increases travel time costs, which might cause highway users to shift to mass transit or cause some people living in that area to 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.

The basic principal 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.

As a result of travel demand elasticity, the overall level of highway investment has an impact on projected travel growth. For any highway investment requirement 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. This effect is discussed in more detail in Chapter 9.

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.

# HERS Pavement Model and Improvement Costs

Two of the key assumptions and internal calculations used by HERS are the rate of pavement deterioration and the unit cost (per lane-mile) of the various improvements recommended by HERS. Both of these have been updated since the previous C&P report.

## *Pavement Deterioration Model*

Versions of HERS (and its predecessor models) used for previous editions of the C&P report incorporated an older pavement deterioration model based on the 1986 version of the American Association of State Highway and Transportation Officials (AASHTO) Pavement Design Guide. For this version, the deterioration models for both flexible and rigid pavement have been updated to reflect the 1993 version of the AASHTO Guide. The new models use the same basic format as the old ones (based on equivalent single-axle loads), but include additional design parameters, such as reliability factors. Forecast pavement deterioration rates under the new models are somewhat lower than with the old model, reflecting the improved design standards, materials, and construction methods that are being applied to modern pavements. Additional research efforts are currently underway that should result in more significant refinements to the pavement modeling in HERS that should be available for the 2008 edition of the C&P report (see Part V).

## *Improvement Costs*

The FHWA has updated both the values used for unit improvement costs and the way in which they are applied. The new improvement cost values were calculated based on highway project data from six states (Oregon, Nebraska, Oklahoma, Indiana, Ohio, and Vermont) that each use AASHTO's Transport system for tracking project costs. The data were then analyzed to derive the cost of typical improvements of different types on different classes of roadways. For rural areas, separate values were calculated by terrain and functional class, consistent with past versions of the cost table. For urban areas, the table format was altered slightly; cost values were now broken down by functional class and by urbanized area size, whereas they had previously been broken down by roadway type (a different field in the HPMS).

The application of the estimated improvement costs to different types of improvements also has been changed. The costs of improvements to existing lanes and the costs of adding lanes are now calculated separately (but aggregated for an improvement including both), making the values in the cost table more intuitive and consistently applied. Realignment costs are now calculated using the same table format described above, rather than using a separate procedure as previously.

For those sections coded in the HPMS as having limited widening feasibility, the costs of adding capacity have been significantly increased to more accurately reflect actual costs of recent projects that have been undertaken in these types of situations. In rural areas, the costs of "high cost lanes" have been set based on the estimated cost of constructing parallel routes; in mountainous areas, this is assumed to involve significant blasting. In densely populated urbanized areas, double-decking or tunneling may be the only potential options for adding highway capacity in this type of situation, and the cost matrix has been adjusted to reflect this. Realignment improvements on sections coded as having limited widening feasibility are also considered to be made at a higher cost, similar to the approach used for lane additions. For sections coded in the HPMS as having unlimited widening feasibility (i.e., three or more lanes), the HERS allows only a certain number of lanes to be added at "normal cost" (which varies depending on the functional class) and applies the high cost lane factors to further widening beyond that point.

Further research is underway in this area that is expected to produce more refined estimates of the per-lane-mile costs for high-cost transportation capacity investments (see Part V).

# HERS Capacity and Delay Analysis

Several modifications have been made to the capacity and delay calculations used by HERS. These include the estimates of highway capacity based on section data, the calculation of work zone delay, procedures used to determine the number of lanes to be added, and limitations on the number of lanes that may be added at normal cost.

## *Highway Capacity Calculations*

The procedures used in the HPMS Submittal software to calculate highway capacity were revised in the 2001 data year, consistent with the *2000 Highway Capacity Manual*. As these calculations apply to the data used in HERS, the capacity calculations used in HERS have been revised to match those used in the HPMS source dataset.

## *Work Zone Delay*

A typical feature of highway projects is that restrictions must be placed on existing travel lanes during at least part of the time that the work is going on (even in cases where lanes are being added). These restrictions can result in significant, temporary losses of effective highway capacity, resulting in additional traveler delay during the time period that the work zone is in place. This work zone delay can represent a significant disbenefit to highway users for some types of improvements. The HERS model has now been modified to include work zone delay in its benefit calculations.

To implement this new procedure in HERS, State departments of transportation were consulted about the duration of and roadway constrictions typically associated with the types of improvements modeled by HERS. The reduced capacity of the roadway is calculated as a function of both reduced capacity per lane and a reduced number of travel lanes. For some types of improvements (such as simple resurfacing on congested freeways and arterials), it was assumed that the capacity restrictions are applied only during off-peak periods. The reduced capacity levels were then used in conjunction with existing travel volumes to calculate the additional travel delay caused by the work zone.

# Incremental Lane Additions

When considering adding lanes to correct a capacity deficiency, HERS calculates the number of lanes that would be needed to accommodate traffic volumes in the future design year (typically 20 years hence). In prior versions, HERS has only considered improvements with this Design Number of Lanes (DNL) when evaluating potential capacity improvements. The model now considers a broader array of potential lane addition improvements, including ½ DNL, ¾ DNL, and DNL+2. For example, if HERS computes a DNL of four lanes, it will now evaluate the effects of adding zero, two, four, or six (the ¾ DNL option would not be invoked; the HERS model typically builds to an even number of lanes).

In some cases, this results in an intermediate widening option (i.e., add two lanes) being chosen where a larger, more costly option either might have been implemented (i.e., add four lanes) or rejected in favor of no lane addition at all. In general, by giving the model more options to choose from, the investment cost of achieving a given level of performance is reduced.

# HERS Operations and Freight Analysis

For this report, HERS has been modified to accept section-specific data inputs from outside the HPMS sample dataset for the first time, which can be applied on an "optional" basis. These additional data inputs fall into two categories: current and future operations strategies and ITS deployments, and freight forecasts.

## *Operations Strategies and Improvements*

For the first time, HERS has been modified to consider the impact of highway operations strategies and ITS deployments on highway system performance. For this initial effort, current and future investments in operations were modeled outside of HERS, but the impacts of these deployments were allowed to affect the internal calculations made by the model, thus also affecting the capital improvements considered and implemented in HERS. As discussed in Part V, a longer-term goal is to analyze operations as alternative investment strategies directly in HERS.

While numerous operations strategies are available to highway authorities (see Chapter 12), 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 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, two 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.

### Operations Investment Costs

The unit costs for each deployment item were taken from USDOT's *ITS Benefits Database and Unit Costs Database* and supplemented with costs based on the Intelligent Transportation Infrastructure Deployment Analysis System (IDAS) model. Costs were broken down into initial capital costs and annual operating and maintenance (O&M) 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.

### 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.
- 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 HERS) 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*

| Operations Strategy | Impact Category | Impact |
|---|---|---|
| **Arterial Management** | | |
| Signal Control | Congestion/Delay | Signal Density Factor = n(nx+2)/(n+2)<br>where<br>n = # of signals per mile<br>x = 1 for fixed time control<br>2/3 for traffic actuated control<br>1/3 for closed loop control<br>0 for real-time adaptive control/SCOOT/SCATS<br>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<br>Safety | New delay = 0.16 hrs per 1000 VMT – 0.13(original delay)<br>-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<br>Safety | -4.5% incident duration<br>-5% fatalities |
| Surveillance Cameras | Incident Characteristics<br>Safety | -4.5% incident duration<br>-5% fatalities |
| On-Call Service Patrols | Incident Characteristics<br>Safety | -25% incident duration<br>-10% fatalities |
| All Combined | Incident Characteristics<br>Safety | Multiplicative reduction<br>-10% fatalities |

## Freight Forecasts

In the sensitivity analyses in Chapter 10 of both this and the 2002 editions of the report, the HERS model's capability to adjust truck volume shares over time was utilized to test the sensitivity of the results to differential rates of future travel growth between trucks and passenger vehicles, based on national-level forecasts. This capability could be applied only on a functional class basis, however (meaning that all sections in a given functional class would have the same truck growth factor).

For this report, HERS has been modified to accept section-specific truck growth forecasts where available. The procedure also allows for alternative base year truck volume levels for individual sections to be substituted for the HPMS values if more detailed data are available (such as from automated truck counters installed on many roads in the United States).

The section-specific truck forecast and volume data used in the Chapter 10 analysis were derived from the FHWA's Freight Analysis Framework (FAF) (see Chapter 13). The FAF data (which use a 1998 base year and include a forecast for 2020) were matched to the 2002 HPMS sample data sections used in HERS in this report where possible. In all, it was possible to match the FAF data to approximately 33,000 of the 111,000 sections in the 2002 HPMS data. For sections that could not be matched, the truck growth factors for each functional class described above were applied.

# Appendix B

# Bridge Investment/ Performance Methodology

The National Bridge Investment Analysis System (NBIAS), first introduced in the 1999 edition of the C&P report, models the investment requirements for bridge preservation and functional improvements. This appendix contains a technical description of the methods used in NBIAS to predict future nationwide bridge conditions and investment requirements, 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 is the successor to the Bridge Needs and Investment Process Model developed by the Federal Highway Administration (FHWA) in 1991 and last used in the 1999 C&P report. The NBIAS incorporates analytical methods from the Pontis Bridge Management System (Pontis). Pontis was first developed by FHWA in 1989 and is now owned by the American Association of State Highway Officials, which licenses the system to over 45 State transportation departments and other agencies.

# NBIAS Overview

The NBIAS is an investment analysis tool used to analyze bridge repair, preservation 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 National Bridge Inventory (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 2002 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.

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 defaults 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. Previous versions of NBIAS used a set of stochastic models to predict the bridge elements that exist in the NBI at an aggregate level. The current version models preservation needs at the element level for each bridge in the NBI. Because the current version required bridge-level data, it was necessary to revise the SQC models for superstructure and substructure elements (including bridge joints and bearings) because previous models could not be used to generate estimates at the bridge level. Revised models 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.

## *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. For the current version of NBIAS, the deterioration models were recalibrated using the historical NBI data for the years 1992 to 2002, resulting in a significant revision of the transition probability matrices.

## *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, represents a new feature of NBIAS added since completion of the 2002 C&P report that is expected to significantly improve the quality of the system's results.

## *Planned Improvements to NBIAS*

Prior versions of NBIAS were very limited in terms of the physical condition measures that could be produced, since bridge elements were modeled at an aggregate level only. The introduction of full individual bridge analysis in the current version will make it possible to include a much broader range of bridge condition measures in future editions of the C&P report. These measures may include average Health Index; average Sufficiency Rating; number of bridges Structurally Deficient and/or Functionally Obsolete; deck area for Structurally Deficient and/or Functionally Obsolete bridges; and predicted deck, superstructure, and substructure component ratings.

With the exception of the Health Index, all of the measures listed above have been defined by FHWA and are detailed in the *NBI Coding Guide* and/or Chapter 3 of this report. The Health Index is an additional measure that can be calculated directly from element data. This measure may range from 0 to 100, with a value of 0 indicating a bridge with all of its elements in the worst defined condition, and a value of 100 indicating a bridge with all of its elements in the best defined condition. The Health Index is useful for characterizing the physical condition of a bridge or set of bridges. It tends to be highly correlated with the Sufficiency Rating, which also is measured on a scale from 0 to 100. However, the Health Index excludes consideration of functional characteristics included in the Sufficiency Rating. This measure was initially defined by the California Department of Transportation and is now included in Pontis.

A series of further improvements are planned to the analytic approach and models in NBIAS. These improvements include:

- Consideration of a broader range of factors in calculation of functional improvement needs, including additional factors quantified in calculation of Sufficiency Rating and Structurally Deficient/Functionally Obsolete status;

- Improved handling of potential needs for adding lanes to existing bridges not presently being modeled in NBIAS (which considers needs for widening existing lanes) or HERS;

- Improved models for action costs and deterioration rates developed using additional baseline data for calibration. Additional work is planned for investigating the feasibility of modeling the dependence of deterioration rates on age and/or other factors not currently addressed in the Markov modeling approach; and

- Inclusion of actual element data rather than predicted element data where such data are available.

# Appendix C

# Transit Investment Condition and Investment Requirements Methodology

This appendix contains a technical description of the methods used to determine transit asset conditions (see Chapter 3) and future investment requirements (see Chapter 7). It is primarily a description of the Transit Economic Requirements Model (TERM).

# 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 that will be required by 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 projects how investment will need to be allocated among transit asset vehicles, guideways, systems, stations, and maintenance facilities—over a 20-year period—and the sensitivity of the investment requirements to variations in the rate of future growth in the demand for transit services.

# TERM Investment Scenarios

TERM projects transit capital investment requirements for the following four investment scenarios:

- **Maintain Conditions**

  In the Maintain Conditions scenario, 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 (2022) that is the same as the asset condition that existed at the beginning of the period (2002). 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 re-investment 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**

  For the Maintain Performance scenario, 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 76 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 (2002) level of average vehicle utilization and average vehicle speed at the end of the 20-year period (2022).

- **Improve Conditions**

  In the Improve Conditions scenario, transit asset rehabilitation and replacement 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 2022. Assets are replaced at 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.

- **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 (2022). 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 in expansion vehicles and related facilities 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.

**Q.** Do all assets reach a condition of 4 at the end of the 20-year investment period?

**A.** 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. The average asset condition reached for investment requirements in this report for the Improve Conditions scenario is estimated to be 3.82 across all asset types. To achieve a higher average condition level would require replacing vehicle and guideway too early in their useful lives.

# 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.** Includes only investments with a cost-benefit ratio greater than 1.0 in TERM's estimates of national transit capital requirements. This process roughly corresponds to the "Maximum Economic Investment" concept in NBIAS.

# Asset Rehabilitation and Replacement Module

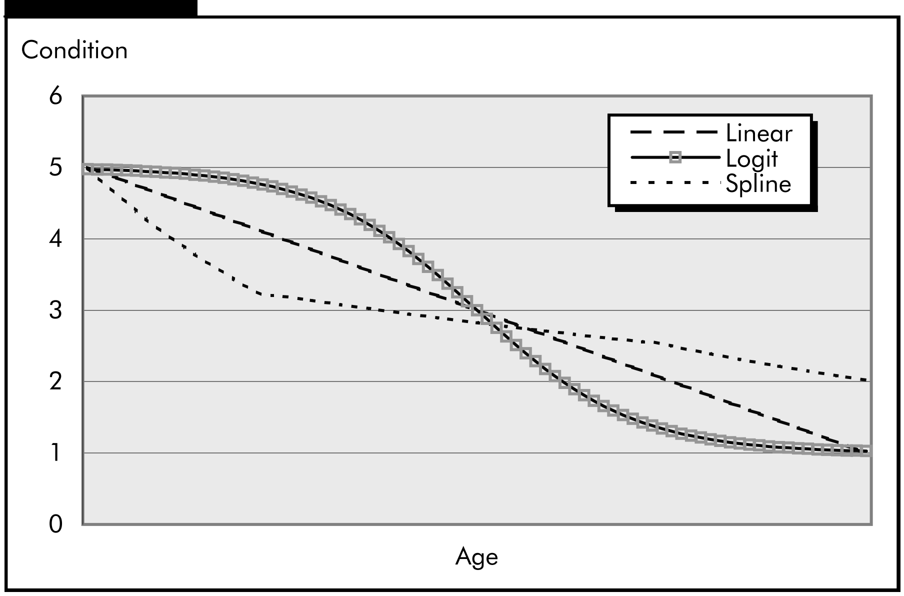
The Asset Rehabilitation and Replacement Module uses statistically determined decay curves to simulate the deterioration of the Nation's transit vehicles, facilities, and other infrastructure components. As the assets age and are used, their condition declines, leading ultimately to investments in rehabilitation and replacement.

The vehicle, maintenance facility, and station decay curves are based on data collected by the Federal Transit Administration (FTA) through engineering surveys performed between 1999 and 2003. 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, and stations, which are in the form of "spline" regression models, differ significantly from the decay curves that continue to be used for other asset types. National Transit Database (NTD) data are applied to these decay curves to estimate conditions, which are subsequently used to estimate rehabilitation and replacement costs. Stations use the same decay curves as maintenance facilities. FTA has just finished conducting physical surveys of a statistically representative sample of stations and will estimate and apply a unique decay curve to calculate investment requirements for stations in subsequent reports.

The decay curves for other nonvehicle infrastructure—guideway, systems, and stations—use "logit" function curves. These decay curves were 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.

These decay curve relationships are applied to a comprehensive inventory of all transit assets utilized by 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 2003, the asset inventory was further updated using data collected through NTD's Asset Condition Reporting module and directly from the New York Metropolitan Transportation Authority. 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. This information has been converted to a 2002-dollar basis by TERM. 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.

**Exhibit C-1** *Asset Decay Curves*



Starting with the 1999 Report, TERM has been able to consider 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).

## Asset Expansion Module

The Asset Expansion Module identifies the level of investment that will 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 (in most cases 2002) available from a sample of 76 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 were used in lieu of projected PMTs when the latter were unavailable. Transit travel growth rates for the 370 urbanized areas for which transit travel projections 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 1.5 percent. Passenger travel growth rate forecasts varied according to region and ranged from 0.95 to 3.15.

## 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. 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.

**Q.** How does TERM treat passenger fares?

**A.** Passenger fares have not been factored into in the benefit-cost analysis used by TERM. Although passenger fares accrue to transit agencies, these funds are simply a transfer from other sectors of the economy, and do not increase benefits to society as a whole. Earlier versions of TERM incorrectly treated passenger fares as a benefit. This revision means that fewer potential transit investments now pass the benefit-cost hurdle in TERM.

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 (parking costs and taxi expenditures).

- 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 vehicle miles traveled 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.

The cost-benefit 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 a reduction in travel time resulting from the expansion of 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.

# Investment Requirements for Rural and Specialized Transit Service Providers

Investment requirements for rural areas are 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. Requirements are 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 2002. (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 requirements 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 to fulfill these unmet rural investment requirements 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 investment requirements provided in the 2002 report also assumed a 3.5 percent average annual growth in the rural fleet.

A similar methodology was applied to estimate the investment requirements of Special Service Vehicles, comprised principally of vans. 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.