2002 Status of the Nation's Highways, Bridges, and Transit:

Conditions & Performance

REPORT TO CONGRESS

U.S. Department of Transportation

Federal Highway Administration

Federal Transit Administration

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Introduction

This is the fifth 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 "2002 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance" report to Congress (C&P report), draws primarily on 2000 data. The 1999 C&P Report, transmitted May 2, 2000, was based on 1997 data.

Report Purpose

This document is intended to provide Congress and other decision makers with an objective appraisal of highway, bridge and transit physical conditions, operational performance, financing mechanisms and future investment requirements. 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 ten chapters of the 1999 edition, with the exception of Chapter 1. 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 multi-modal 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 and usage 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 revenues 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, "Bridges" provides additional detail on the conditions, composition and performance of bridges beyond that covered in Part I, as well as a discussion of the Highway Bridge Replacement and Rehabilitation Program and the National Bridge Inspection Program. This section includes some of the information that was previously submitted in separate reports to Congress on "The Status of the Nation's Highway Bridges: Highway Bridge Replacement and Rehabilitation Program and National Bridge Inventory."

- **Chapter 11** describes the conditions and performance of the Nation's bridges, along with the Federal bridge programs.

Part IV, "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 12** describes the relationship between national security and the highway and transit systems.
- **Chapter 13** identifies ways that the Nation's highway transportation system benefits households and businesses.
- **Chapter 14** illustrates the importance of public transportation by exploring user characteristics and public transportation benefits.
- **Chapter 15** discusses results of current research on the macroeconomic benefits of highway investments, in comparison to the microeconomic modeling used to derive the highway investment requirements identified in Chapter 7.
- **Chapter 16** discusses pricing as a potential solution to some of the congestion problems identified in Chapter 4.

- **Chapter 17** defines the concept of Transportation Asset Management (TAM), and describes current Federal efforts to assist State and local governments in developing TAM frameworks to help them optimize their allocations of resources.
- **Chapter 18** discusses current Federal efforts to assist State and local governments in improving their ability to project future travel, through the Travel Modeling Improvement Program.
- **Chapter 19** describes the relationship between air quality and highway and transit infrastructure, a critical issue in assessing the desirability of future investments.
- **Chapter 20** describes current Federal safety programs, and how they address the safety issues introduced in Chapter 5.
- **Chapter 21** discusses the potential for operations strategies to address the congestion problems identified in Chapter 4.
- **Chapter 22** discusses the role of freight transportation and identifies future investment requirements specific to the freight area.

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 23** discusses the conditions, performance, and future investment requirements for the Interstate System.
- **Chapter 24** provides comparable information for the National Highway System (NHS).
- **Chapter 25** quantifies investment requirements relating to NHS Intermodal Freight Connectors.
- **Chapter 26** analyses the costs and benefits of investments in rail grade crossings.
- **Chapter 27** assesses transit systems on Federal lands. This section is a companion to a section in the 1999 C&P report that discussed highways on Federal lands.

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 the 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 condition data are obtained from the National Bridge Inventory (NBI), which includes all bridges that are covered by the National Bridge Inspection Standards and are located on a public road. Generally, each bridge is inspected at least once every 2 years, although bridges with higher risks of engineering problems are inspected more frequently, and certain low-risk bridges get less frequent inspections.

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. Supplementing this information on transit facilities and fleets with additional information collected directly from transit operators provides a complete picture of the Nation's transit facilities and equipment.

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 Personal Transportation Survey (NPTS) 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).

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.

This edition of the report is the first in which the National Bridge Investment Analysis System (NBIAS) model has been used to develop the bridge investment requirements. Comparably to HERS, NBIAS includes benefit/cost analysis in its calculations. Previous bridge estimates were derived using engineering criteria only.

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).

Highlights

This is the first Conditions and Performance Report that begins to capture the effects of investment in highways, bridges and transit undertaken since the enactment of the Transportation Equity Act for the 21st Century (TEA-21) in 1998. Based on data for 2000, the report also reflects enhancements in ongoing work by the Federal Highway and Federal Transit Administrations 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.

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 25.0 percent between 1997 and 2000. This equates to 14.4 percent increase in constant dollar terms. Highway capital spending alone rose to $64.6 billion in 2000, a 33.7 percent increase over 1997.

The increased Federal funding levels for highway capital investment under TEA-21 through 2000 have been matched and exceeded by increases in State and local investment. Taken as a whole, State and local governments did not simply substitute Federal funds for their own during this robust economic period. Instead, they poured billions of additional dollars into transportation projects beyond the minimum increases necessary to meet Federal matching requirements. As a result, the State and locally-funded share of highway capital investment increased from 1997 to 2000. The State and local share of capital outlay had remained in a range from 54 to 59 percent between 1987 and 1997. In 1998, however, the State and local share of highway capital outlay increased above 60 percent for the first time since 1959, and remained above that level through 2000.

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 52.0 percent in 2000. The combined result of the increase in total capital investment and the shift in the types of improvements being made was a 45.7 percent increase in spending on system preservation, from $23.2 billion in 1997 to $33.6 billion in 2000. System preservation projects tend to have shorter lead times and are often less controversial than system expansion projects, 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 20.8 percent from $21.6 billion to $25.9 billion.

It is important to note that due 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. Consequently the full effect of TEA-21 on the condition and the performance of the nation’s highways and bridges has not yet been realized.

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 82.5 percent in 1993 to 86.0 percent in 2000. The percentage of bridge deck area considered deficient dropped from 30.9 percent in 1996 to 27.9 percent in 2000. These improvements, however, were not uniform across all highways and bridges. The condition of higher-order roads, for example, has improved considerably since 1993, while conditions on many lower-order roads have worsened. 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 use of that infrastructure—has steadily deteriorated over the past decade. In 1987, for example, a trip that would take 20 minutes during non-congested periods required, on average, 25.8 minutes under congested conditions. By 2000, the same trip under congested conditions required 30.2 minutes, or an additional 4.4 minutes.

Future Investment Scenarios

There is significant room for increases in highway capital investment that would result in positive net benefits to the American people, in terms of reductions in travel time, vehicle operating costs, crashes, emissions, and highway agency costs. The 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 Cost to Improve highways and bridges is projected to be $106.9 billion for 2001-2020 (stated in constant year 2000 dollars). This is 65.3 percent higher than the $64.6 billion of total capital investments by all levels of government in 2000. 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.

Even maintaining the overall conditions and performance of highways and bridges at current levels would require significantly more combined investment by all levels of government. 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 2000 levels, based on projections of future highway use. The average annual investment is projected to be $75.9 billion (in constant $2000) for 2001-2020, which is 17.5 percent larger than the $64.6 billion of capital spending in 2000.

Capital spending by all levels of government is projected to increase in constant dollar terms over the remainder of the life of TEA-21, which will tend to reduce the "gap" between average annual spending and the Cost to Maintain. However, this assumes that Federal, State and local governments will be in a financial position to allow them to continue to increase their highway and bridge investments, albeit at slower rates than those observed from 1997 to 2000. All levels of government may not be able to sustain the rate of increase in infrastructure investment observed in recent years, but the full effects that recent reductions in State and local tax receipts will have on their level of infrastructure investment are not yet clear.

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 year 2000 levels, or projected levels for 2001 to 2003, it is projected that recent trends observed in the condition and performance of the highway system would continue. At this range of investment levels, the operational performance of the highway system is expected to further deteriorate: average speeds would decline, the amount of delay experienced by drivers would increase, and the average length of congested periods on the Nation's urban principal arterials would increase. Recent trends towards improvements in bridges 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 preceding edition of the C&P report suggested that it would be cost-beneficial to devote a larger share of future increases in highway capital investment towards system preservation. As discussed above, such a shift did occur between 1997 and 2000, resulting in significant improvements in the physical conditions of the Nation's highway and bridge infrastructure. However, the operational performance of the highway system continued to decline over this period.

In part because combined Federal, State and local infrastructure investment has been more successful in addressing physical conditions than operating performance since 1997, the future investment requirement analyses in this report now suggest that it would be cost-beneficial to devote a larger share of future increases in highway capital investment towards system expansion.

Conclusion

Since the enactment of TEA-21, State and local governments—spurred in part by higher levels of Federal investment—have poured billions of dollars into highway infrastructure. 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 future funding might be reoriented 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 were exceeded by the combined investments of State and local governments from 1997 through 2000.

Total funding by Federal, State and local governments, increased by 20 percent between 1997 and 2000, and by 15 percent in constant dollar terms. Total spending on capital investment by all levels of government increased by 19 percent over the same period. Federal funding for capital investment increased by a total of three percent, while State and local funding increased by 37 percent. Increases in State and local funding drove the Federal share of capital funding for transit down from 54 percent in 1997 to 47 percent in 2000.

Since the implementation of TEA-21, the allocation of transit capital expenditures by type of investment has remained relatively constant. In 2000, 58 percent of transit capital expenditures were for facilities, 31 percent for rolling stock and 11 percent were for other capital investment. These funds were drawn from all sources—Federal, State and local—including formula, New Starts, Fixed Guideway Modernization, and Bus and Bus Facility funds. The composition of capital expenditures in 1997 was almost identical. 58 percent of transit capital expenditures were for facilities, 29 percent for rolling stock, and 13 percent for other capital investment.

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 2000, the number of urban transit vehicles increased by 2.6 percent, track mileage grew by 6.6 percent, the number of stations increased by 5.4 percent, and the number of urban maintenance facilities grew by 4.1 percent.

Transit Use Has Increased

With new and modernized transit vehicles and facilities, passengers use has also increased, particularly transit rail use. Passenger miles traveled on transit increased by 12.2 percent between 1997 and 2000. Passenger miles traveled on rail increased by 16.4 percent, more than twice the 7.6 percent increase that occurred on non-rail modes. The distance traveled by transit vehicles in service also increased by 9.6 percent. Vehicle occupancy reached a new high in 2000, primarily as a result of increased occupancy rates on rail vehicles.

Physical Conditions Have Remained Constant

Bus and rail vehicle conditions have remained relatively constant since 1997. Bus conditions have improved slightly as a result of new vehicle purchases, and rail conditions have declined marginally. The condition of rail vehicles for earlier years has been adjusted downward from that reported in the last C&P Report, as a result of an improved approach to the calculation of deterioration.

The conditions of bus and rail maintenance facilities have declined since 1997. About 75 percent of the decline in rail facility condition was due to methodological revisions. Changes since 1997 in the condition of other rail infrastructure have varied. Specifically, the condition of power systems and structures has improved slightly, although it is estimated that more than 20 percent of all structures remain in substandard condition. Station conditions show solid improvement, and track conditions have remained constant. Conditions of yards have declined slightly, but all remain in adequate or better condition.

Operational Performance Has Decreased for Rail

Vehicle utilization rates have increased for rail and decreased for other modes. Heavy, light and commuter rail utilization reached new highs in 2000, with commuter rail showing the highest utilization. Bus, demand response and vanpool utilization decreased. Average rail operating speeds have declined since 1997, primarily due to increased use of older, slower rail systems.

Future Investment Requirements

The average annual Cost to Improve both the physical condition of transit assets and transit operational performance to targeted levels by 2020 is estimated to be $20.6 billion in 2000 dollars, 128 percent higher than transit capital spending in 2000. The estimated average annual Cost to Maintain transit asset conditions and operating performance is estimated to be $14.8 billion, 64 percent more than 2000 capital spending. More than 50 percent of these projected funding requirements are for asset rehabilitation and replacement.

Not surprisingly, with more than 90 percent of passenger miles traveled on transit systems in areas with populations of over 1 million, more than 90 percent of transit investment requirements are expected to be in these urban areas. These increased investment requirements reflect an enlarged transit infrastructure base, updated capital cost estimates for vehicles, and a downward revision in the average condition of rail vehicles as a result of changes in methodology. As in the past, a higher proportion of projected capital outlays will be for non-vehicle purchases than for the purchase of vehicles. The largest increase in investment needed to maintain performance through the expansion of the asset base will be for fixed guideway elements and vehicles. To "improve performance," significant investment will be required in system design and rights-of-way acquisition.

Projected investment requirements are sensitive to forecasts of passenger miles traveled. The estimated investment requirements presented in this report are based on an increase of 1.6 percent in the average annual passenger miles traveled, which reflects the average of transit travel forecasts by Metropolitan Planning Organizations. This projected rate is well below the average annual growth of passenger miles traveled since 1995 of 3.4 percent. Should these projected rates prove to be understated, the projected investment requirements will be higher.

Conclusion

Increased Federal funding for transit capital investment under TEA-21, combined with a substantial increase in local government funding, has expanded transit infrastructure and permitted the average condition of system assets to be maintained between 1997 and 2000. However, an overall increase in transit rail use has led to a decline in the performance of rail modes, as the average operating speeds decreased with the increased use of older, slower rail assets. As the Nation's population continues to increase, with larger concentrations of people in urban areas, the need for investment in transit infrastructure will continue to grow.

The Role of Highways and Transit

America's transportation system facilitates the movement of goods and people within and between cities and regions, linking the Nation together through a wide variety of modes. The surface transportation system serving the United States today reflects investment and location decisions made by both governments and private enterprise over many years.

The Federal government has played a key role throughout the country's history in shaping the transportation system, both in regulating interstate commerce and in funding and facilitating transportation improvements.

The Role of Highway Transportation

America's highways connect all regions and States to one another. They are striking in their versatility, having been engineered to allow for a wide array of users and vehicles simultaneously. Highway transportation depends on both public and private inputs and investment.

Highway transportation in the United States plays a significant role in two major areas:

Personal Mobility. 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.

Freight Movement. Highways are a key conduit for freight movement in the United States, accounting for 54 percent of total freight transport by weight (and 83 percent by value) in 1998. Highways can be used for hauls of virtually any length, from coast-to-coast shipments to short mail and parcel deliveries.

The Role of Public Transportation

Transit provides the following benefits to passengers, communities, and the Nation:

Access, Choice and Opportunity. More Americans are choosing to ride transit, whether to reduce travel time, ease the stress of a daily commute, or contribute to a healthier environment. For those with no access to personal forms of transportation, public transportation provides access to community resources and job opportunities.

Economic Growth and Development. Transit spurs economic activity, creates jobs, boosts property values and tax earnings, and connects employers and workers.

Safe and Healthy Communities. Public transportation helps to protect the environment, conserve energy, and ensure the safety and security of our citizens.

The Complementary Roles of Highways and Transit

Highways and transit serve distinct but overlapping markets. Highway and transit investments expand the choices available to people by increasing their travel options. While highways provide the highest degree of mobility, transit is essential for those that do not have access to a private vehicle. Highway investments can also encourage transit usage by improving access to transit stations and facilities, and improve operating efficiency for transit modes that use highways. Alternatively, transit can help mitigate highway congestion by offering faster and more reliable transportation than private vehicles on some highways during peak travel times.

System and Use Characteristics: Highway and Bridge

There were over 3.95 million miles of public roads in the United States in 2000. **This mileage was overwhelmingly rural and locally-owned**. About 3.09 million miles were in rural areas in 2000, or 78 percent of total mileage. The remaining 860,000 miles were in urban communities. There were 586,930 bridges in the United States in 2000.

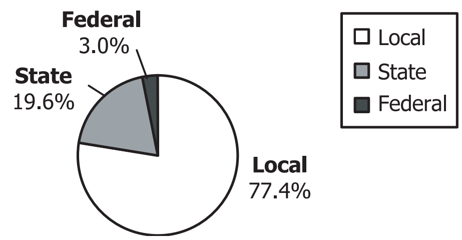
Numerous trends are changing the extent and use of the American highway network. **While locally-owned road mileage increased between 1993 and 2000, rural mileage decreased during that period**. This has been an ongoing trend, partly reflecting the reclassification of Federal roads and the growth of metropolitan areas throughout the United States.

Percentage of Highway Miles, Lane Miles, and Vehicle Miles Traveled by Functional System, 2000

FUNCTIONAL SYSTEM	MILES	LANE-MILES	VEHICLE-MILES TRAVELED
Rural Areas			
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	11.0%	10.6%	7.6%
Minor Collector	6.9%	6.6%	2.1%
Local	53.5%	51.3%	4.6%
Subtotal Rural	**78.2%**	**76.6%**	**39.4%**
Urban Areas			
Interstate	0.6%	0.9%	14.4%
Other Freeway and Expressway	0.4%	0.5%	6.4%
Other Principal Arterial	1.4%	2.3%	14.5%
Minor Arterial	2.3%	2.8%	11.8%
Collector	2.2%	2.3%	5.0%
Local	15.3%	14.6%	8.6%
Subtotal Urban	**22.2%**	**23.4%**	**60.6%**
Total	**100.0%**	**100.0%**	**100.0%**

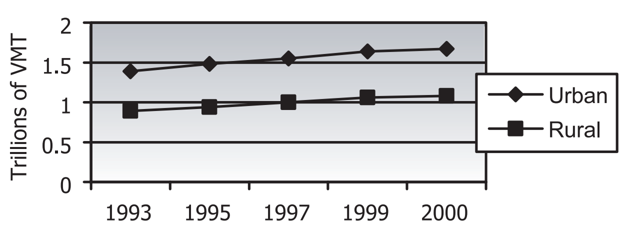
In terms of ownership, about 77 percent of miles were locally-controlled, 19 percent were controlled by States, and the remaining 3 percent were controlled by the Federal Government. **The share of locally-owned roads has steadily increased, while the shares of State and Federal roads have decreased.** Much of the change in Federal ownership has occurred as Federal land management agencies reclassified some of their mileage.

Highway Mileage by Jurisdiction, 2000



Americans traveled 2.7 trillion vehicle miles in 2000. While highway mileage is mostly rural, a majority of highway travel (61 percent) occurred in urban areas in 2000. Since 1997, however, **rural travel has grown at a faster average annual rate** (2.8 percent) than urban travel (2.6 percent). This represents a change from the last Conditions and Performance Report, when urban travel growth rates were greater than the preceding decade. Still, vehicle miles traveled (VMT) increased on every highway functional system between 1997 and 2000.

Highway Vehicle Travel, 1993 to 2000



The growth in VMT has exceeded the increase in highway lane miles. **Between 1993 and 2000, lane miles grew by 0.2 percent annually, while VMT increased by 2.7 percent annually.** VMT for combination trucks grew faster between 1997 and 2000 than VMT for single-unit vehicles and passenger vehicles.

System and Use Characteristics: Transit

Transit system coverage, capacity, and use in the United States increased during the 1990s.

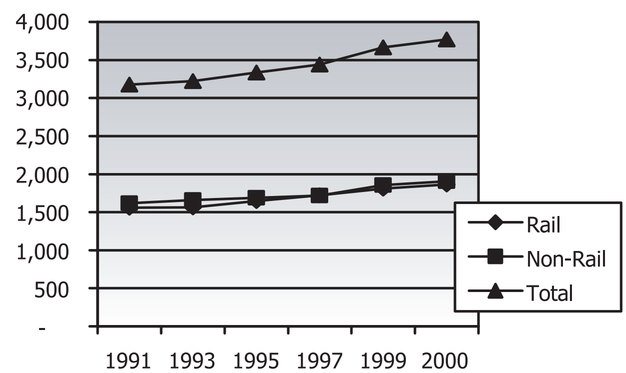
The ownership and operation of public transportation services in the United States was transferred from private companies to publicly-owned and operated entities with the passage of the Urban Mass Transportation Act of 1964. Since that time, metropolitan planning agencies have taken on more responsibility for public transportation policy.

In 2000, public transportation agencies in urban areas operated 106,395 vehicles, of which 82,545 were in areas of more than 1 million people. Rail systems covered 10,572 miles of track with 2,825 stations. Rail and non-rail public transportation systems combined operated 1,269 vehicle maintenance facilities. In addition, an estimated 19,185 public transportation vehicles operated in rural areas and 28,664 special service vehicles serving the disabled and elderly were operated by agencies receiving Federal Transit Administration (FTA) funds.

Public transportation systems operated 9,221 route miles of rail service in 2000, an absolute increase of 31.7 percent since 1991. Non-rail route miles were 163,303 in 2000, an increase of 9.4 percent over the same time period.

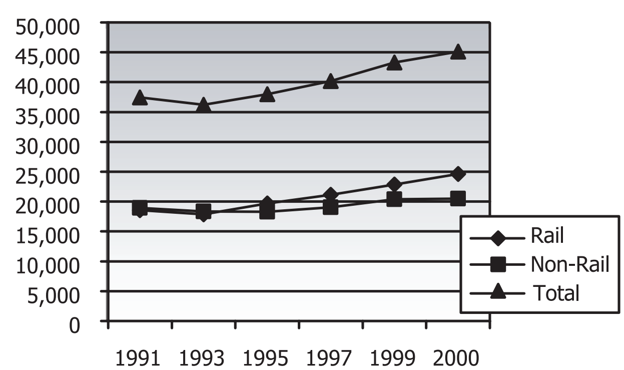
Public transportation system capacity as measured in vehicle revenue miles, and adjusted for vehicle capacity, increased by 18.7 percent from 1991 to 2000. Rail capacity increased 19.7 percent, and non-rail capacity by 17.7 percent. Capacity for rail and non-rail in 2000 was almost identical, approximately 1.9 billion capacity equivalent miles each, for a total of 3.8 billion.

Public Transportation Capacity, 1991-2000 (millions of capacity equivalent miles)



Transit passenger miles increased by 24.5 percent between 1993 and 2000, from 36.2 billion to 45.1 billion. Growth in passenger miles was most pronounced for rail transit modes, increasing 37.7 percent, from 17.9 billion in 1993 to 24.6 billion in 2000.

Urban Passenger Transit Miles (millions)

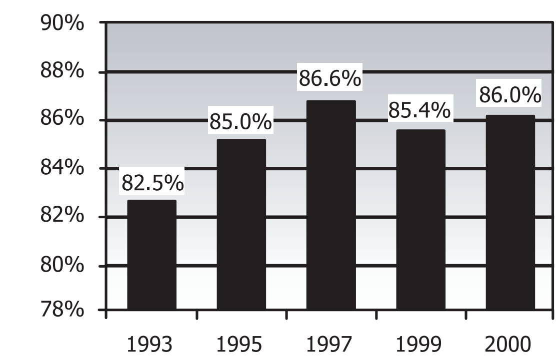


Public transportation vehicle occupancy remained relatively stable between 1993 and 2000, at an average of between 11 to 12 passengers per vehicle, adjusted for capacity. Vehicle occupancy increased for rail vehicles from 11.4 to 13.2 passengers and decreased for non-rail vehicles from 11.1 to 10.8 passengers.

System Conditions: Highway and Bridge

The ride quality of 86.0 percent of the total road mileage is rated "Acceptable" for 2000, up from 85.4 percent in 1999. Of the total rural road miles, 89.0 percent are rated as having acceptable ride quality, while 79.8 percent of total small urban road miles and 76.6 percent of the total road miles in urbanized areas are rated as having acceptable ride quality.

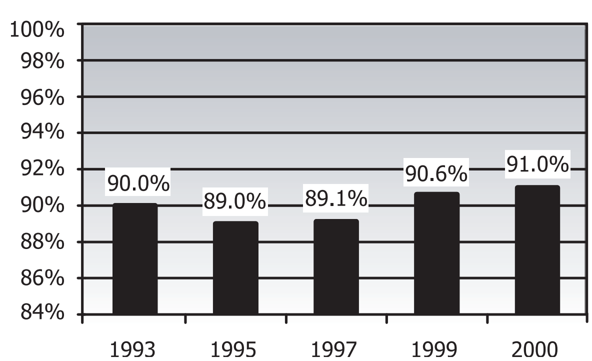
Miles with "Acceptable" Ride Quality



On the National Highway System (NHS), 93.0 percent of the pavements meet or exceed standards for acceptable ride quality. **Of all vehicle miles traveled (VMT) on the NHS, 91.0 percent were on pavements with acceptable ride quality.**

The condition of higher order roads improved, while those of the lower order roads declined.

VMT on NHS Acceptable Pavements



Three indicators are commonly used to describe bridge condition. Bridge component ratings provide a detailed description of elements, but these are more widely used within the engineering community. The number of deficient bridges is widely used by policymakers to describe bridge quality nationwide, but this indicator fails to provide a specific description of bridge elements. The Federal Highway Administration has developed a new indicator that will provide a better measure of bridges impact on mobility: the amount of deck area on deficient bridges.

In 2000, 27.9 percent of the Nation's bridge deck area was on bridges that were classified as structurally deficient or functionally obsolete. This percentage decreased on every functional system from 1996 to 2000. Rural Interstate bridges had the smallest amount in 2000 (about 15 percent), while urban collector bridges had the largest amount (39.6 percent).

Deficient Bridge Deck Area by Functional System, 2000

FUNCTIONAL SYSTEM	
Rural	
Interstate	15.0%
Other Principal Arterial	17.6%
Minor Arterial	22.9%
Major Collector	22.7%
Minor Collector	22.5%
Local	29.1%
Subtotal	**21.8%**
Urban	
Interstate	31.6%
Other Freeway and Expressway	28.9%
Other Principal Arterial	36.4%
Minor Arterial	37.3%
Collector	39.6%
Local	36.4%
Subtotal	**33.6%**
Bridge Total	**27.9%**

System Conditions: Transit

U.S. transit system conditions are determined by the aggregate number and type of transit vehicles in service, their average age and condition, the physical conditions and ages of bus and rail maintenance facilities, and the conditions of transit rail infrastructure components such as track, power systems, stations, and structures.

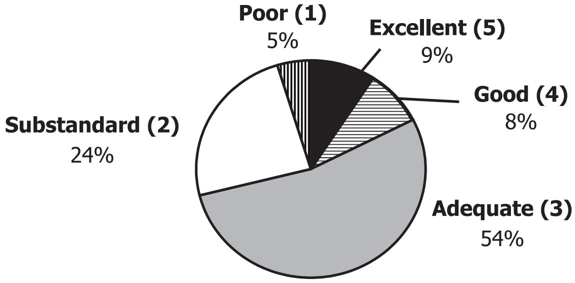
The Federal Transit Administration has undertaken extensive engineering surveys and collected a considerable amount of data on the U.S. transit infrastructure to evaluate transit asset conditions. A rating system of 1 to 5 is used to describe asset conditions.

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.

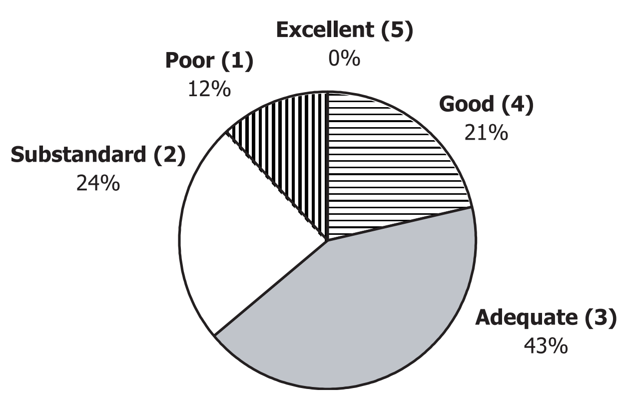
In 2000, the average condition of urban bus vehicles was 3.07, compared with 2.96 in 1997. The percentage of bus maintenance facilities in adequate or better condition decreased from 77 to 71 percent during this same period.

Distribution of Condition of Urban Bus Maintenance Facilities, 2000



The average condition of rail vehicles declined gradually throughout the 1990s. In 2000, all rail vehicles were estimated to have an average condition level of 3.55, down marginally from a re-estimated condition level of 3.61 in 1997. The average conditions of rail vehicles and rail facilities, except those for commuter rail, have been re-estimated to be lower than was reported in the last edition of this report based on additional information collected by engineering surveys between 1999-2001. This does not reflect a true decline in condition in earlier years for which the condition levels have also been revised. Urban rail maintenance facilities continue to age and their condition continues to decline. In 2000, 64 percent of all urban rail maintenance facilities were in good or better condition compared with 77 percent in the 1997. About 75 percent of this decline was due to methodological revisions.

Distribution of Condition of Urban Rail Maintenance Facilities, 2000



The average condition of the remaining non-vehicle transit infrastructure in 2000 is estimated to be similar to the average condition which existed in 1997, as reported in the 1999 C&P Report.

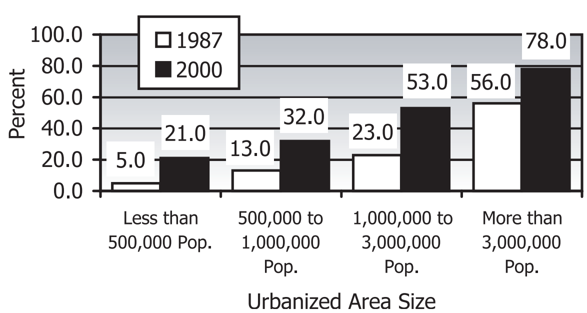
Operational Performance: Highway

Since the last edition of the C&P Report, FHWA has adopted three new measures of operational performance. **These measures clearly show congestion is increasing throughout the Nation.**

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 2000, an average peak period trip required 51.0 percent more time than the same trip under non-peak, non-congested conditions. In 1987, a 20-minute trip during non-congested periods required 25.8 minutes under congested conditions. The same trip in 2000 required 30.2 minutes, or an additional 4.4 minutes. Between 1987 and 2000, the percent of additional travel time grew fastest in urbanized areas with a population between 1 million and 3 million.

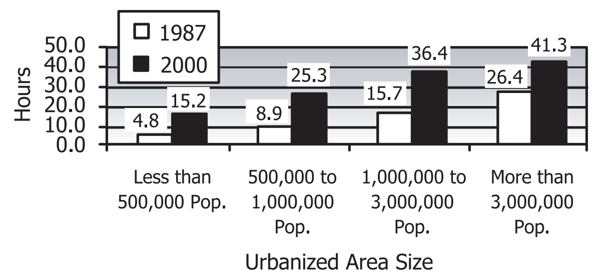
Percent of Additional Travel Time, 1987 vs 2000



Annual Hours of Delay:

Annual Hours of Traveler Delay is an indicator of the total time an individual loses due to traveling under congested conditions. Cities with less than 500,000 population experienced the greatest percentage growth in the average annual delay experienced by drivers, from 4.8 hours in 1987 to 15.2 hours in 2000—an increase of 217 percent. Drivers in cities with populations under 500,000 were experiencing close to the same delays in 2000 as communities with populations between 1 million and 3 million in 1987.

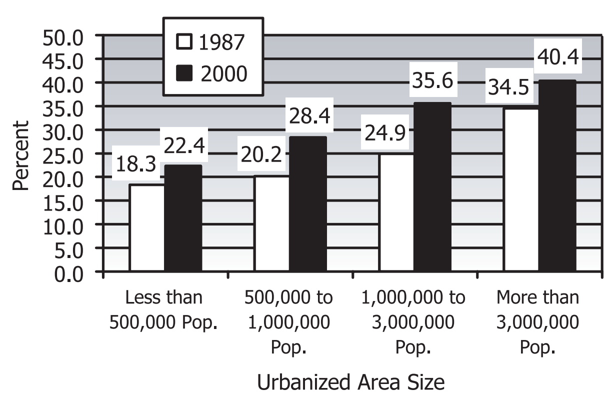
Annual Hours of Traveler Delay, 1987 vs 2000



Percent of Travel Under Congested Conditions:

Percent of Travel Under Congested Conditions is defined as the percentage of traffic on freeways and principal arterial streets in an urbanized area moving at less than free flow speeds. Congested travel increased from 31.7 percent in 1992 to 33.1 percent in 2000. Based on this measure, the congested period, or "Rush Hour," increased from 5 to 5.3 hours per day over this period—approximately 18 minutes. For urban areas with populations greater than 3 million, 40.4 percent of daily travel in 2000 was under congested conditions.

Percent of Travel Under Congested Conditions, 1987 vs 2000

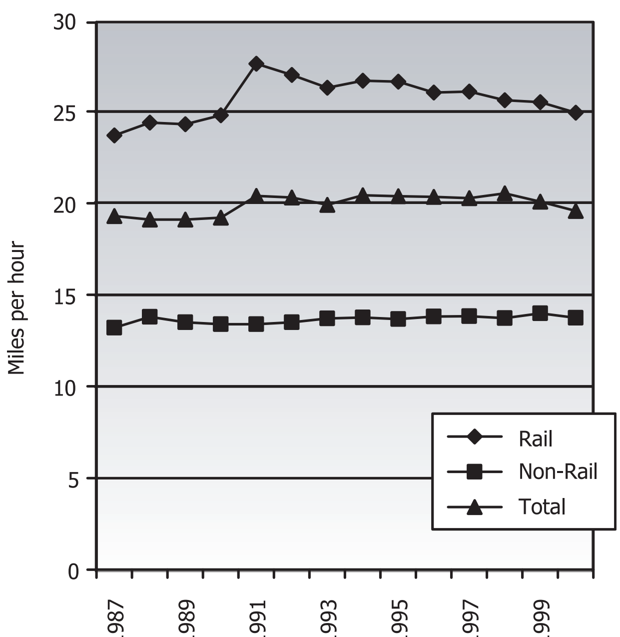


Operational Performance: Transit

Average bus speed has remained relatively constant over the past decade, while rail speeds have declined very slightly from their peak in 1991, reflecting growth in the utilization of systems with heavy use and slower speeds.

Travel Speed: The average operating speed of all transit modes in 2000 was 19.6 miles per hour, down from 20.3 in 1997. The average speed for rail modes was 24.9 miles per hour, and the average of non-rail modes, 13.7 miles per hour compared with 26.1 and 13.8, respectively, in 1997.

Transit Operating Speeds, 1987-2000

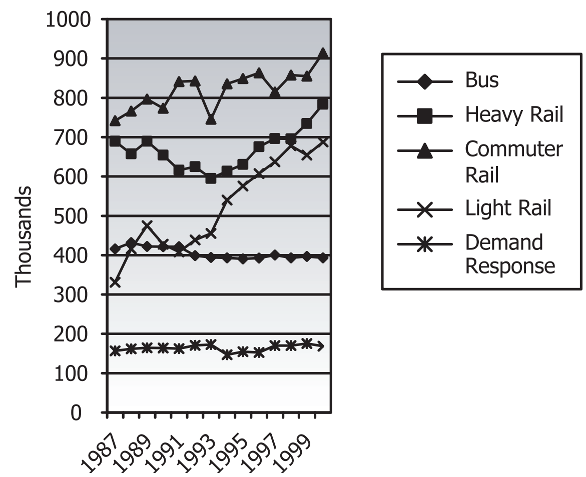


Vehicle Utilization: Vehicle utilization is measured as passenger miles per vehicle adjusted to reflect differences in the capacities of each type of vehicle. On average, rail vehicles operate at a higher utilization level than non-rail vehicles. Between 1997 and 2000 vehicle utilization for rail vehicles increased while decreasing for bus and demand response vehicles.

Vehicle Utilization Passenger Miles per Capacity-Equivalent Vehicle

MODE	UTILIZATION	
	1997	2000
Heavy Rail	697	784
Commuter Rail	815	914
Light Rail	638	688
Bus	401	393
Demand Response	170	169

Vehicle Utilization Passenger Miles per Capacity-Equivalent Vehicle, 1987-2000



Frequency and Reliability of Service: Waiting times vary according to the type of passenger making the trip. Passengers with limited incomes and without access to a private vehicle have the longest average waiting time (12.1 minutes); passengers with above-poverty incomes without access to a private vehicle have a slightly lower average waiting time (8.9 minutes); and those with access to a vehicle, but who choose to use transit (often to avoid road congestion), have the lowest average waiting time (7.3 minutes).

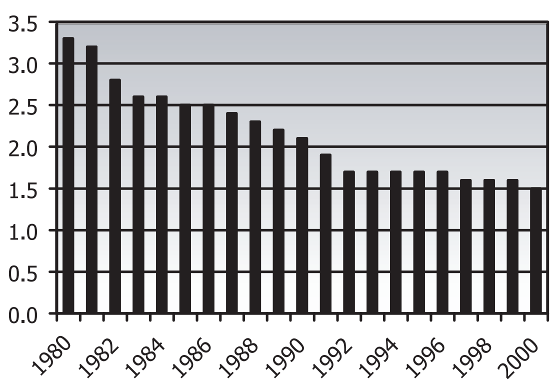
Seating Conditions: Seating conditions, measured by the percentage of passengers who find a seat unavailable upon boarding, are slightly worse for those with lower incomes and without access to a car.

Safety Performance: Highway

Safety is the top priority for the U.S. Department of Transportation. The Safety Strategic Goal in the Department's 2003 Performance Plan aims to "promote the public health and safety by working toward the elimination of transportation-related deaths and injuries."

Over the past thirty years, remarkable progress has been made in making highways safer, with **highways becoming safer even as travel sharply increased.** The exhibit below, for example, describes the fatality rate per 100 million vehicle miles traveled from 1980 to 2000. **The fatality rate has decreased**, from 3.3 in 1980 to 1.5 in 2000, which met the Department's Performance Plan target.

Fatality Rate, 1980-2000



The injury rate has also declined in recent years, as detailed in the exhibit below. In 1988, the rate was 169 per 100 million vehicle miles traveled; by 2000, that rate had dropped to 116. While significant, the declining injury rate falls short of the Performance Plan goal of 113 per 100 million vehicle miles.

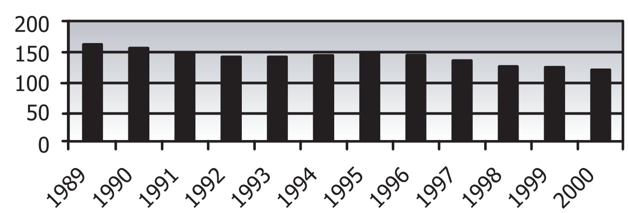
Alcohol impairment is a leading cause of crashes and a serious public safety problem in the United States. In 2000, alcohol was involved in 40 percent of fatal crashes and 8 percent of all crashes.

There are three main groups involved in alcohol-impaired driving:

- The largest group, **21- to 34-year-old adults**, was responsible for 31 percent of all fatal crashes in 2000. Studies show that these drivers tend to have much higher levels of intoxication than other age groups.
- **Chronic drunk drivers** are another large group. Fatally injured drivers with a blood alcohol concentration greater than 0.10 grams per deciliter were six times as likely to have a prior conviction for driving while intoxicated than fatally injured sober drivers.
- Finally, **underage drinkers** are disproportionately over-represented in impaired driving statistics.

Speeding and alcohol impairment are closely linked in many crashes. In 2000, 23 percent of underage *speeding* drivers involved in fatal crashes were intoxicated. By contrast, 10 percent of underage *nonspeeding* drivers involved in fatal crashes were intoxicated.

Injury Rate, 1989-2000



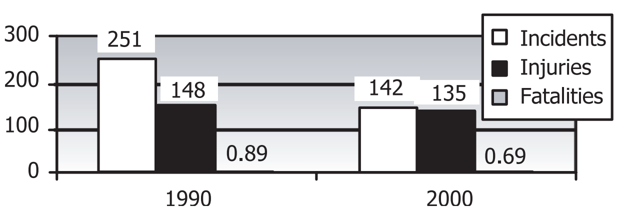
While the number of overall highway fatalities and injuries has decreased in recent years, this is not uniformly true for all vehicle groups. The number of occupants killed in passenger cars, for instance, decreased from 21,566 in 1993 to 20,492 in 2000. In contrast, the number of occupants killed in light and large trucks, motorcycles, and other vehicles all increased during this period.

Safety Performance: Transit

Public transit in the United States has been and continues to be a highly safe mode of transportation as evidenced by the decrease in incidents, injuries, and fatalities reported by transit service providers for the vehicles they operate directly. (They exclude occurrences on contracted transportation).

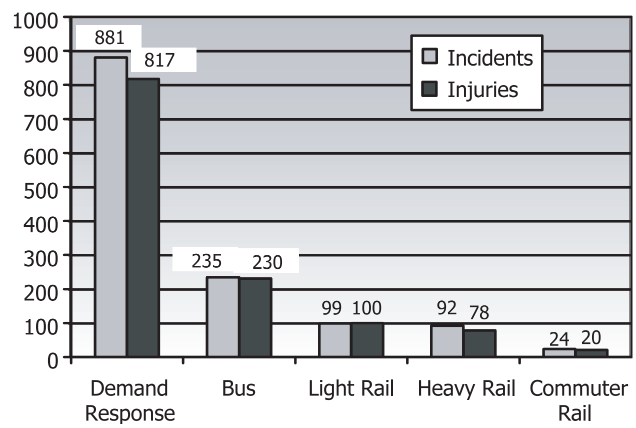
Reportable transit safety incidents include collisions and any other type of occurrence (e.g., derailment) that result in injury or death, or fire or property damage in excess of $1,000. Injuries and fatalities include those suffered by riders as well as by pedestrians, bicyclists, and people in other vehicles. Injuries and fatalities may occur either while traveling or while boarding, lighting, or waiting a for a transit vehicle.

Incidents, Injuries and Fatalities per 100 Million PMT, 1990 and 2000



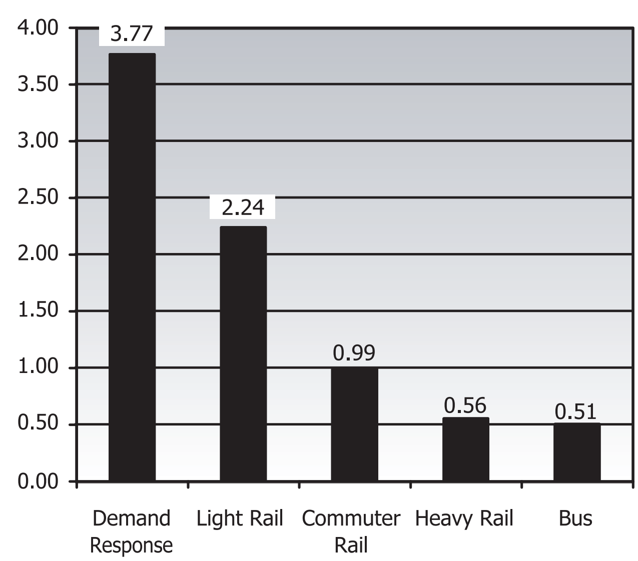
In absolute terms, incidents were 36 percent lower in 2000 than in 1990, injuries 7 percent higher, and fatalities 11 percent lower. When adjusted for changes in the level of transit usage, incidents per 100 million passenger miles traveled (PMT) fell from 251 in 1990 to 142 in 2000—a decrease of 45 percent. Injuries per 100 million PMT fell from 148 to 135, a decrease of 9 percent; and fatalities declined from .89 to .69, a decrease of 25 percent. Transit vehicles that travel by road have higher incident and injury rates than those that travel on fixed guideways. Incident and injury rates have consistently been the highest for demand response vehicles with widely fluctuating fatality rates often well above those for other types of transit services. Buses, likewise, have consistently had incident and injury rates above rail transit modes, but unlike demand response vehicles, buses rank among the lowest in fatality rates. Commuter rail, by contrast, has had the lowest incident and injury rates.

Incidents and Injuries per 100 Million PMT, 2000



Fatality rates for light rail have, on average, been higher and shown considerably more year-to-year variation over the past decade than commuter and heavy rail.

Fatalities per 100 Million PMT, 2000

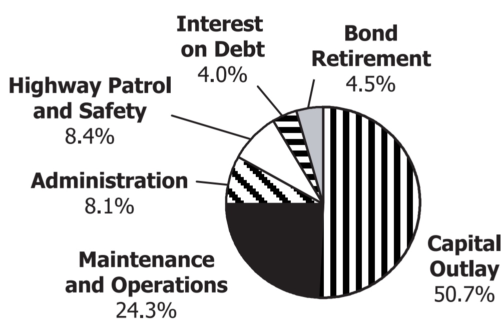


Finance: Highway and Bridge

Taken together, all levels of government spent $127.5 billion for highways in 2000. The Federal government funded $27.7 billion (21.7 percent). States funded $67.0 billion (52.6 percent). Counties, cities, and other local government entities funded $32.7 billion (25.7 percent).

Total highway expenditures by all levels of government increased 25.0 percent between 1997 and 2000. Highway spending rose faster than inflation over this period, growing 14.4 percent in constant dollar terms.

Highway Expenditures by Type, 2000

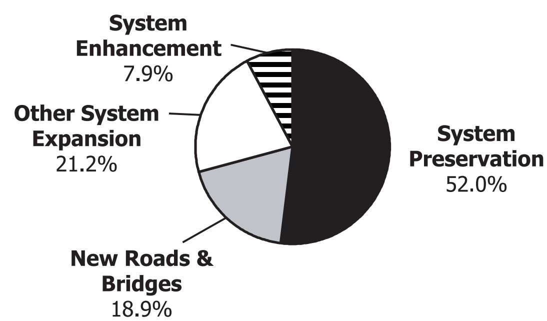


Of the total $127.5 billion spent for highways in 2000, $64.6 billion (50.7 percent) went for capital outlay. This was the first time this percentage exceeded 50 percent since 1975.

Capital outlay grew by 33.7 percent between 1997 and 2000. Federal funds accounted for $25.8 billion (39.9 percent) of total capital outlay. Large increases in Federal investment under the Transportation Equity Act for the 21st Century were outpaced by even larger increases in State and local investment, as the combined State and local share of funding for capital outlay rose from 58.4 percent in 1997 to 60.1 percent in 2000.

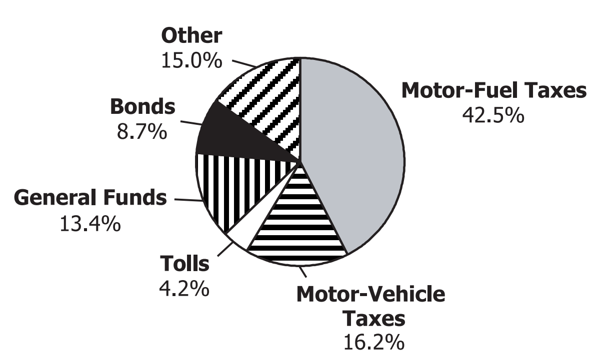
State and local governments devoted a larger share of their capital spending to the preservation of their existing roads and bridges in 2000 than in 1997. The share of capital funds used for system preservation rose from 47.6 percent to 52.0 percent. All levels of government spent a combined $33.6 billion of capital funds for system preservation in 2000; $12.2 billion went for new roads and bridges; $13.7 billion went for adding new lanes to existing roads; and $5.1 billion went for system enhancements, such as safety, operational or environmental enhancements.

Distribution of Highway Capital Outlay By Improvement Type, 2000



Highway-user revenues—the total amount generated from motor-fuel taxes, motor-vehicle fees, and tolls—were $100.6 billion in 2000. Of this, $81.0 billion (80.5 percent) was spent on highways. This represented 62.9 percent of the total revenues generated by all levels of government in 2000 for use on highways.

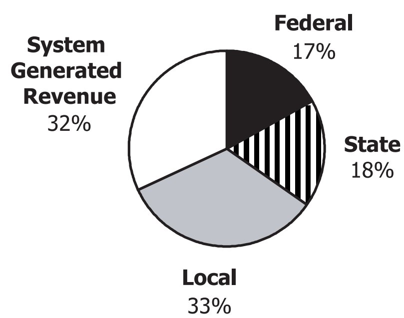
Revenue Sources for Highways, 2000



Finance: Transit

In 2000, $30.8 billion was available from all sources to finance public transportation investment and operations. Public transportation 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 2000, Federal funds accounted for 17 percent of all public transportation revenue sources, State funds for 18 percent, local funds for 33 percent, and system generated funds for 32 percent.**

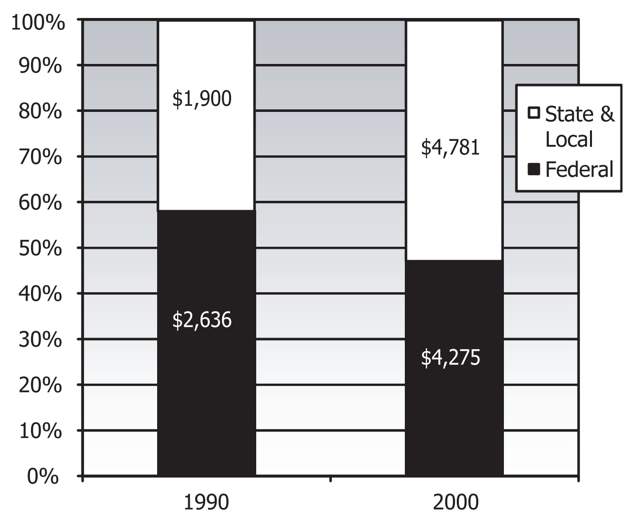
Transit System Revenue Sources, 2000



Eighty percent of Federal funds allocated to public transportation are from a dedicated portion of the Federal motor fuel tax and 20 percent are from general revenues. Federal funding for public transportation in constant 2000 dollars increased by 12.3 percent between 1999 and 2000, compared with a 2.4 percent increase between 1998 and 1999.

In 2000, total capital expenditures on public transportation were $9.1 billion dollars. Federal capital assistance was $4.2 billion dollars, accounting for 47 percent of this amount. Between 1990 and 2000, Federal funding for capital investment grew at an average annual rate of 4 percent, while funding from State and local governments, grew at a 9 percent average annual rate. State and local funding now accounts for a higher percentage of total capital investment expenditures.

Composition of Transit Capital Investment Funding, 1990 and 2000



In 2000, 58 percent of capital spending was for facilities, 31 percent for rolling stock, and 11 percent for other capital, an almost identical allocation as in 1997.

Operating expenses for transit totaled $20.0 billion in 2000. As in 1997, about 50 percent of operating expenses was for vehicle operations, 30 percent for vehicle and non-vehicle maintenance, and 20 percent for administrative expenses and purchased transportation. Bus operations accounted for 55 percent of operating expenditures in 2000 ($11.0 billion), heavy rail operations for 20 percent ($3.9 billion), and commuter rail for 13 percent ($2.7 billion). From 1997 to 2000, operating expenses for demand response vehicles increased by 21 percent, for light rail by 26 percent, for bus operations by 13 percent, for commuter rail by 18 percent and for heavy rail by 13 percent.

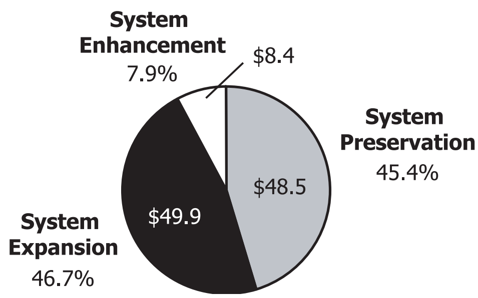
Capital Investment Requirements: Highway and Bridge

The average annual **Cost to Improve Highways and Bridges for the 20-year period 2001–2020 is projected to be $106.9 billion. This represents the investment by all levels of government required to implement all cost-beneficial improvements on highways and bridges.** This level of investment would address the existing backlog of highway ($271.7 billion) and bridge ($54.7 billion) deficiencies, as well as new deficiencies as they arise during the 20-year period, when it is cost-beneficial to do so.

Investment requirements for system preservation make up 45.4 percent of the total Cost to Improve Highways and Bridges. This includes all *capital* investment required to preserve the condition of the pavement and bridge infrastructure, such as resurfacing, rehabilitation, and reconstruction. This does not include the costs of routine maintenance.

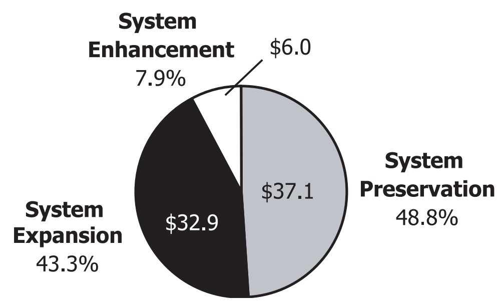
Investment requirements for system expansion make up 46.7 percent of the total Cost to Improve Highways and Bridges. The remaining 7.9 percent of the Cost to Improve is not directly modeled; this represents the current share of capital spending on system enhancements such as safety, operational, and environmental investments.

Cost to Improve Highways and Bridges Distribution by Improvement Type



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 2020 will match their year 2000 values.** For bridge preservation, it represents the level of investment required to maintain the existing backlog of bridge deficiencies at its current level. 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. Agency costs, such as maintenance, and societal costs, such as emissions, are also considered in the analysis, although they are not directly targeted. The average annual investment required for the **Cost to Maintain Highways and Bridges is projected to be $75.9 billion**.

Cost to Maintain Highways and Bridges Distribution by Improvement Type



The scope of user costs has been expanded from those considered in previous reports to include an estimate for delays resulting from incidents, as well as for recurring daily congestion. A reliability premium has also been added to reflect the additional costs that unpredictable delays impose beyond those of expected delays for which drivers can plan. Including these items in the analysis makes it considerably more expensive to maintain average user costs.

Capital Investment Requirements: Transit

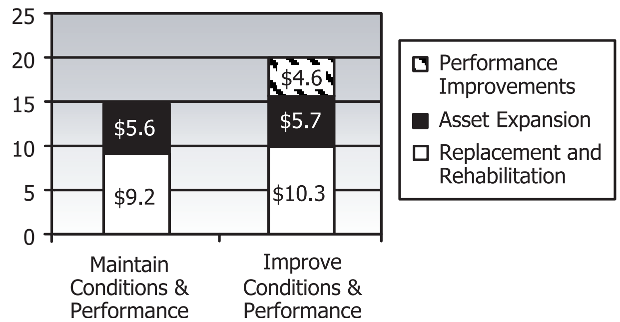
Estimated transit capital investment requirements have increased substantially since the 1999 Report. These requirements are estimated for the period 2001-2020 for four scenarios. The Maintain Conditions scenario projects the level of transit capital investment necessary to maintain average asset conditions over this 20-year period, and the Improve Conditions scenario projects the investment necessary to raise the average condition of each major 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 increase average vehicle speeds and reducing average vehicle occupancy rates.

Summary of Transit Average Annual Investment Requirements, 2001-2020 (Billions of 2000 Dollars)

CONDITIONS	PERFORMANCE	AVERAGE ANNUAL COST	
		1997	2000
Maintain	Maintain	$10.8	$14.8
Improve	Maintain	$14.4	$16.0
Maintain	Improve	$11.1	$19.5
Improve	Improve	$16.0	$20.6

Average annual investment requirements are estimated to be $14.8 billion to Maintain Conditions and Performance ($10.8 billion in 1997) and $20.6 billion to Improve Conditions and Performance ($16.0 billion in 1997). Under the Maintain scenario, $9.2 billion annually would be needed for asset rehabilitation and replacement and $5.6 billion for asset expansion. Under the Improve scenario, $10.3 billion would be needed annually for replacement and rehabilitation, $5.7 billion for asset expansion, and $4.6 billion for performance improvements.

Annual Cost to Maintain and Improve Conditions and Performance by Investment Type (Billions of 2000 Dollars)

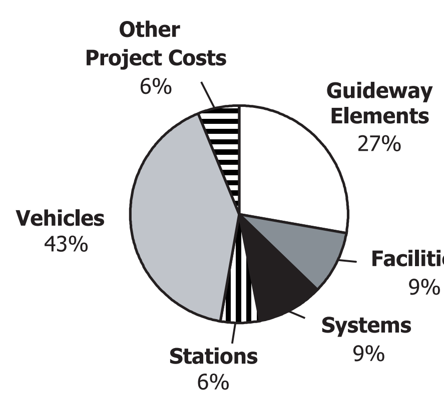


Vehicles, i.e., rolling stock, account for the largest percentage of investment requirements, followed by guideway elements—tracks, tunnels and bridges.

Average Annual Transit Investment Requirements by Asset Type to Maintain Conditions and Performance, 2001-2020 (Billions of 2000 Dollars)

Guideway Elements	$4.1
Facilities	$1.4
Systems	$1.4
Stations	$0.9
Vehicles	$6.2
Other Project Costs	$0.9

Distribution of Costs by Asset Type to Maintain Conditions and Performance, 2001-2020

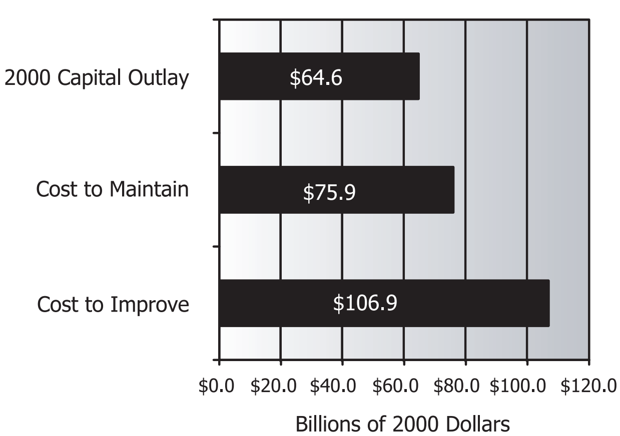


Comparison of Spending and Investment Requirements: Highway and Bridge

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 obtained.

Federal, State, and local capital expenditures for highways and bridges totaled $64.6 billion in 2000. **Capital outlay by all levels of government would have to increase by 17.5 percent above this level to reach the projected $75.9 billion Cost to Maintain Highways and Bridges level. An increase of 65.3 percent would be required to reach the projected $106.9 billion Cost to Improve Highways and Bridges level.**

2000 Capital Outlay vs Highway and Bridge Investment Requirements

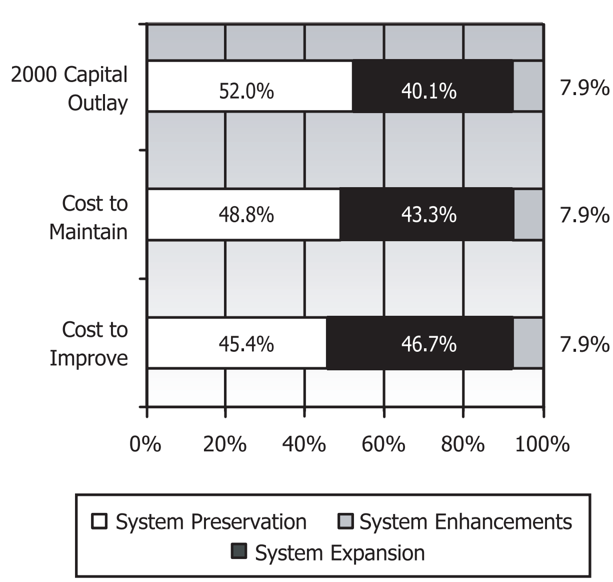


Capital spending by all levels of government grew sharply between 1997 and 2000 and is projected to continue to increase in constant dollar terms from 2000 to 2003, albeit at a slower rate. These projected increases in combined Federal, State and local capital spending would move the Nation closer to the level of the investment requirement scenarios. However, capital outlay would still have to increase 11.3 percent above projected annual spending over this period to reach the Cost to Maintain level, and would need to increase 56.6 percent to reach the Cost to Improve level.

In 2000, 40.1 percent of highway capital outlay went for system expansion, including the construction of new roads and bridges and the widening of existing facilities. **The analytical models used to develop the investment requirements in this report suggest that if capital investment increases, it would be cost beneficial to devote a larger share to system expansion** to alleviate the effects that future travel growth would have on recurring and non-recurring delay.

For the Cost to Maintain Highways and Bridges, 43.3 percent of the projected 20-year investment requirements are for system expansion. If funding increases above this level, the analysis suggests increasing investment in system expansion, so that for the Cost to Improve Highways and Bridges, 46.7 percent of the total investment requirements are for system expansion.

Investment Requirements and 2000 Capital Outlay Distribution by Improvement Type



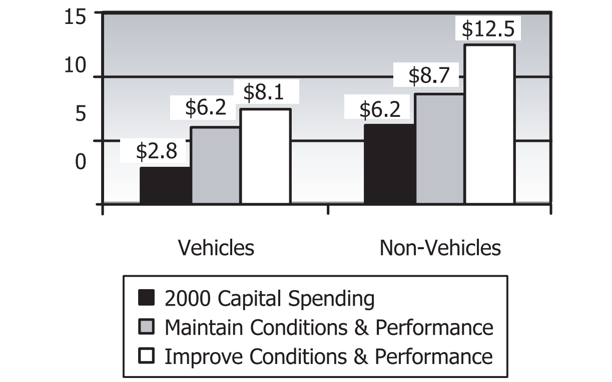
Comparison of Spending and Investment Requirements: Transit

Transit capital expenditures from Federal, State, and local governments totaled $9.1 billion in 2000, below the estimated annual investment requirements for the 20-year period from 2001-2020. The annual capital investment necessary to Maintain Conditions and Performance is estimated to be $14.8 billion, 64 percent above actual spending in 2000. The investment required to Improve Conditions and Performance is estimated to be $20.6 billion, 128 percent above actual 2000 capital spending.

These comparisons, however, overestimate the gap between capital investment requirements and future funding for transit capital investment. This overestimation results from the lags that occur between the authorization of capital funds, their obligation and actual capital spending. Since TEA-21, annual obligations by FTA for capital investment have grown rapidly to $7.2 billion in FY 2000 from $4.1 billion in FY 1998, an increase of 76 percent. These higher levels have not yet worked their way through the process into capital spending. As these higher levels of authorized funds are obligated and spent, capital investment will rise and the gap between actual capital spending and estimated annual capital investment requirements will decrease.

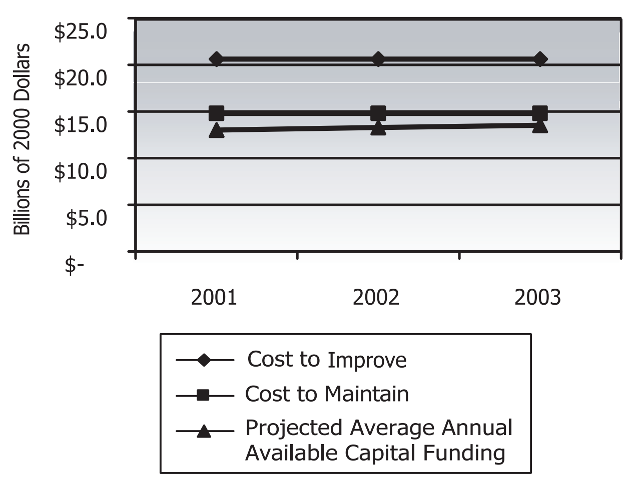
To Maintain Conditions and Performance investment in transit vehicles would need to be 117 percent above the $2.8 billion spent in 2000, and investment in non-vehicle assets 40 percent above the $6.2 billion spent in 2000. To Improve Conditions and Performance investment in vehicles would need to be 184 percent above the 2000 amount and investment in non-vehicle assets 101 percent above the 2000 amount.

A Comparison 2000 Capital Spending with Average Annual Investment Requirements (Billions of Dollars)



Projected funding levels, which are based on TEA-21 authorizations, flexible funding estimates and allocations from State and local governments are considerably closer to estimated investment requirements than current capital spending with the gap declining over the duration of the TEA-21 period. By 2003, investment requirements to Maintain Conditions and Performance are estimated to exceed estimated average annual available funding levels by 10 percent, and those to Improve Conditions and Performance by 52 percent.

Available Capital Funding vs Investment Requirements



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 45.7 percent from $23.0 to $33.6 billion between 1997 and 2000. 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.

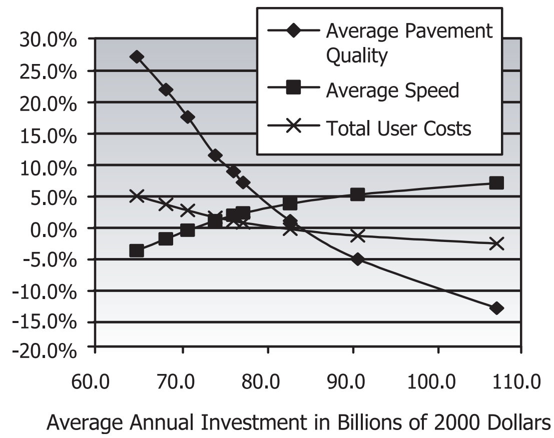
Investment in system expansion has also increased, but at a much lower rate relative to outlays for system preservation. While the rate of growth in average annual hours of traveler delay has decreased, the level of investment has not stopped the overall growth in congestion.

Impact of Future Investment on Highway Conditions and Performance

If average annual highway capital investment from 2001 to 2020 reaches the projected $106.9 billion **Cost to Improve Highways and Bridges** level and is applied in the manner suggested by the analysis, the average pavement quality is projected to improve by 13.9 percent relative to year 2000 levels. Improvements in highway operational performance would cause average speeds to rise by 6.0 percent, while average highway user costs would decline by 3.6 percent.

If all levels of government combined invested at the **Cost To Maintain** projected level of $75.9 billion, and shifted more of their investment toward system expansion to address increasing congestion problems, average speeds would improve, while average pavement roughness would worsen. By definition, user costs would remain at year 2000 levels.

Projected Changes in 2020 Highway Condition and Performance Measures Compared to 2000 Levels at Different Possible Funding Levels



Impact of Investment on Travel Growth

While future travel growth will be primarily driven by factors such as population growth and growth in economic activity, the amount of travel growth on a highway segment may also be affected by the level of investment on that segment. Investments that reduce the economic cost of using a facility may lead to increased use, while increasing congestion on an unimproved roadway may 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 1.96 percent. If highway-user costs declined, as they would under the Cost to Improve scenario, this rate would increase to 2.19 percent per year.

Impacts of Investment: Transit

The Transit Economic Requirements Model (TERM) does not estimate the impact of capital investment in transit infrastructure on the demand for transit services. Rather, assumed growth in passenger miles traveled (PMT) is the driving factor in estimating transit investment needs. For this reason, it is impossible to determine how achieving the required investment levels would affect transit ridership, user costs, and the potential for additional capital investment. There is evidence, however, to suggest that investments in transit infrastructure in areas with latent transit demand will increase ridership.

Historically and since 1993, actual investment in transit capital infrastructure has been less than estimated investment requirements to Maintain Conditions and Performance.

Changes in Condition and Age

As indicated in Chapter 3, **the average condition of bus vehicles has been relatively constant over the last 13 years, with a very slight improvement in 1993. The average condition of rail vehicles**, on the other hand**, appears to be gradually declining—from 3.91 in 1987 to 3.55 in 2000**. The average age of bus vehicles, including vans, gradually declined during the early nineties but has remained relatively constant (at about 7 years) since 1996. The average age of the rail fleet has increased from 15.6 years in 1987 to 20.4 years in 1997, and 21.8 years in 2000. As fleet size has increased since 1987, the absolute number of overage vehicles—both bus and rail—has also increased. In 2000, there were 16,000 overage buses, 44 percent more than in 1987, and 6,770 overage rail vehicles, 138 percent more than in 1987. Although the conditions of non-vehicle infrastructure appear to have improved since 1997, a significant percentage of these assets are in less than adequate condition.

Changes in Performance

In 2000, the average rail speed was 24.9 miles per hour, its lowest rate since 1990, and rail vehicle utilization rates reached new highs in 2000, well above the utilization rates that existed in the early 1990s. This reflects increased usage in the larger, older systems, which tend to have slower speeds.

Historical Capital Investment and Conditions and Performance

Capital spending levels have been approximately equal to or slightly higher than the pure replacement and rehabilitation levels necessary to Maintain Conditions. However, about half of current capital spending appears to have been allocated to rehabilitation and replacement, with the remainder going to asset expansion. Although past spending levels appear to have Maintained Conditions for buses and to have almost Maintained Conditions for rail vehicles, the absolute number of overage bus and rail vehicles has increased. During the past few years, funding levels have been sufficient to Maintain Performance for bus modes of public transport, but the performance of rail modes has declined slightly.

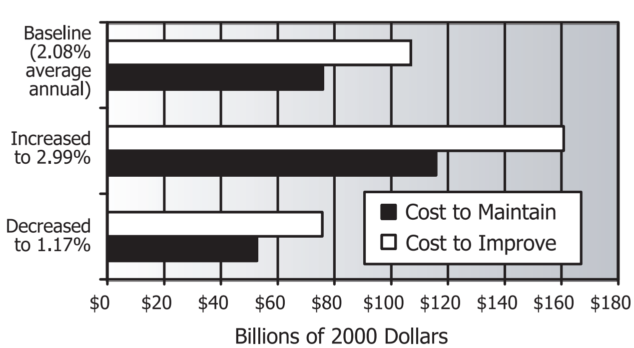
Sensitivity Analysis: Highway and Bridge

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 Cost to Maintain Highways and Bridges and Cost to Improve Highways and Bridges to changes in these assumptions.

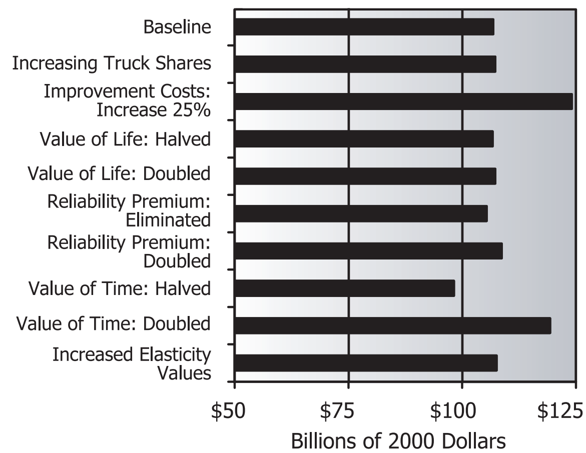
Travel Forecasts

The Highway Economic Requirements System (HERS) assumes that the State-supplied baseline travel forecast for each highway section represents not what future travel *will* be, but what it *would* be if investment rose to the level required to keep highway user costs constant. The aggregate annual growth rate drawn from these section level forecasts is 2.08 percent. If instead, the 2.99 average annual VMT growth rate observed from 1980 to 2000 were a better predictor of future constant price VMT growth, then the estimated Cost to Maintain and Cost to Improve would each be over 50 percent higher. Conversely, if the "true" annual VMT growth that would occur at a constant level of service were only 1.17 percent, the Cost to Maintain and Cost to Improve would fall significantly.

Impact of Alternate Baseline VMT Growth Assumptions on Average Annual Investment Requirements



Impact of Other Alternate Assumptions on the Average Annual Cost to Improve Highways and Bridges



Value of Time

The value of time in HERS was developed using a standard methodology adopted by the Department, but other values are used inside and outside the Federal government. Doubling the value of time would increase the Cost to Improve by 11.7 percent. Cutting it in half would reduce the Cost to Improve by 8.1 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 Cost to Improve by 16.1 percent. The increased cost of individual projects would be partially offset in this scenario by some projects that would no longer be cost-beneficial.

Note:
The impacts of alternative model parameters and procedures 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.

Sensitivity Analysis: Transit

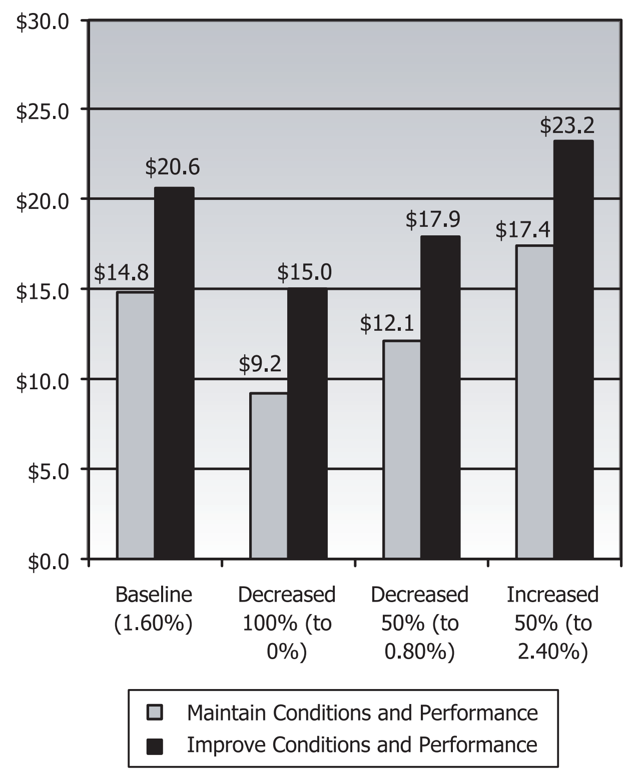
This chapter examines the sensitivity of projected transit investment requirements to variations in the values of the following exogenously determined model inputs: passenger miles traveled (PMT), capital costs, and the value of time. These alternative projections illustrate how transit requirements will vary according to different assumptions on these input values.

Sensitivity to Changes in PMT

The Transit Economic Requirements Model (TERM) relies heavily on forecasts of PMT in large urbanized areas. These forecasts are primary factors behind TERM estimates of the investment necessary to expand the Nation's transit infrastructure to maintain and improve performance. Transit PMT forecasts are generally made by MPOs along with projections of vehicle miles traveled (VMT) for the regional transportation planning process and implicitly incorporate assumptions about the relative growth of transit and automobile travel. **The average annual growth rate in PMT of 1.6 percent used in this report is a weighted average of the most recent (primarily 2001) MPO forecasts available from 33 metropolitan areas.** (PMT increased at an average annual rate of 3.2 percent between 1993 and 2000.)

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, as PMT growth rates influence asset expansion costs, which comprise a larger portion of total estimated Maintain Conditions and Performance needs. **A 50 percent increase/decrease in growth will increase/decrease the cost to Maintain Conditions by 18 to 19 percent and the cost to Improve Conditions and Performance by 13 to 14 percent.** Needs decrease significantly if PMT remains constant.

Growth on Transit Annual Investment Requirements (Billions of 2000 Dollars)



Sensitivity to a 25 Percent Increase in Capital Costs

A 25 percent increase in costs increases the amount necessary to Maintain Conditions and Performance and to Improve Conditions and Performance by close to the full 25 percent. Total benefits continue to exceed total costs for most investments even this 25 percent increase.

Sensitivity to a Change in the Value of Time

The value of time is used to estimate the total benefits 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.

Federal Bridge Program/Status of the Nation's Bridges

The Nation's Bridges

States, local agencies, and the Federal Highway Administration conduct inspections of their bridges and culverts on public roads. The National Bridge Inventory (NBI) is the official repository for information collected through the inspection program, reflecting the condition of the Nations' bridges. The data is also used as the basis for the distribution of Highway Bridge Replacement and Rehabilitation Program (HBRRP) funding among the states as well as to establish eligibility for funding for individual bridges.

Nation's Bridges

	FED	STATE	LOCAL	OTHER	TOTAL
Rural Bridges					
Interstate	30	27,417	14	42	27,503
Other Arterials	565	71,301	2,501	156	74,523
Collectors	1,306	68,559	73,113	293	143,271
Local	6,856	27,534	174,973	761	210,124
Subtotal Rural	**8,757**	**194,811**	**250,601**	**1,252**	**455,421**
Urban Bridges					
Interstate	1	27,058	368	354	27,781
Other Arterials	50	44,435	17,539	575	62,599
Collectors	22	5,000	9,690	230	14,942
Local	110	4,675	20,440	434	25,659
Subtotal Urban	**183**	**81,168**	**48,037**	**1,593**	**130,981**
Rural & Urban					
Interstate	31	54,475	382	396	55,284
Other Arterials	615	115,736	20,040	731	137,122
Collectors	1,328	73,559	82,803	523	158,213
Local	6,966	32,209	195,413	1195	235,783
Total	**8,940**	**275,979**	**298,638**	**2,845**	**586,402**

Federal Bridge Program

The National Bridge Program was established in 1971 to address safety concerns on the nation's bridges. A key element of the program is the National Bridge Inspection Program (NBIP). The inspection program is based on the National Bridge Inspection Standards (NBIS) adopted by the FHWA and the American Association of State Highway and Transportation Officials (AASHTO). Federal funding is provided through the HBRRP.

Inspection standards extend to procedures, frequency, personnel qualifications, reports, and inventories. The purpose of the inspection program is to locate and evaluate existing bridge deficiencies to assure their owners will act to keep them safe for the traveling public. Through the HBRRP, Congress has authorized more than $56 billion in federal funds for bridge replacement and rehabilitation projects.

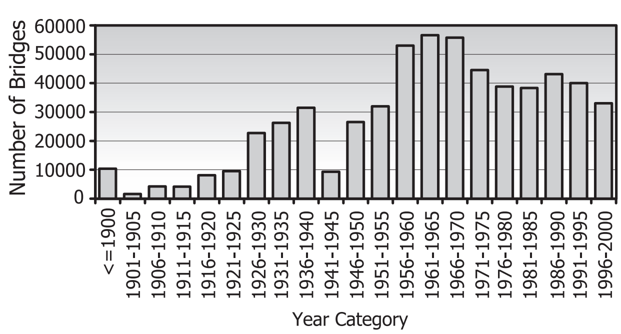
Approximately 30 percent of the structures on the Nation's highway system are either structurally or functionally deficient. This total has been decreasing over the past few years.

A structurally deficient bridge is not necessarily subject to immediate collapse, but has been identified as being restricted to lighter vehicles or is in immediate need of rehabilitation to remain open to 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.

Aging Bridges

The Nation's bridges are deteriorating with age. At the same time, the amount of traffic on them is increasing putting a greater strain on the existing system. Older structures will require increasing future maintenance to remain functional or will need to be replaced on a systematic basis to maintain the integrity of the Nation's highway system.

Year of Construction



National Security

The terrorist attacks on the United States on September 11, 2001, highlighted the need to better understand transportation security. The investment requirement projections described elsewhere in this report do not explicitly consider security-related benefits of investment in the highway and transit networks. Highways and transit, however, impact security in four important ways.

First, the Strategic Highway Network (STRAHNET) allows the Department of Defense to mobilize against global and domestic threats. STRAHNET is a 61,044-mile system of roads deemed necessary for emergency mobilization and peacetime movement. **This mileage includes the 45,376-mile Interstate Highway system and 15,668 miles of other important public highways**.

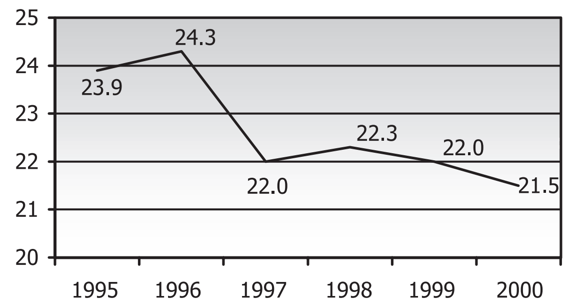
Strategic Highway Corridor Network (STRAHNET) Mileage in 2000

Interstate	45,376
Non-Interstate	15,668
Total	**61,044**

The percentage of STRAHNET pavement mileage with acceptable ride quality increased from 93.6 percent in 1995 to 96.3 percent in 2000.

Bridges are an important part of the STRAHNET. In 2000, there were 102,859 STRAHNET bridges. The percent of STRAHNET bridges rated deficient declined from 23.9 percent in 1995 to 21.5 percent in 2000.

Percent of STRAHNET Bridges Rated Deficient



Second, highways and transit systems also allow Federal, State, and local officials to respond to emergencies by evacuating populated areas. Highways need excess capacity to accommodate a sudden flow of vehicles in one direction, and to simultaneously allow the quick movement of emergency vehicles in the opposite direction. Transit systems need capacity to deal with the rapid evacuation of metropolitan areas.

Another element of transportation security is the need to improve the integrity of trucks and containers. The Department of Transportation is working with other agencies to create a system to track containers and identify the custodians of the cargo during transportation.

Finally, highways and transit systems are themselves strategic assets. Disruptions can paralyze regional or national economies, making it important to "harden" these structures against threats. The Department of Transportation is working with other agencies to better monitor the critical components of transit systems and better understand how to "harden" sensitive structures like bridges and tunnels.

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Highway Transportation in Society

On average, each man, woman, and child in this country spends an hour a day traveling in cars and buses or walking. The 100 million U.S. households generate more than a billion person trips and over nine billion person-miles of travel in a typical day. Together, increasing demand for transportation, growing affluence of travelers, and rising values of goods being shipped have placed a premium on fast, reliable transportation. The highway transportation system serves households and businesses in a variety of ways.

Commuting

Approximately 123 million people in the United States commuted to work outside the home in 2000.

Trucking

The logistical needs of business establishments are met by about 21 million trucks traveling more than 412 billion miles.

Household Expenditures

Highway transportation meets many household needs, and represents a major household expense. Households spent, on average, $7,000 per year on transportation, more than any other expenditure category except housing.

Travel Demand

Since 1969, the population of the United States has increased by 32 percent while person-miles of travel increased by 143 percent. The number of U.S. households grew by 58 percent over the same period, while the rate of household vehicle travel grew nearly three times as fast—163 percent.

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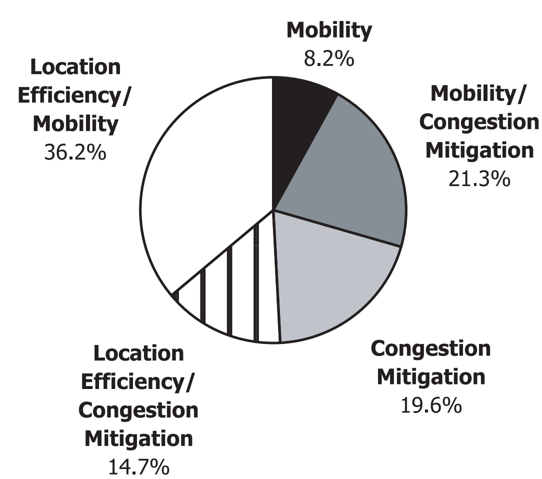
The Importance of Public Transportation

Through the Transit Performance Monitoring System (TPMS), FTA collected data between 1996 and 1998 from onboard passenger surveys of auto ownership, frequency of transit use, and transit trip purpose to gain a better understanding of user characteristics and differences across geographic regions and cities of varying sizes.

Forty-nine percent of rail users and 68 percent of all users surveyed did not have access to a car at the time they made their trip. Slightly more than 70 percent of all the transit trips in the surveys were made by passengers using transit 5 days or more a week. Fifty percent of all passengers surveyed were on their way to or from work. The most frequently reported way of reaching transit was by walking, with about 70 percent of all those surveyed starting their transit trip in this way.

The following pie chart shows the composition of mobility, congestion mitigation, and location efficiency benefits provided by transit to transit riders. In many cases, trips provide more than one type of benefit. Transit also provides significant environmental and other benefits which onboard passenger surveys are unable to capture.

Benefits of Transit to Riders



Macroeconomic Benefits of Highway Investment

The economic benefits of transportation infrastructure investment have traditionally been measured at the level of individual projects. In recent years, however, there has been growing interest in measuring the overall contribution to the economy made by many separate investments in highways and other transportation infrastructure.

Traditional microeconomic benefit-cost analysis tools such as HERS focus on reductions in costs of travel time, vehicle operations, maintenance, and crashes. Macroeconomic measures of highway investment benefits for the production sector capture the total savings in firms' production and distribution costs that result directly from an increased supply of highway capital. They may also capture indirect improvements in the productivity of labor and other capital.

These micro- and macroeconomic measures of transportation investment benefits may each include benefits not captured by the other approach, and thus have their own strengths and weaknesses. For example, macroeconomic measures reflect market outcomes at the regional or national level, while microeconomic approaches may include valuations of benefits that do not result from market activity. However, macroeconomic measures may also capture benefits such as logistic cost savings and increased competition through market area expansion that are not reflected in microeconomic models.

FHWA has been a major sponsor of recent research on macroeconomic approaches to measuring highway investment benefits. These studies have found that the economic returns on highway capital investment were very high in the 1960s, but had declined to the average rate of return on private capital by the 1980s.

Pricing

Some of the congestion problems facing America's road network can be traced to imbalances between highway travel demand and supply, due to the "underpricing" of highway use. Road pricing can be a key long-term strategy for managing the Nation's transportation system more effectively and enhancing economic efficiency by improving the allocation of costs among users. FHWA's Value Pricing Pilot Program and its predecessor—the Congestion Pricing Pilot Program—have funded pilot projects to demonstrate the potential of this strategy.

Some types of road pricing projects that have been implemented in the U.S. over the past few years include variable tolls on existing toll facilities, variable tolls on added highway lanes, and the conversion of high-occupancy vehicle (HOV) lanes to high-occupancy/ toll (HOT) lanes. A key feature of such projects is that the prices charged to highway users vary by the time of day, reflecting the greater costs that motorists impose on the highway system during congested periods. These projects have been found to be effective in encouraging shifts in driver behavior (such as moving trips to off-peak hours) and making more efficient use of highway capacity. They also provide an option for premium service for users who may be particularly pressed for time due to business or personal commitments.

Other pricing concepts have been proposed and may be implemented in the future. These include fast and intertwined regular (FAIR) lanes, mileage-based pricing, and parking cash-out.

A recent study examining the effects of different value pricing policies on a hypothetical congested freeway found that the net benefits of such policies might greatly exceed their costs of implementation.

Asset Management

A new initiative in the transportation community, Transportation Asset Management (TAM), provides a framework for the optimal allocation of resources by transportation agencies. TAM is a strategic approach to managing and investing in transportation infrastructure. When implemented, it will dramatically change the fundamentals of investment decisions.

The breakthrough of TAM arises from the fact that the expenditure of funds will (1) be based on trade-off analysis where alternatives are considered across functions, asset classes, and even modes; (2) be driven by customer requirements as reflected in performance goals; (3) include economic as well as engineering considerations; (4) incorporate an extended time horizon; and (5) be systematic and fact-based.

At its core, TAM will lead to the highest possible total return on investment, eventually reducing the gap between what the Nation needs to spend on its transportation assets and what it actually spends. When fully implemented, TAM has the potential to reduce the total life cycle costs of providing transportation services, and to improve safety, system reliability, pavement smoothness, and financial performance.

FHWA has identified four overarching themes: (1) ensuring the availability of necessary data and information; (2) developing innovative analytical tools and techniques, business processes and practices; (3) teaching, training, and bringing awareness to the people that will influence final investment decisions, and (4) providing assistance in deploying the tools, techniques, and processes.

Travel Model Improvement Program

Among the most important inputs used by State and local governments in transportation planning are forecasts of future travel demand. To assist transportation planners with this important function, the Department of Transportation—in conjunction with the Environmental Protection Agency—has established the Travel Model Improvement Program (TMIP).

The TMIP consists of four primary components:

Outreach. This includes training, direct technical assistance, and building a community of practice among modelers to facilitate mutual support in the modeling process.

Near Term Improvements. This program aims to improve the capabilities of existing forecasting procedures, including models of trip generation and trip distribution, mode choice, and assignment procedures.

Long Term Improvements. The TMIP looks to redesign the travel forecasting process through development and deployment of the Transportation Analysis and Simulation System (TRANSIMS). This model uses state-of-the-art microsimulation technology to simulate both the movements of individuals and vehicles and the activities of households.

Freight Forecasting, Data Collection, and Land Use Modeling. The TMIP has special efforts devoted to improving the understanding of freight movement and freight forecasting procedures, the quality of travel data collection, and the impacts of transportation improvements on regional land use patterns.

Air Quality

While the Clean Air Act has controlled pollutant emissions from all air pollution sources, the greatest success can be found in the control of on-road mobile sources. **Emissions reductions from motor vehicles have accounted for 84 percent of the total emissions reductions of the six criteria pollutants since 1970.**

Air pollutant levels nationally have improved considerably, and although some areas have shown increases, concentration levels in most urban areas, where problems have historically been the most severe, have shown marked improvement in response to stringent controls.

Percent Decrease in Concentration of Criteria Pollutants [1]

POLLUTANT	1980-1999	1990-1999
Carbon Monoxide (CO)	57	36
Lead (Pb)	94	60
Nitrogen Dioxide (NO_2)	25	10
Ozone (O3)[2]	20	4
Particulate Matter (PM_{10})	[3]	18
Sulfur Dioxide (SO_2)	50	36

[1] National Air Quality and Emissions Trends Report, 1999, EPA OAQPS, Research Triangle Park, NC, March 2001. http://www.epa.gov/oar/aqtrnd99/.

[2] This ozone concentration is based on the 1-hour ozone NAAQS. In 1997, EPA promulgated a new 8-hour ozone National Ambient Air Quality Standard. However, due to legal challenges, this 8-hour standard has not yet been implemented.

[3] Concentration measurements of PM10 for 1980 are not available.

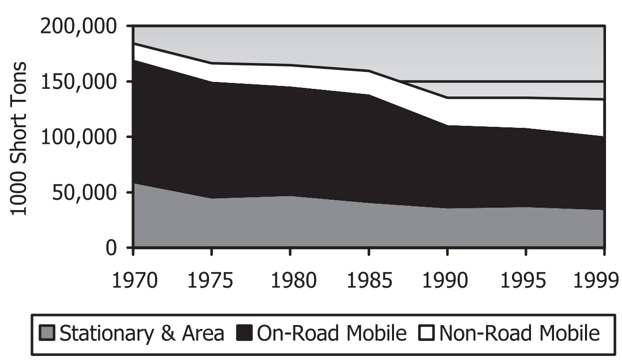
Since 1970, population has increased 38 percent; the number of people employed has increased 68 percent; the Gross Domestic Product has increased 147 percent; the number of drivers has increased 68 percent; and total vehicle miles traveled (VMT) per year have increased 142 percent. **Despite these challenges, national on-road motor vehicle emissions have declined 77 percent**.

Increasingly tight EPA engine and fuel standards for both cars and trucks have been instrumental in decreasing emissions, and will continue to do so. Emissions reductions have also been the focus of other programs, such as the Congestion Mitigation and Air Quality Improvement Program, which authorized over $8 billion in TEA-21 for transportation projects aimed at reducing emissions.

Transit vehicles account for a very small percentage of total vehicle emissions, less than one percent of the total. Transit operators, however, are still making strides in improving emissions from transit vehicles through the introduction of clean-burning, more fuel-efficient buses. **Since 1992, the share of alternative fuel buses in the transit fleet increased from 1.2 percent in 1992 to 7.5 percent in 2000. Alternative fuel transit buses currently operate in 39 States.**

Transit use also contributes to the reduction in air emissions from automobile and truck sources. **Public transportation produces about 90 percent less volatile organic compounds, more than 95 percent less carbon monoxide, and almost 50 percent less nitrogen oxides and carbon dioxide than private vehicles** that transport the same number of people.

Total Emissions of Carbon Monoxide, NOx, VOCs, and PM_{10}



Reducing pollutant emissions from motor vehicles has been the major factor to this trend in cleaner air, while enhancing the community and social benefits of transportation. Technological innovations, cleaner fuels, and targeted highway and transit programs have reduced emissions significantly over the past 30 years, and this trend is projected to continue well into the future.

Federal Safety Initiatives

Over the past four decades, the U.S. Department of Transportation has used several tools to reduce highway fatalities and injuries. These include regulations, grants, public education campaigns, engineering and technological research. Rather than adopting a single policy to improve safety, the Department uses many initiatives and interacts with both the public and private sectors.

The public's acceptance of safety restraint systems, for example, represents one of the great public policy success stories of the past two decades. This resulted from a two-pronged effort involving education and enforcement. The exhibit below describes the estimated number of lives saved from seat belts, air bags, and child restraint systems in 1994 and 2000.

Lives Saved by Restraint Systems

RESTRAINT TYPE	1994	2000
Seat Belts	9,206	11,889
Air Bags	276	1,584
Child Restraints	308	316

The Department distributes grants to States to reduce crashes through better responsible driving. The Department also partners with industries and public interest groups; in the 1980s and 1990s, for example, a public-private partnership helped reduce the number of alcohol-related driving fatalities.

The Department also works to improve safety through engineering and technological research. Intelligent Transportation Systems, for example, have smoothed traffic flow by warning drivers of hazardous conditions and providing technology for better incident response and enforcement.

The Federal Transit Administration (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.

The Modal Safety program requires States with fixed guideway systems to designate an independent oversight agency to oversee the safety of rail systems not regulated by the Federal Railroad Administration (FRA). Currently, 22 States and 36 systems are included in the program. FTA audits the affected States for compliance with the rule and provides technical assistance. FTA participates with FRA in developing shared track and shared corridor safety standards and the granting of waivers for shared track operations.

The bus component of the modal safety program is a *Bus Testing Program* to ensure that 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 *Modal Transit Safety Bus Program*, initiated by FTA in 1998, provides guidance in driver selection and training, vehicle maintenance, drug and alcohol abuse programs, and safety data acquisition and analysis.

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Operations Strategies

Historically, highway agencies have focused most of their attention on building and maintaining roads. Much less attention has been paid to operating the road system to provide the highest level of service possible. With increasing congestion, the expense and difficulty of building new facilities, and the need for safe and secure highways, this view has begun to change.

Many highway officials now recognize that operations strategies can make a major difference in how the highway system performs.

Operations strategies can influence the reliability, timeliness, security, and safety of highway use; this chapter primarily looks at the first two impacts.

Reliable, predictable travel times are especially important in a society where travelers put a high value on their own time and where many goods are relatively expensive and are needed in tightly scheduled manufacturing and distribution systems.

A reliable transportation system, however, is inadequate if it does not get travelers to their destinations within a reasonable time.

Traveler needs and economic efficiency are not served if highways slow consistently to a crawl. In addition to the temporary sources of capacity loss and delay, recurring congestion and poor traffic control increase travel time, adding significantly to the cost of travel and goods movement.

With more attention to operations, lives will be saved and Americans will be less vulnerable to congestion, incidents, work zones, weather, and traffic control problems.

Chapter 22 | **Executive Summary**

Freight

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

Nearly seven million businesses rely on the U.S. transportation network to conduct local business, engage in interstate commerce, and carry out international trade. At the same time, more than 100 million households rely on freight transportation to provide access to goods and services produced by businesses both here and abroad.

Although commercial vehicles account for less than 10 percent of all vehicle-miles of travel, **truck traffic is growing faster than passenger vehicle traffic and 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 likely to grow substantially if the demand for freight transportation doubles over the next 20 years, as expected by many forecasters.

More than 25,000 miles of highway will carry more than 5,000 commodity-carrying trucks per day. **Approximately one-fifth of that mileage will be significantly congested.** Congestion is particularly onerous for freight companies and manufacturers who depend on the efficient shipment of materials and finished products. Congestion represents a hidden tax to these firms, which value speed and reliability. The U.S. Department of Transportation is working with its State and local partners to reduce congestion and eliminate bottlenecks in the surface transportation system.

Chapter 23 | **Executive Summary**

Interstate System

The Interstate System is the highest-order functional system. In 2000, it included 46,675 route miles. About 71 percent of these miles were in rural areas, and 29 percent were in urban communities. Between 1993 and 2000, rural Interstate route miles grew by about 0.2 percent annually, while urban Interstate route miles grew by about 0.6 percent annually. The Interstate System included 55,679 bridges in 2000.

Travel on rural and urban Interstates grew faster between 1993 and 2000 than on any other functional system. Congestion has also increased. The percent of congested daily travel grew from 26.7 percent in 1997 to 29.1 percent in 2000. Conditions, however, have mostly improved. The percent of Interstate miles with "Acceptable" ride quality, for example, increased between 1993 and 2000.

An average highway preservation investment of $2.95 billion on rural Interstates would be sufficient to maintain average pavement condition at its current level. For urban Interstates, this number is $5.24 billion.

For rural Interstates, average user costs would be maintained at an average annual investment level of $4.65 billion. For urban Interstates, this number is between $15.7 and $16.3 billion.

Current levels of highway preservation and system expansion investment on rural Interstates are close to the levels that would be necessary to maintain conditions and performance in the future. **On urban Interstates, however, substantial increases would be required to prevent both average physical conditions and operational performance from becoming severely degraded.**

Chapter 24 | **Executive Summary**

National Highway System

The National Highway System (NHS) comprises the most important routes for trade and commerce in the U.S. It includes all Interstates and over 84 percent of other principal arterials. The NHS comprises only 4.1 percent of total road mileage in the U.S. but accounts for 44.3 percent of total VMT.

About 48.3 percent of NHS VMT is on pavement with "Good" ride quality, and 90.9 percent is on pavement with "Acceptable" ride quality versus 43.3 percent and 86.6 percent, respectively, for overall highway system. The number of NHS bridges rated deficient has decreased from 25.8 percent in 1996 to 21.5 percent in 2000 and the percentage of deck area of NHS bridges rated deficient has declined from 35.9 percent in 1996 to 30.8 percent in 2000.

Between 1997 and 2000, total daily vehicle miles of travel (DVMT) per lane-mile on the NHS increased by 7.8 percent. The rate of growth was greater in rural areas (8.9 percent) than in urban areas (6.8 percent).

An average annual investment of $47.4 billion would be sufficient to make all cost-beneficial highway improvements and eliminate the deficient bridge backlog on NHS roads. This amount is 55 percent above 2000 capital spending on the NHS.

The NHS share of the Cost to Maintain Highways and Bridges is $37.0 billion (49 percent), which is 21 percent above current funding levels. In 2000, capital spending on the NHS was $30.6 billion, or 47.3 percent of total capital outlay. The suggested NHS share of investment at the Cost to Maintain level would be larger (48.7 percent) than the current share, and would be smaller (44.4 percent) at the Cost to Improve level of expenditure.

Chapter 25 | **Executive Summary**

NHS Freight Connectors

National Highway System (NHS) freight connectors serve as critical links between the mainline NHS and major intermodal terminals. A 2000 Federal Highway Administration report to Congress on the condition and performance of intermodal connectors identified 517 freight-only terminals composed of ocean and river ports, 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 report concluded **that connectors to ports have twice the percentage of mileage with pavement deficiencies when contrasted to non-Interstate NHS routes.** 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. 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 needed pavement or lane width improvements, while 243 miles (roughly 12 percent) have adequate pavement, lane, and shoulder width.

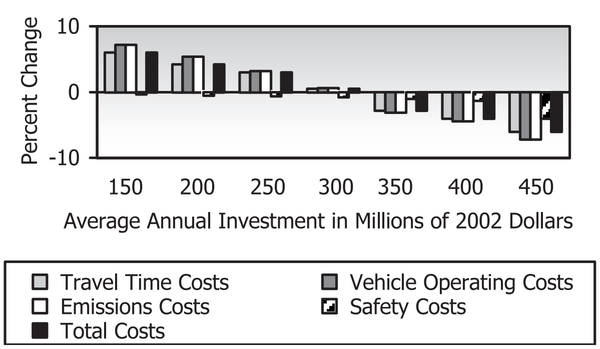
Addressing this backlog of deficiencies would cost $2.597 billion. Improving service to cope with expected increases in freight volumes would cost about $4.291 billion.

Chapter 26 | **Executive Summary**

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 spend up to $7.8 billion in lost time at grade crossings over the next 20 years.** Auto users could spend 123 million more hours delayed at crossings and truckers could log an additional 6.6 million hours behind closed gates in 2022 compared to 2002.

Projected Change In 2022 Highway User and Emissions Costs at Grade Crossings Compared To 2002 Levels For Different Possible Funding Levels



An estimated $300 million annual investment in grade separation over the next 20 years could maintain highway user costs <u>at grade crossings</u> at 2002 levels. A projected annual investment of $450 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 are also reflected in the estimates of the Cost to Maintain and Cost to Improve Highways and Bridges presented in Chapter 7.

Transit on Federal Lands

Federal lands account for approximately 29 percent of the land area of the United States, principally in the western part of the country. These lands include those owned by the National Park Service (NPS), the Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS) and the U.S. Forest Service (USFS).

Transit can serve as a cost-effective method of accommodating an increasing number of visitors to popular Federal lands while preserving the natural environment and providing visitors with a pleasant experience. Transit services have been put in place or are the process of being developed in the most heavily visited National Parks and in some smaller NPS sites without parking facilities. In Fiscal Year 2001, NPS and FHWA set aside approximately $8.4 million from the Federal Lands Highway Program (FLHP) for transit projects. USFWS offers transit services to the National Wildlife Refuge at Sanibel Island, Florida, and the Santa Anna National Wildlife Refuge, Texas. A transit system is being developed on both USFS and NPS lands to serve Grand Canyon National Park.

A 2001 study of transit needs on Federal Lands managed by the Interior Department identified significant transit needs at NPS, BLM, and USFWS sites. Total transit needs for the 20-year period (2001 to 2020) are estimated to be $1.71 billion in 1999 dollars ($17.45 billion in 2000 dollars). NPS will have the largest transit needs, estimated at just under $1,554 million, followed by USFWS with estimated needs of $126 million, and BLM with estimated needs of $30 million. (In 2000 dollars, $1,586 million, $129 million and $31 million, respectively.)

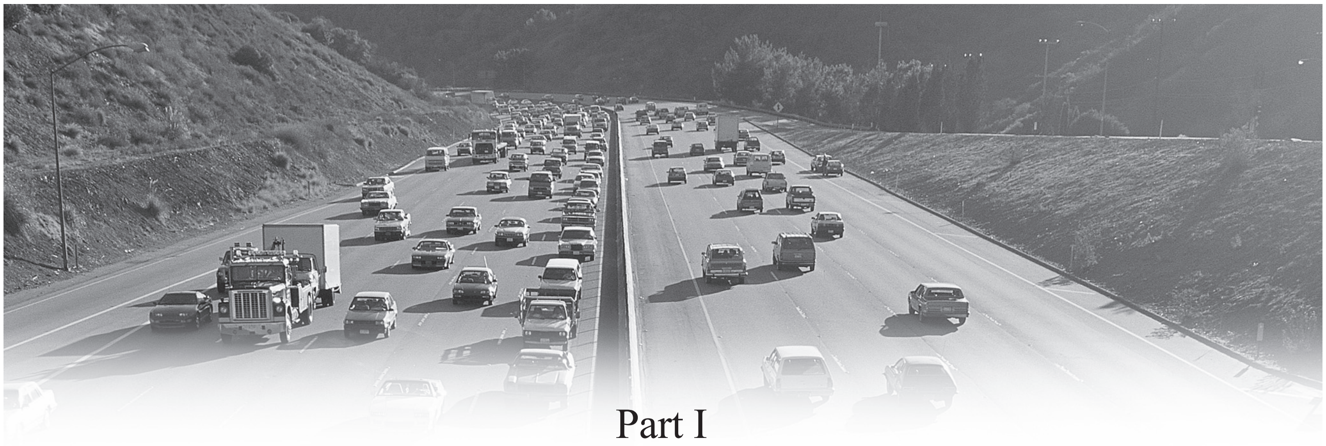
Investment Requirements Methodology

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 addition of incident delay to the calculations of congestion levels; updating the routines for estimating vehicle emissions costs; and refinements to procedures incorporating travel demand elasticity in the model.

The **National Bridge Investment Analysis System (NBIAS)** is used for the first time in this report as 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.

Appendix C presents the **Transit Economic Requirements Model (TERM)**, used to estimate transit investment requirements in urbanized areas. TERM estimates 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. The results in this report reflect revisions in estimated depreciation schedules for rail vehicles, facilities and stations.



Part I

Description of Current System

Introduction

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

- Chapter 1, **The Role of Highways and Transit**, provides a broad overview of the functions served by the Nation's highways and transit systems. The basic concepts introduced here are expanded upon in other chapters of the report.

- Chapter 2, **System and Use 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 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 Nation's urban transportation systems have enabled the growth of America's cities, linking workers with employers, wholesalers with retailers, markets with buyers, and residents with recreational and cultural facilities. The intercity transportation system helps 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 destinations.

These transportation functions are served by a wide variety of modes. Airways and airports provide rapid, long-distance transportation services for travelers, mail, and freight. 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, improvements in vehicle technology, including steamships, locomotives, automobiles, and airplanes, have greatly expanded both the speed and flexibility of transportation movements, allowing economic activity to concentrate in cities and spread across the country. Harnessing the potential of these technologies has required large investments in guideways and facilities, including ports and canals, railroads and terminals, highways and bridges, and airports and airways. The development of these facilities has also been greatly aided by advancements in bridge, tunnel, pavement, building, and communications technologies.

The Federal government has played a key role throughout the country's history in shaping the transportation system, both in regulating interstate commerce and in funding and facilitating transportation improvements. Examples of the latter include the construction of the National Road in the early 19th Century; the Pacific Railroad Act of 1862; inland waterways built by the Army Corps of Engineers; the Federal-Aid Highway Program and the Interstate Highway System of the 20th Century; and Federal assistance for mass transit operators beginning in the 1960's.

This report focuses on the infrastructure quality and operating characteristics of two key surface transportation modes: highways (and their component bridges) and mass transit (including buses and urban rail). These two modes are closely linked in their function, funding, and program administration. Highways and transit both play a key role in providing mobility in urban and rural areas. Most Federal funding for highways and transit is drawn from the Highway Trust Fund. The Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) manage the Federal role in highway and transit infrastructure, respectively. These two agencies work closely with each other and other Federal, State, and local agencies to ensure that the vast public investment in transportation is maintained and that future transportation needs can be met in accordance with national policy goals.

The Role of Highway Transportation

Highways form the backbone of America's transportation system, connecting all regions and States to one another. This extensive highway network is nearly ubiquitous in its reach across America. For example, a survey conducted in 1996 for a U.S. automobile magazine found that no point in the 48 contiguous states is greater than 30 miles from a paved highway or dwelling. Moving people and goods across this network is critical to meeting the everyday needs of our Nation's people.

America's highways are striking in their versatility, having been engineered to allow for a wide array of users and vehicles simultaneously. A given stretch of urban interstate freeway might be shared by large commercial trucks and vacationers passing through the area; local workers commuting to jobs in buses, carpools, and private autos; residents running errands or shopping; delivery trucks bringing merchandise to shops or homes; and business people and contractors driving from one customer to another.

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 by private firms, and to mass transit, which is generally provided by public agencies, either directly or through contracted private operators. Understanding this dual nature of highway travel is important in understanding how public policy affects the efficient use of the highway network.

Another key feature of highways, experienced by millions each day, is that they are subject to congestion. High traffic volumes relative to highway capacity (experienced especially during peak travel periods) can lead to reduced travel speeds and stop-and-go traffic, even on freeways (which have controlled access and no traffic signals). Crashes and adverse weather conditions can also temporarily and unpredictably reduce capacity, causing additional travel delay. While these congested periods are generally associated with morning and evening weekday commuting flows, they may also coincide with weekend shopping, recreational travel, and traffic incidents.

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, leading to the high rates of automobile ownership and use found in the United States.

Freight Movement. Highways are a key conduit for freight movement in the United States, accounting for 54 percent of total freight transport by weight (and 83 percent by value) in 1998. Highways can be used for hauls of virtually any length, from coast-to-coast shipments to short mail and parcel delivery trips. While technological and legal limits on truck size make other modes (such as railroads and barges) more suitable for long-distance movements of bulk commodities, highways are important for drayage movements between terminal facilities (such as ports and railheads).

The Role of Public Transportation

Public transportation plays a vital role in enhancing the productivity and the quality of life in the United States. It promotes access to employment, community resources, medical care, and entertainment in communities across America. Both those who choose to ride, and those who have no other choice benefit from its presence. By reducing congestion, air pollution, and travel times, it even benefits those who choose not to ride.

Transit provides the following major benefits to passengers, communities and the Nation:

Access, Choice and Opportunity. Whether to reduce travel time, ease the stress of a daily commute, or contribute to a healthier environment, more and more Americans are choosing to ride transit. For some Americans, there is no choice; over 90 percent of public assistance recipients do not own a car and must rely on public transportation for access to community resources and job opportunities. Public transit serves provides a basic mobility service to these persons and to all others without access to a car.

Economic Growth and Development. Transit spurs private sector development, generates business activity, creates jobs, boosts property values and tax earnings, and connects employers and workers. Effective transit policies within a broader community development plan can also help to mitigate suburban sprawl that may accompany unmanaged growth. Communities with good public transit systems are economically thriving communities and offer location advantages to businesses and individuals choosing to work or live in them.

Safe and Healthy Communities. Public transportation helps communities and the Nation to protect the environment, conserve energy, and ensure the safety and security of our citizens. In addition to contributing to a reduction in road congestion, each additional transit trip reduces automotive emissions and contributes to meeting local air quality goals. Our public transportation agencies are also contributing to a cleaner environment through the use of more clean-burning compressed natural gas (CNG) and other alternatively fueled buses. High occupancy transit vehicles move more people at lower energy cost, and public transportation is leading the effort in testing new, energy-efficient hybrid electric technologies. Public transportation provides emergency transportation to help cope with natural disasters or terrorist incidents. To the degree that public transportation facilities provide a locus for public activities, they provide a sense of community and thus enhance neighborhood safety and security.

Balanced Transportation: The Complementary Roles of Highways and Transit

Highways and transit serve distinct but overlapping markets in our national transportation system, which complement each other in many ways. 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.

Highway and transit investments can expand the travel choices available to people. By providing alternative means of reaching a destination, highways and transit allow individuals to choose the travel path which best meets their needs and desires. A high-quality transit system allows people desiring to live in a dense, urban environment to do so without sacrificing their mobility, while an adequate highway network can do the same for people who desire a more suburban lifestyle. A high-quality highway network benefits shippers by allowing them to choose the mode which best meets their needs for transporting their products. Highways also provide a principal means of intercity travel for people.

Transit modes such as buses, vanpools, and demand response services share roadways with private autos and are affected by highway pavement and traffic conditions. Highway investment can thus benefit both transit operations and auto users. Conversely, transit improvements may draw current auto users to that mode, thereby reducing highway congestion or freeing up capacity for other users who are deterred by existing traffic conditions. A high quality transit system can also increase the effectiveness of highways by encouraging and supporting carpooling. Reliable transit service can serve as a backup mode for riders in both formal and informal arrangements at times when carpools don't adequately serve their travel needs, thus making carpooling more attractive and contributing indirectly to the efficient use of existing road capacity.

Highway investments can also encourage transit usage and improve operating efficiency. Since 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, adequate highway access may promote the use of mass transit by encouraging economic development near transit stations. Good highway access to transit stations in outlying areas, coupled with sufficient parking capacity, can also broaden the appeal of transit to those who would find it difficult to complete their trips using only transit.

Chapter 2

System and Use Characteristics

Summary

Exhibit 2-1 summarizes the key findings in this chapter, comparing system and use characteristics data in this report with the 1997 values shown in the 1999 Conditions and Performance Report. Some of the 1997 values have subsequently been revised, and this is reflected in the second column as appropriate. The third column contains comparable values based on 2000 data.

Exhibit 2-1

Comparison of System and Use Characteristics with Those in the 1999 C&P Report

	1997 DATA		2000 DATA
STATISTIC	**1999 REPORT**	**REVISED**	
Percentage of Total Highway Miles Owned by Local Governments	75.3%	76.2%	77.4%
Percentage of Total Highway Miles Owned by State Governments	20.3%	19.5%	19.6%
Percentage of Total Highway Miles Owned by the Federal Government	4.3%		3.0%
Local Transit Operators in Urbanized Areas	542	565	614
Rural and Specialized Transit Service Providers	4,920		4,888
Total Rural Highway Miles (population under 5,000)	3.11 million		3.09 million
Total Urban Highway Miles (population equal or above 5,000)	0.84 million		0.86 million
Total Highway Miles	3.95 million		3.95 million
Transit Route Miles (Rail)	8,602		9,221
Transit Route Miles (Non-Rail)	156,733		163,303
Total Transit Route Miles	165,335		172,524
Total Rural Highway Lane Miles (population under 5,000)	6.37 million	6.38 million	6.32 million
Total Urban Highway Lane Miles (population equal or above 5,000)	1.89 million		1.93 million
Total Highway Lane Miles	8.26 million	8.27 million	8.25 million
Urban Transit Capacity-Equivalent Miles (Rail)	1.72 billion		1.87 billion
Urban Transit Capacity-Equivalent Miles (Non-Rail)	1.72 billion		1.90 billion
Urban Transit Capacity-Equivalent Miles (Total)	3.44 billion		3.77 billion
Vehicle Miles Traveled on Rural Highways (population under 5,000)	1.00 trillion		1.09 trillion
Vehicle Miles Traveled on Urban Highways (population equal or above 5,000)	1.56 trillion		1.67 trillion
Vehicle Miles Traveled on All Highways	2.56 trillion		2.68 trillion
Transit Passenger Miles (Rail)	21.14 billion		24.60 billion
Transit Passenger Miles (Non-Rail)	19.04 billion		20.50 billion
Transit Passenger Miles (Total)	40.18 billion		45.10 billion

There were over 3.95 million miles of public roads in the United States in 2000, of which 3.09 million miles were in rural communities (rural communities are defined as those places with fewer 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 2000; States controlled about 20 percent; and the Federal Government owned about 3 percent. Hence, the Nation's highway system is overwhelmingly *rural* and *local.*

In 2000, there were 172,524 transit route miles, of which 163,303 miles were non-rail. Both rail and non-rail systems have experienced growth over the past decade. The number of public transit operators in urbanized areas increased by 8.6 percent from 565 in 1997 to 614 in 2000. The number of rural and specialized transit providers decreased by 0.7 percent from 4,920 to 4,888 over this same period.

Total highway lane-mileage was 8.25 million in 2000. Lane-miles have grown at an average annual rate of about 0.2 percent since 1993, mostly in urban areas. Urban lane-mileage grew to more than 1.9 million by 2000, while rural lane-mileage shrank to 6.3 million. This shift is largely due to growth in metropolitan areas and the reclassification of some rural routes as urban.

Transit capacity-equivalent miles report the distance traveled by a transit vehicles in passenger-carrying revenue service as measured by vehicle revenue miles adjusted for the carrying capacity of each type of transit vehicle. Total urban transit-capacity equivalent mileage increased from 3.44 billion miles in 1997 to 3.77 billion miles in 2000, including 1.87 billion for rail and 1.90 billion for non-rail, following a 1990s trend of an almost even split between rail and non-rail modes.

The number of vehicle-miles traveled (VMT) between 1993 and 2000 grew by an average of 2.7 percent annually. About 1.1 trillion vehicle-miles traveled were on rural highways, and about 1.7 trillion were on urban roads. Traffic has increased in metropolitan areas, but it has also grown in rural communities where there is increased truck traffic and visits by tourists to recreation centers.

Urban transit passenger miles grew at an average annual rate of 2.1 percent between 1991 and 2000. Passenger mile growth on rail modes was considerably faster than on non-rail, increasing from 18.5 billion passenger miles in 1991 to 24.6 billion passenger miles in 2000, a 3.2 percent average annual increase. Non-rail passenger miles climbed from 18.9 billion in 1991 to 20.5 billion in 2000, an average annual increase of 0.9 percent.

Highway and Bridge System and Use Characteristics

System Characteristics

Highways and bridges are typically classified by either *ownership* or *purpose*, a distinction used in previous editions of the Conditions and Performance Report. Ownership can be determined by which jurisdiction has primary responsibility over a particular structure, while purpose and level of service are identified by the structure's function. This chapter presents highway miles by jurisdiction and system and use characteristics by functional classification. It also adds a new dimension by examining the deployment of Intelligent Transportation Systems on highways and bridges.

Highways and Bridges by Ownership

Ownership is largely split among the Federal, State, and local governments. Roads and bridges owned by these governments are considered "public," while structures owned privately are commonly considered "nonpublic."

States own almost 20 percent of the Nation's road system. The Federal Government has control over about 3 percent of the network, primarily in National parks and forests and on Indian reservations.

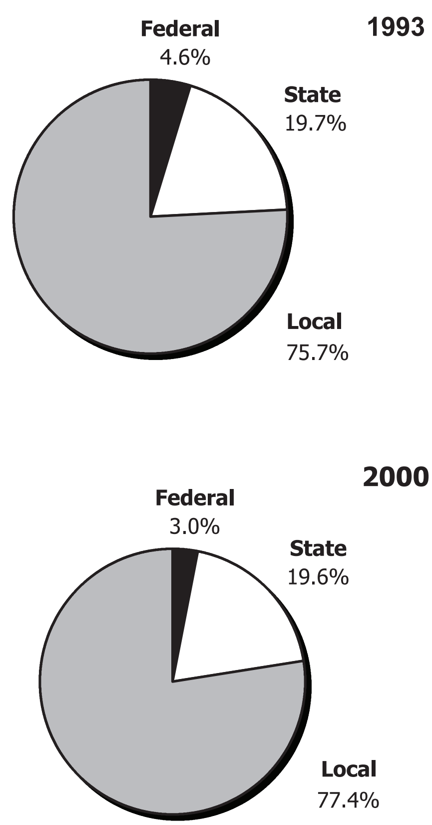
Over 77 percent of American roads are locally owned, although some intergovernmental agreements may authorize States to construct and maintain locally-owned highways. About 1,050 counties in the United States have at least 1 mile of public roads owned by the Federal Government. Most of these counties 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 steadily over the past decade. The share of local public road mileage increased from 75.7 to 77.4 percent between 1993 and 2000. During that same period, the share of State-owned public road mileage declined slightly, from 19.7 to 19.6 percent.

The most dramatic change has been the decline in Federally-owned public road mileage. Between 1993 and 2000, the share of Federal road mileage plummeted from 4.6 to 3.0 percent. This is not a new trend. Federal road mileage reached a peak in 1984, when 7 percent of all public roads were

Exhibit 2-2

Highway Mileage by Owner, 1993 and 2000



Source: Highway Performance Monitoring System.

owned by the Federal Government, and has steadily decreased over the past two decades. Much of the change has occurred as Federal land management agencies reclassified some of their mileage from public to non-public status.

Another trend is the increase in urban highway mileage. This is described in Exhibit 2-3, which shows that mileage in small urban areas grew by an average annual rate of 1 percent between 1993 and 2000. In larger urbanized areas with at least 50,000 residents, the growth rate was slightly smaller.

Exhibit 2-3

Highway Mileage by Owner and by Size of Area, Selected Years 1993-2000

	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural Areas (under 5,000 in population)						
Federal	179,603	170,574	167,369	116,869	116,725	-6.0%
State	660,241	660,667	661,473	662,590	663,755	0.1%
Local	2,257,005	2,259,064	2,280,042	2,297,724	2,308,843	0.3%
Subtotal Rural	**3,096,849**	**3,090,305**	**3,108,884**	**3,077,183**	**3,089,323**	**0.0%**
Small Urban Areas (5,000-49,999 in population)						
Federal	355	494	482	460	458	3.7%
State	27,160	27,442	27,455	27,490	27,596	0.2%
Local	136,537	139,825	143,847	146,468	148,094	1.2%
Subtotal Small Urban Areas	**164,052**	**167,761**	**171,784**	**174,418**	**176,148**	**1.0%**
Urbanized Areas (50,000 and over in population)						
Federal	943	983	980	1,044	1,026	1.2%
State	80,747	83,016	83,429	83,811	83,943	0.6%
Local	566,121	574,319	587,427	593,484	597,836	0.8%
Subtotal Urbanized Areas	**647,811**	**658,318**	**671,836**	**678,339**	**682,805**	**0.8%**
Total Highway Miles						
Federal	180,901	172,051	168,831	118,373	118,209	-5.9%
State	768,148	771,125	772,357	773,891	775,294	0.1%
Local	2,959,663	2,973,208	3,011,316	3,037,676	3,054,773	0.5%
Total	**3,908,712**	**3,916,384**	**3,952,504**	**3,929,940**	**3,948,276**	**0.1%**
Percent of Total Highway Miles						
Federal	4.6%	4.4%	4.3%	3.0%	3.0%	
State	19.7%	19.7%	19.5%	19.7%	19.6%	
Local	75.7%	75.9%	76.2%	77.3%	77.4%	
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	

Source: Highway Performance Monitoring System.

Q. **If a government owns a highway, is it solely responsible for that facility?**

A. Not necessarily. Some roads owned by the Federal Government are maintained by State highway agencies. Additionally, the designation of a public road as a Federal-aid highway does not alter its ownership as a State or local road—it only means that its importance has made that road eligible for Federal-aid construction and rehabilitation funds.

Exhibits 2-4 and 2-5 describe highway bridges by owner. Most bridges in the United States are owned by State or local governments. Approximately 50.9 percent of all highway bridges are owned by counties and municipalities. A slightly smaller amount of all highway bridges, about 47.2 percent, are owned by State agencies. Only 1.4 percent of all bridges are owned by Federal agencies, mostly within the Department of the Interior, and 0.5 percent are owned privately or by other entities.

Exhibit 2-4

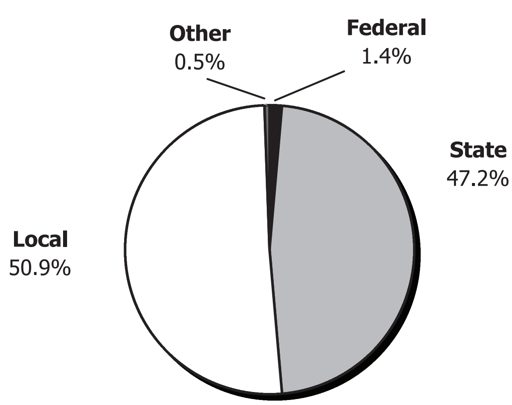
Bridges by Owner, 1996, 1998, and 2000

	NUMBER OF BRIDGES		
Owner	**1996**	**1998**	**2000**
Federal	6,171	7,448	8,221
State	273,198	273,897	277,106
Local	299,078	298,222	298,889
Private	2,378	2,278	2,299
Unknown/Unclassified	1,037	1,131	415
	581,862	**582,976**	**586,930**

Source: National Bridge Inventory.

Exhibit 2-5

Highway Bridges by Owner, 2000



Source: National Bridge Inventory.

Q. **How many highway bridges are owned by railroads?**

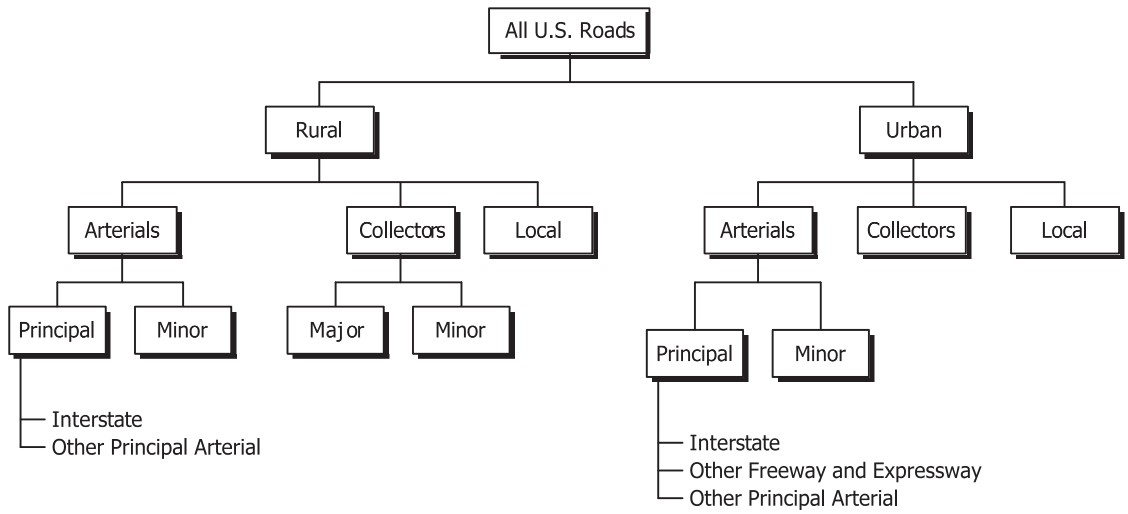
A. According to the National Bridge Inventory, private railroad companies owned 1,076 highway bridges in 2000. This represents 46.8 percent of all privately-owned highway bridges in the United States.

Highways and Bridges by Purpose

Another way to classify roads is by purpose, which is commonly measured by functional classification. The HFCS is the basic organization used for most of this report. Exhibit 2-6 describes the hierarchy of the HFCS.

Exhibit 2-6

Highway Functional Classification Hierarchy



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 urban areas with more than 50,000 people, and most urban areas with more than 25,000 people, are connected by rural principal arterial highways. These are typically interrupted only because of unusual geographic or traffic conditions (for example, connections to international borders, coastal cities, waterports, and airports). The rural principal arterial network is divided into two subsystems, Interstate highways and other principal arterials.

In 2000, the rural principal arterial system accounted for about 3.3 percent of total miles in the United States. This small portion of highways carried 47.0 percent of rural travel and 18.8 percent of total travel in the United States. The other element of the rural arterial system, minor arterials, represented 3.5 percent of total U.S. miles. Minor arterials carried 15.7 percent of rural travel and 6.2 percent of total travel in the United States.

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 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 all rural arterials that intercept urban boundaries. In 2000, the urban principal arterial system accounted for 1.8 percent of total miles in the United States; however, this network carried 58.4 percent of urban travel and 35.5 percent of total travel in the United States.

Urban minor arterial roads provide service for trips of moderate length and at a lower level of mobility. They connect with urban principal arterial roads and collector routes. In 2000, the urban minor arterial network represented 2.3 percent of total U.S. mileage. This system carried 19.3 percent of urban travel and 11.7 percent of total travel in the United States.

Collectors provide a lower degree of mobility than arterials. They are designed for travel at lower speeds and for shorter distances. For the most part, collectors are two-lane roads that collect and distribute travel from 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 major collectors accounted for 11 percent of total U.S. miles in 2000. They carried 19.2 percent of rural traffic and 7.6 percent of total travel in the United States.

Rural minor collectors are typically spaced at intervals, consistent with population density, to collect traffic from local roads and to insure that all small urban areas are served by a collector road. The rural minor collector system accounted for 6.9 percent of total U.S. mileage in 2000. These roads carried 5.3 percent of rural travel and 2.1 percent of total travel in the United States.

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. In 2000, the urban collector network accounted for 2.2 percent of U.S. road mileage. It carried 8.1 percent of urban travel and 4.9 percent of total U.S. travel.

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. In 2000, rural local roads represented 53.5 percent of total U.S. road mileage. Local roads carried only 11.1 percent of rural travel and 4.6 percent of total travel in the United States. Urban local roads, meanwhile, accounted for 15.3 percent of total U.S. road mileage, 14.1 percent of urban travel, and 8.5 percent of total U.S. travel.

Exhibit 2-7 summarizes the *percentage* of highway miles, lane miles, and vehicle-miles traveled by functional system. The share of mileage on rural highways has decreased slightly since 1997, dropping from 78.7 to 78.2 percent, a trend described earlier in Exhibit 2-3. The share of lane-miles on rural highways also decreased slightly, from 77.1 to 76.6 percent; however, the share of vehicle-miles traveled in rural areas actually grew, from 39.1 percent in 1997 to 39.4 percent in 2000.

The share of urban mileage increased slightly between 1997 and 2000, but the share of urban vehicle-miles traveled decreased during that same period. The share of urban highway mileage grew from 21.3 to 21.8 percent, and urban lane mileage increased from 22.9 to 23.4 percent. Although rural mileage is shrinking, travel continues to grow in rural areas.

Exhibit 2-7

Percentage of Highway Miles, Lane Miles, and Vehicle Miles Traveled by Functional System and by Size of Area, 2000

FUNCTIONAL SYSTEM	MILES	LANE-MILES	VEHICLE-MILES TRAVELED
Rural Areas (under 5,000 in population)			
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	11.0%	10.6%	7.6%
Minor Collector	6.9%	6.6%	2.1%
Local	53.5%	51.3%	4.6%
Subtotal Rural	**78.2%**	**76.6%**	**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	3.0%	2.9%	1.2%
Subtotal Small Urban Area	**4.5%**	**4.6%**	**6.7%**
Urbanized Areas (50,000 and over in population)			
Interstate	0.3%	0.8%	13.6%
Other Freeway and Expressway	0.2%	0.5%	6.1%
Other Principal Arterial	1.0%	1.8%	12.4%
Minor Arterial	1.8%	2.2%	10.3%
Collector	1.7%	1.8%	4.2%
Local	12.3%	11.7%	7.4%
Subtotal Urbanized Areas	**17.3%**	**18.8%**	**53.9%**
Total	**100.0%**	**100.0%**	**100.0%**

Source: Highway Performance Monitoring System.

Exhibit 2-8 offers some insight into total public road length in the United States. In 2000, there were over 3.9 million route miles in the United States. About 78.2 percent of this mileage was in rural communities, or 3.1 million route miles. The remaining 21.7 percent of route mileage, or 859,368 miles, was in urban communities. Overall route mileage increased by an average annual rate of about 0.1 percent between 1993 and 2000. Mileage decreased by 0.1 percent in rural America and increased by 1.8 percent in metropolitan communities.

Exhibit 2-8

Highway Route Miles by Functional System and by Size of Area, Selected Years 1993-2000

FUNCTIONAL SYSTEM	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural Areas (under 5,000 in population)						
Interstate	32,795	32,703	32,919	33,077	33,152	0.2%
Other Principal Arterial	97,127	98,039	98,358	98,936	99,015	0.3%
Minor Arterial	137,752	137,440	137,791	137,746	137,862	0.0%
Major Collector	432,993	432,492	433,500	433,733	433,927	0.0%
Minor Collector	282,853	274,750	273,043	272,346	272,488	-0.5%
Local	2,123,619	2,125,054	2,141,111	2,103,009	2,115,299	-0.1%
Subtotal Rural	**3,107,139**	**3,100,478**	**3,116,722**	**3,078,847**	**3,091,743**	**-0.1%**
Small Urban Areas (5,000-49,999 in population)						
Interstate	1,694	1,731	1,744	1,777	1,794	0.8%
Other Freeway and Expressway	1,261	1,282	1,253	1,226	1,219	-0.5%
Other Principal Arterial	12,570	12,432	12,477	12,470	12,473	-0.1%
Minor Arterial	19,200	19,538	19,635	19,760	19,800	0.4%
Collector	20,973	21,301	21,338	21,436	21,535	0.4%
Local	108,440	111,566	115,420	117,768	119,342	1.4%
Subtotal Small Urban Areas	**164,138**	**167,850**	**171,867**	**174,437**	**176,163**	**1.0%**
Urbanized Areas (50,000 and over in population)						
Interstate	11,313	11,569	11,651	11,709	11,729	0.5%
Other Freeway and Expressway	7,656	7,740	7,864	7,957	7,977	0.6%
Other Principal Arterial	40,434	40,622	40,993	40,973	41,084	0.2%
Minor Arterial	68,099	69,475	70,050	70,187	70,502	0.5%
Collector	64,407	66,623	67,312	67,166	67,263	0.6%
Local	456,134	462,537	474,044	480,741	484,650	0.9%
Subtotal Urbanized Areas	**648,043**	**658,566**	**671,914**	**678,733**	**683,205**	**0.8%**
Total Highway Route Miles	**3,919,320**	**3,926,894**	**3,960,503**	**3,932,017**	**3,951,111**	**0.1%**

Source: Highway Performance Monitoring System.

Exhibit 2-9 describes the number of highway lane-miles by functional system. In 2000, 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. In small urban areas with between 5,000 and 50,000 residents, for example, lane mileage grew by about 1.0 percent annually between 1993 and 2000, while rural lane mileage dropped by about 0.1 percent annually during that same period.

Exhibit 2-9

Highway Lane Miles by Functional System and by Size of Area, Selected Years 1993-2000

FUNCTIONAL SYSTEM	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural Areas (under 5,000 in population)						
Interstate	132,559	132,346	133,573	134,611	135,000	0.3%
Other Principal Arterial	240,714	245,164	248,921	252,692	253,192	0.7%
Minor Arterial	286,860	288,222	288,872	287,474	287,605	0.0%
Major Collector	873,988	872,767	875,393	872,205	872,647	0.0%
Minor Collector	565,705	549,500	546,085	544,692	544,976	-0.5%
Local	4,247,239	4,250,107	4,282,222	4,206,017	4,230,598	-0.1%
Subtotal Rural	**6,347,065**	**6,338,106**	**6,375,066**	**6,297,691**	**6,324,018**	**-0.1%**
Small Urban Areas (5,000-49,999 in population)						
Interstate	7,141	7,269	7,365	7,526	7,626	0.9%
Other Freeway and Expressway	4,741	4,828	4,747	4,656	4,627	-0.3%
Other Principal Arterial	36,768	37,135	37,618	37,654	37,702	0.4%
Minor Arterial	42,937	44,390	44,982	44,776	45,208	0.7%
Collector	43,491	43,755	44,216	43,980	44,525	0.3%
Local	216,881	223,132	230,839	235,536	238,684	1.4%
Subtotal Small Urban Areas	**351,959**	**360,509**	**369,767**	**374,128**	**378,372**	**1.0%**
Urbanized Areas (50,000 and over in population)						
Interstate	62,754	64,865	65,603	66,507	66,507	0.8%
Other Freeway and Expressway	34,864	35,705	36,655	37,113	37,113	0.9%
Other Principal Arterial	130,769	143,572	146,585	148,077	148,077	1.8%
Minor Arterial	176,130	183,595	185,273	180,434	180,434	0.3%
Collector	136,305	143,517	145,927	143,620	143,620	0.7%
Local	912,267	925,073	948,087	961,484	961,484	0.8%
Subtotal Urbanized Areas	**1,453,089**	**1,496,327**	**1,528,130**	**1,537,235**	**1,537,235**	**0.8%**
Total Highway Lane Miles	**8,152,113**	**8,194,942**	**8,272,963**	**8,209,054**	**8,254,658**	**0.2%**

Source: Highway Performance Monitoring System.

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 and the widening of existing roads, a significant percentage is attributable to functional reclassification. As rural communities have grown above 5,000 in population, their existing roads have been reclassified as small urban mileage. The same situation has occurred as small urban areas have grown above 50,000 in population; their mileage has been reclassified as urbanized. While the current data available do not facilitate quantifying the share of urban mileage growth attributable to functional reclassification, this would be a promising area for future research.

Exhibit 2-10

Bridges by Functional System, 1996, 1998, and 2000

	NUMBER OF BRIDGES		
FUNCTIONAL SYSTEM	**1996**	**1998**	**2000**
Rural			
Interstate	28,638	27,530	27,797
Other Arterial	72,970	73,324	74,796
Collector	144,246	143,140	143,357
Local	211,059	210,670	209,415
Subtotal Rural	**456,913**	**454,664**	**455,365**
Urban			
Interstate	26,596	27,480	27,882
Other Arterial	59,064	60,901	63,177
Collector	14,848	14,962	15,038
Local	24,441	24,969	25,684
Subtotal Urban	**124,949**	**128,312**	**131,781**
Total	**581,862**	**582,976**	**587,146**

Source: National Bridge Inventory.

Exhibit 2-10 describes the number of highway bridges by functional classification. Of the 587,146 highway bridges in the United States in 2000, 77.6 percent were in rural communities and 22.4 percent were in urban areas. The number of urban bridges—and those on arterial systems—grew steadily from 1996 to 2000. It is presumed that the number of urban bridges grew because of the reclassification of highways (and associated bridges) from a rural to urban designation.

Information presented on bridge composition up to this point has examined ownership and functional classification by "counting" the number of bridges. Examining structures by numbers gives all bridges in the network equal priority. Thus, a small local bridge is counted the same way as either New York's George Washington Bridge or San Francisco's Golden Gate Bridge. That is why it may be desirable to consider the size of the structure, which is done using bridge deck area.

Exhibit 2-11

Percentage of Deck Area by Functional System, 1996, 1998, and 2000

	1996	**1998**	**2000**
FUNCTIONAL SYSTEM			
Rural			
Interstate	8.8%	8.4%	8.2%
Other Arterial	15.2%	15.4%	15.7%
Collector	14.2%	13.9%	13.5%
Local	10.7%	10.7%	10.3%
Subtotal Rural	**48.9%**	**48.3%**	**47.6%**
Urban			
Interstate	19.1%	19.5%	19.4%
Other Arterial	25.4%	25.7%	26.6%
Collector	3.1%	3.0%	2.8%
Local	3.5%	3.6%	3.6%
Subtotal Urban	**51.1%**	**51.7%**	**52.4%**
Bridge Total	**100.0%**	**100.0%**	**100.0%**

Source: National Bridge Inventory.

Exhibit 2-11 shows that despite the higher percentage of bridges in rural areas, more deck area is actually in urban communities (52.4 percent). Urban bridges tend to be larger and longer than rural bridges.

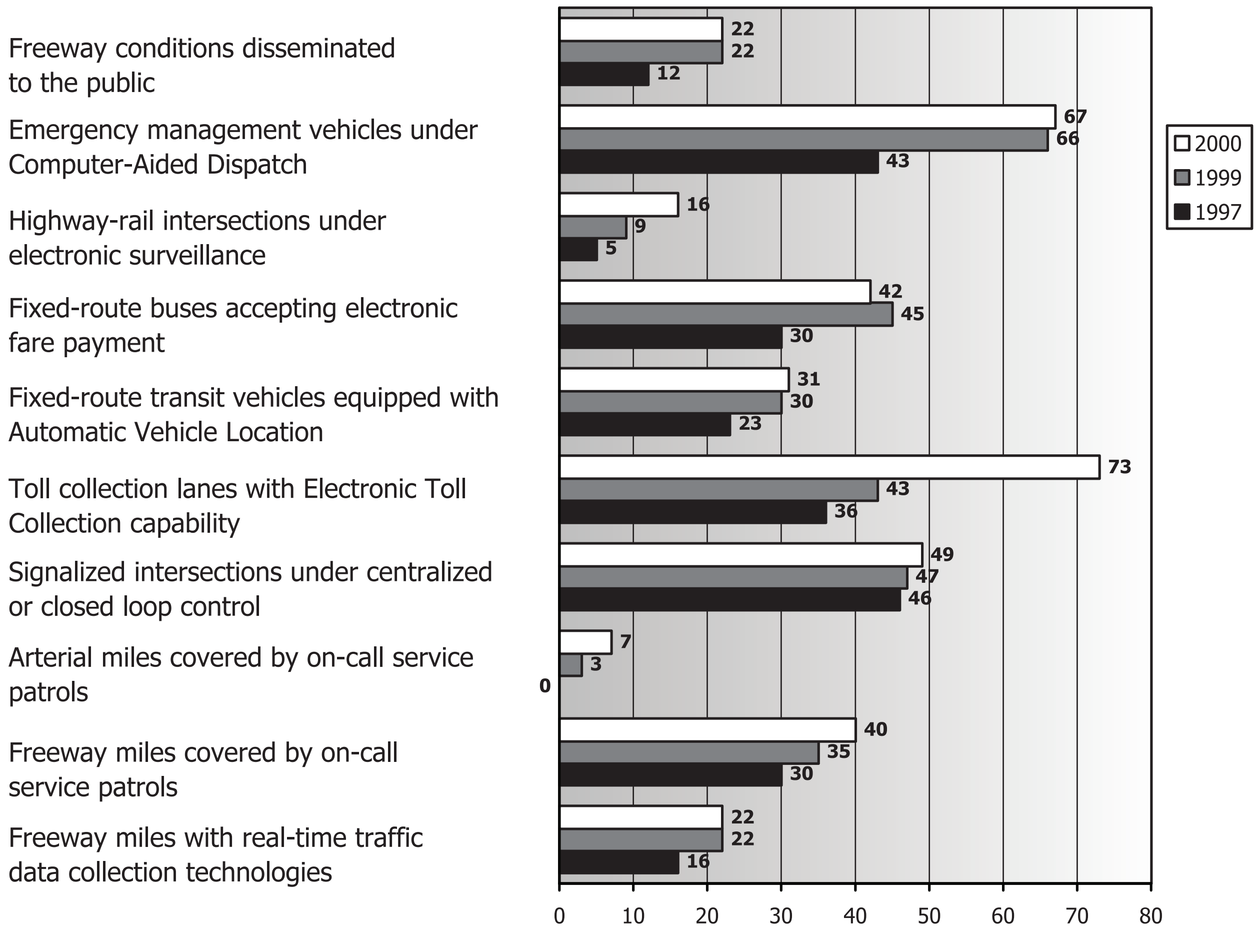
Intelligent Transportation System Characteristics

All of the previous exhibits represent a traditional look at the highway system—its mileage, ownership, functional classification, and use. This edition of the C&P report introduces a new measurement: the extent of ITS on the highway network. ITS use advanced technology to improve highway safety and efficiency. The deployment of ITS for national security, operations, and freight management is described more fully in subsequent chapters.

Exhibit 2-12 describes the deployment of ITS devices in 75 metropolitan regions, based on a survey by the FHWA Intelligent Transportation Systems Joint Program Office. More regions are using electronic tolling than any other ITS device (73 percent in 2000), followed by computer-aided emergency management vehicles (67 percent). 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 7 percent in 2000.

Exhibit 2-12

Deployment of Intelligent Transportation Systems (ITS) in 75 Metropolitan Areas, 1997, 1999, and 2000



Source: "Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the United States," July 2001.

Use Characteristics

This section describes highway infrastructure use, which is typically defined by vehicle miles traveled (VMT). During the 1990s, Americans traveled at record levels, a phenomenon prompted by the booming economy, population growth, and other socioeconomic factors. VMT grew by an average annual rate of 2.7 percent between 1993 and 2000, and by the end of that period, Americans were traveling more than 2.7 trillion vehicle miles annually. About 1.1 trillion miles were on rural highways, and about 1.7 trillion were on urban roads. Exhibit 2-13 describes these statistics.

While highway mileage is mostly rural, a majority of highway travel (61 percent) occurred in urban areas in 2000. Since 1997, however, rural travel has grown at a faster average annual rate (2.8 percent) than urban

Exhibit 2-13

Vehicle Miles (VMT) and Passenger Miles of Travel (PMT), 1993-2000 (Millions of Miles)

FUNCTIONAL SYSTEM	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural (under 5,000 in population)						
Interstate	209,470	224,705	241,451	261,485	270,314	3.7%
Other Principal Arterial	203,149	215,988	229,133	244,469	249,138	3.0%
Minor Arterial	148,023	156,253	164,129	170,149	172,780	2.2%
Major Collector	185,611	194,420	202,588	207,721	210,498	1.8%
Minor Collector	48,579	50,386	52,538	58,140	58,571	2.7%
Local	102,948	105,819	111,959	125,939	128,331	3.2%
Subtotal Rural	**897,779**	**947,571**	**1,001,798**	**1,067,904**	**1,089,632**	**2.8%**
Small Urban Area (5,000-49,999 in population)						
Interstate	16,297	17,310	18,393	20,485	21,138	3.8%
Other Freeway and Expressway	8,353	8,854	9,251	9,583	9,892	2.4%
Other Principal Arterial	51,088	53,202	55,359	57,351	58,147	1.9%
Minor Arterial	36,464	39,270	40,845	42,407	43,005	2.4%
Collector	17,282	18,710	19,749	20,135	20,412	2.4%
Local	25,919	27,970	28,309	32,907	33,277	3.6%
Subtotal Small Urban Area	**155,403**	**165,317**	**171,906**	**182,868**	**185,871**	**2.6%**
Urbanized Areas (50,000 and over in population)						
Interstate	303,324	327,329	346,376	366,390	376,153	3.1%
Other Freeway and Expressway	132,344	141,980	151,231	162,839	168,214	3.5%
Other Principal Arterial	298,558	313,676	332,448	337,904	343,088	2.0%
Minor Arterial	236,815	251,470	263,296	273,955	283,854	2.6%
Collector	96,102	104,453	111,874	113,053	116,596	2.8%
Local	175,917	179,392	176,268	203,136	203,960	2.1%
Subtotal Urbanized Areas	**1,243,060**	**1,318,300**	**1,381,495**	**1,457,278**	**1,491,864**	**2.6%**
Total Highway Vehicle Miles	**2,296,243**	**2,431,188**	**2,555,198**	**2,708,050**	**2,767,367**	**2.7%**
Total Passenger Miles Traveled	3,858,920	3,868,070	4,089,366	4,304,270	4,394,703	**1.9%**

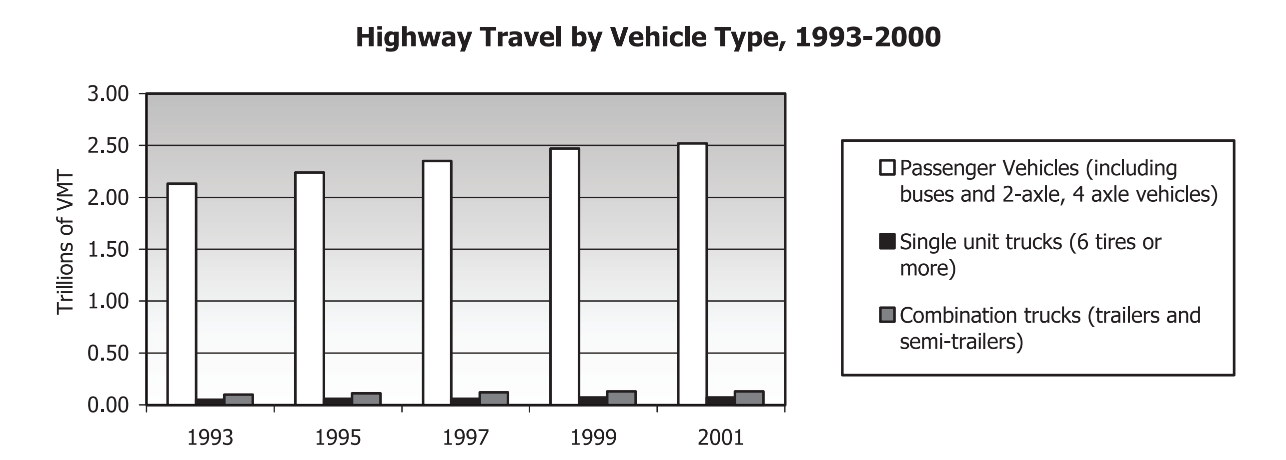
Source: Highway Performance Monitoring System.

travel (2.6 percent). This is a change since the last C&P report, when urban travel growth rates were higher over the preceding decade.

Exhibits 2-14 and 2-15 expand on the information in Exhibit 2-13. They describe 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 trucks (SU) having 6 or more tires; and combination trucks (Combo), including trailers and semi-trailers.

As Exhibits 2-14 and 2-15 show, travel grew the fastest on rural and urban interstates, particularly among combination trucks. Between 1993 and 2000, for example, combination truck traffic grew by 4.4 percent on rural interstates and 5.5 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 truck travel grew by 3.2 percent per year, and combination truck travel grew by 3.9 percent per year.

Exhibit 2-14



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

Exhibit 2-15

Highway Travel by System and Vehicle Type, 1993-2000
(Millions of VMT)

FUNCTIONAL SYSTEM VEHICLE TYPE	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural Interstate						
PV	169,500	180,031	188,969	207,046	214,175	3.4%
SU	5,982	6,708	7,667	8,073	8,260	4.7%
Combo	32,826	36,644	41,642	42,976	44,377	4.4%
Other Arterials						
PV	314,469	331,539	349,555	369,592	375,973	2.6%
SU	11,374	12,980	13,668	13,978	13,643	2.6%
Combo	23,724	24,076	25,467	26,713	28,003	2.4%
Other Rural						
PV	304,389	315,687	338,590	359,785	365,170	2.6%
SU	12,505	12,948	13,671	13,965	13,759	1.4%
Combo	11,936	12,676	12,447	12,236	12,589	0.8%
Total Rural						
PV	788,358	827,257	877,114	936,423	955,318	2.8%
SU	29,861	32,636	35,006	36,016	35,662	2.6%
Combo	68,486	73,396	79,556	81,925	84,969	3.1%
Urban Interstate						
PV	294,703	315,888	330,668	348,531	358,906	2.9%
SU	6,513	7,148	7,906	8,494	8,719	4.3%
Combo	16,183	18,492	20,641	23,792	23,472	5.5%
Other Urban						
PV	1,053,429	1,101,516	1,144,334	1,185,168	1,211,708	2.0%
SU	20,398	22,923	23,933	25,794	26,202	3.6%
Combo	18,446	23,567	24,303	26,667	26,767	5.5%
Total Urban						
PV	1,348,132	1,417,404	1,475,002	1,533,699	1,570,614	2.2%
SU	26,911	30,071	31,839	34,288	34,921	3.8%
Combo	34,629	42,059	44,944	50,459	50,239	5.5%
Total						
PV	2,136,490	2,244,661	2,352,116	2,470,122	2,525,932	2.4%
SU	56,772	62,707	66,845	70,304	70,583	3.2%
Combo	103,115	115,455	124,500	132,384	135,208	3.9%

PV=Passenger Vehicles (including buses and 2-axle, 4-tire vehicles,
SU=Single Unit Trucks (6 tires or more),
Combo=Combination Trucks (trailers and semi-trailers).

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

U.S. Transit System Characteristics

Transit Services and Jurisdiction

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 transit aid funds 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.

Before 1960, the Federal Government had not focused on transit issues. But by the end of the 1950s it was becoming clear to all levels of government that developing and sustaining public transportation services was an important national and 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.

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—Maryland, Delaware, New Jersey, Connecticut, and Rhode Island—own and operate transit services while five more States—Pennsylvania, California, Illinois, Minnesota, Texas, and Washington—have created initiatives for dedicated transit funding. This trend toward State involvement is likely to increase as a result of the planning provisions mandated by the Clean Air Act Amendment of 1990 (CAAA), the Intermodal Surface Transportation Equity Act of 1991 (ISTEA), and the Transportation Equity Act for the 21st Century (TEA-21).

As many local governments have come to understand the regional nature of transportation problems, metropolitan planning organizations have assumed more responsibility for formulating 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.

While most transit use continues to occur in major metropolitan areas, it is becoming increasingly important in small urban areas and rural areas. In 2000, there were 614 local public transit operators serving 408 both large and small urbanized areas, 1,215 operators serving rural areas, and 3,673 providers of specialized service to the elderly and disabled in both urban and rural areas.

Urban Transit Systems

The urban transit system continues to grow in the United States. In 2000, urban transit systems operated 106,395 vehicles, of which 82,545 were in urbanized areas of more than 1 million people. Rail operators controlled 10,572 miles of track and served 2,825 stations. There were also 759 maintenance facilities in urban areas for transit vehicles in use compared with 729 in 1997. Between 1997 and 2000, the number of urban transit vehicles increased by 2.6 percent, track mileage grew by 6.6 percent, the number of stations increased by 5.4 percent, and the number of urban maintenance facilities grew by 4.1 percent.
[See Exhibit 2-16].

Exhibit 2-16

Urban Mass Transit Active Fleet and Infrastructure, 2000

	URBANIZED AREAS OVER 1 MILLION	URBANIZED AREAS UNDER 1 MILLION	TOTAL
Vehicles			
Buses	45,017	20,418	65,435
Heavy Rail	10,260	0	10,260
Light Rail	1,273	65	1,338
Self-Propelled Commuter Rail	2,461	5	2,466
Commuter Rail Trailers	2,712	31	2,743
Commuter Rail Locomotives	565	11	576
Vans	10,596	5,638	16,234
Other (including Ferryboats)	5,361	1,982	7,343
Rural Service Vehicles (*)	0	19,185	19,185
Special Service Vehicles (**)	4,300	24,364	28,664
Total Active Vehicles	**82,545**	**71,699**	**154,244**
Infrastructure			
Track Mileage			
Heavy Rail	2,178	0	2,178
Commuter Rail	7,081	283	7,365
Light Rail	949	52	1,001
Other Rail	23	6	29
Total Track Mileage	**10,232**	**341**	**10,572**
Stations			
Heavy Rail	1,009	0	1,009
Commuter Rail	1,134	17	1,151
Light Rail	556	59	615
Other Rail	40	10	50
Total Transit Rail Stations	**2,739**	**86**	**2,825**
Maintenance Facilities (***)			
Heavy Rail	53	0	53
Commuter Rail	62	0	62
Light Rail	26	4	30
Ferryboat	6	1	7
Buses	272	221	493
Demand Response	44	66	110
Other Rail	3	1	4
Rural Transit (*)	0	510	510
Total Maintenance Facilities	**466**	**803**	**1,269**

(*) Status of Report on Public Transportation in Rural American 2000.

(**) FTA, Fiscal Year Trends Report on the Use of Section 5310 Elderly and Persons with Disabilities Program Funds.

(***) Includes owned and leased facilities; directly operated service only.

Source: National Transit Database (NTD.)

Coverage of Transit Systems (Urban Route Miles)

The coverage of the U.S. transit network may be analyzed by examining the historical trend of urban transit directional route miles. Directional route mileage measures the distance covered by a transit route independent of the number of vehicles that serve that route, i.e., when routes overlap, the mileage is counted separately for each route. Directional route miles are counted for vehicles traveling in a particular direction. This accounts for such transit route features as one-way loops. Routes may be along fixed guideways (as in the case of rail modes) or separated bus guideways, or may share city streets with other vehicles (as with most bus routes).

> **Q. What is the role of Ferry Boats?**
>
> **A.** Ferries in the United States operate in 43 states and territories, including Puerto Rico and the Virgin Islands. Though found most often in major metropolitan areas like Seattle and New York City, ferry operations also serve smaller urban and rural areas, often providing island communities their only surface transportation link. The Alaskan ferry system—the Alaskan Marine Highway—is the only surface transportation serving communities along Alaska's Southeast coast and along the Aleutian Island chain.

Transit directional rail route miles (route miles) increased consistently between 1991 and 2000 at an average annual rate of 3.1 percent, raising their share of total transit route miles from 4.5 to 5.3 percent. This increase reflects the "New Start" rail systems and extensions that have become operational during this period. Non-rail route miles grew at a 1.0 percent average annual rate between 1991 and 2000, but declined slightly (0.4 percent) between 1999 and 2000, primarily as a result of a decline in motor bus route miles. This decline contributed to a 0.3 percent decline in total transit route miles between 1999 and 2000, but, on average, total transit route miles grew at an average of 1.1 percent annually between 1991 and 2000. *[See Exhibit 2-17].*

Exhibit 2-17

Urban Transit Route Miles, 1991-2000

	1991	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1991
Rail	7,003	7,334	8,206	8,602	9,170	9,221	3.1%
Non-Rail	149,332	158,779	158,076	156,733	163,911	163,303	1.0%
Total	**156,335**	**166,113**	**166,282**	**165,335**	**173,081**	**172,524**	1.1%
Percent Rail	4.5%	4.4%	4.9%	5.2%	5.3%	5.3%	

Source: National Transit Database.

System Capacity

Capacity-equivalent vehicle revenue miles (VRM) is the distance traveled by a transit vehicle in passenger-carrying revenue service, adjusted by the carrying capacity of the type of transit vehicle, with the capacity of a motor bus representing the baseline. For example, if a commuter rail vehicle has a seating capacity of 2.2 times the capacity of an average motor bus, each commuter rail vehicle VRM is multiplied by 2.2 to calculate commuter rail capacity-equivalent VRMs. In 2000, transit operators supplied 3.77 billion capacity-equivalent miles of service in the United States. Of this total, slightly less than half was provided by rail modes and slightly more than half by non-rail modes. Between 1991 and 2000, capacity-equivalent VRM provided by

Exhibit 2-18

Transit Capacity
Urban Transit Capacity-Equivalent Vehicle Revenue Miles, 1991-2000
(Millions)

	1991	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1991
Rail	1,558	1,564	1,646	1,722	1,811	1,866	2.0%
Non-Rail	1,619	1,659	1,689	1,718	1,856	1,905	1.8%
Total	**3,178**	**3,223**	**3,335**	**3,440**	**3,668**	**3,771**	**1.9%**
Percent Rail	49.0%	48.5%	49.4%	50.0%	49.4%	49.5%	

Source: National Transit Database.

rail increased at an average annual rate of 2.0 percent compared with a 1.8 percent average annual increase by non-rail modes. Since 1997, however, capacity-equivalent VRM provided by non-rail modes have increased slightly more rapidly than those provided by rail, at a 3.5 percent average annual rate compared to a 2.7 percent for rail. *[See Exhibit 2-18]*.

Passenger Travel

Passenger miles traveled (PMT), or the total number of miles traveled by passengers in transit vehicles, increased at an average annual rate of 2.1 percent between 1991 and 2000. *[See Exhibit 2-19]*. Passenger travel growth on rail modes was more than three times higher than on non-rail modes (3.2 percent versus 0.9

Exhibit 2-19

Urban Transit Passenger Miles, 1991-2000
(Millions)

	1991	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1991
Rail	18,551	17,867	19,682	21,138	22,875	24,603	3.2%
Non-Rail	18,921	18,353	18,289	19,042	20,404	20,498	0.9%
Total	**37,472**	**36,220**	**37,971**	**40,180**	**43,279**	**45,100**	**2.1%**
Percent Rail	49.5%	49.3%	51.8%	52.6%	52.9%	54.6%	

Source: National Transit Database.

percent on an average annual basis). In 2000, PMT on rail was 24.6 billion and accounted for nearly 55 percent of total PMT while, as noted above, rail accounts for only 5 percent of urban transit route miles. Passenger miles traveled have grown rapidly since 1993, following a decline between 1989-93. This rapid growth was fueled principally by significant increases in rail PMT while the change in travel on non-rail modes has been erratic. This difference again reflects the recent expansion of rail transit in the United States.

Vehicle Occupancy

Vehicle occupancy is calculated as passenger miles traveled divided by capacity-equivalent VRM. This measure relates the level of transit service consumed by passengers to the level transit service provided by transit operators. In 2000, vehicle occupancy was 12.0 passengers per capacity-equivalent vehicle for all transit services, 13.2 passengers for rail modes, and 10.8 passengers for nonrail modes. Although vehicle occupancy reached a new high in 2000, it has remained relatively constant over the past decade. The high level of occupancy reached in 2000 resulted from an increase in the occupancy of rail vehicles; the number of passengers per capacity equivalent non-rail vehicle declined slightly. *[See Exhibit 2-20]*.

Exhibit 2-20

Vehicle Occupancy
Passengers per Capacity-Equivalent Transit Vehicle, 1991-2000

	1991	1993	1995	1997	1999	2000
Rail	11.9	11.4	12.0	12.3	12.6	13.2
Non-Rail	11.7	11.1	10.8	11.1	11.0	10.8
Total	**11.8**	**11.2**	**11.4**	**11.7**	**11.8**	**12.0**

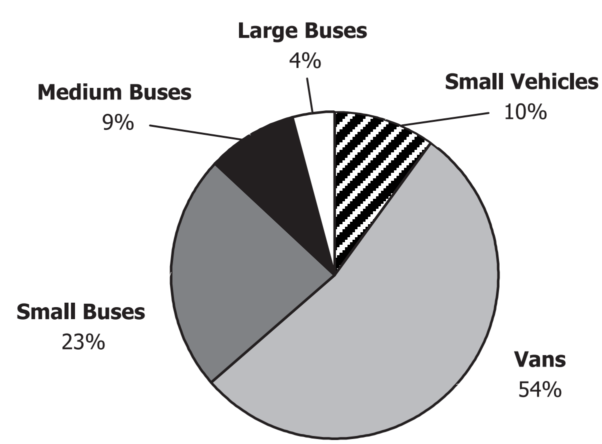
Source: National Transit Database.

Rural Transit Systems

Data on rural transit operators is available from surveys conducted by the Community Transportation Association of America and funded by the Federal Transit Administration (FTA). Rural operators are defined as those providing service outside urbanized areas or to areas with populations of less than 50,000. Two surveys were conducted in 1997 and 2000 with a total of 158 rural transit operators responding. Data collected from June 1997 to June 1999 have been combined for the purposes of this analysis. *[See Exhibit 2-21]*.

Exhibit 2-21

Fleet Composition of Rural Transit Operators, 1999



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

In 1997, there were 1,215 rural transit operators. While the number of rural transit providers remained relatively constant, fleet sizes expanded dramatically between 1994 and 1999. The 108 providers that responded 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.

The majority of rural transit operators' vehicles are small buses (16 to 24 passengers) and vans (8 to 15 passengers). According to the recent survey, vehicle fleets of rural transit operators are comprised principally of vans, which account for 54 percent of a rural fleet on average, and small buses, which account for 23 percent on average. Small vehicles (fewer than 8 passengers) accounted for an average of 10 percent of rural fleets, medium buses (25 to 35 passengers) for 9 percent and large buses (more than 35 passengers) for a mere 4 percent.

Transit System Characteristics for Americans with Disabilities and the Elderly

The Americans with Disabilities Act (ADA) is intended to ensure that persons with disabilities have access to public transportation vehicles and facilities. Since its passage in 1990, transit operators have been working towards upgrading their regular vehicles fleets to accommodate the disabled. In 2000, 74 percent of all rail vehicles and 73 percent of all non-rail vehicles were ADA compliant. Forty-seven percent of commuter rail vehicles (excluding commuter rail locomotives), 89 percent of heavy rail vehicles, and 83 percent of motor bus vehicles were ADA compliant.

In addition to the services provided by urban transit operators, there are about 3,673 private and non-profit agencies that receive FTA Section 5310 funding for the provision of "special" public transportation services to persons with disabilities and the elderly. 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. These providers operate vehicles ranging from large buses to station wagons. Vans account for approximately 75 percent of the "special service" national fleet, small buses for 13 percent, and large buses and automobiles for 12 percent.

Approximately 75 percent of the vehicles purchased in FY 2000 were wheelchair accessible, about the same as in the past few years. *[See Exhibits 2-22 and 2-23]*.

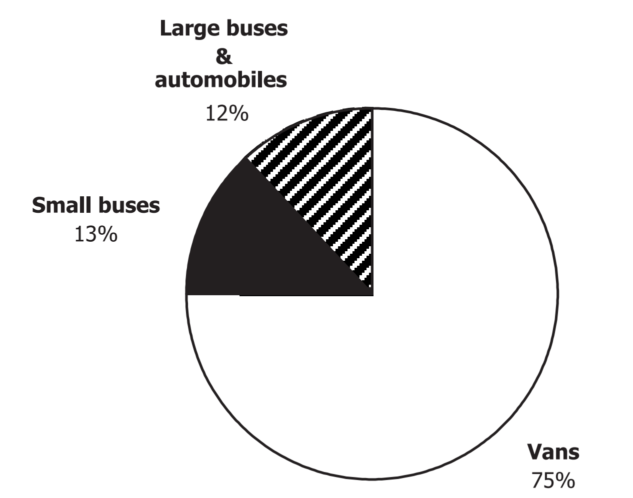
Under the ADA, FTA was given responsibility for identifying "key rail stations" and facilitating the accessibility of these stations to disabled persons.

In 2000, there were 689 key rail stations. 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

Exhibit 2-22

Composition of Special Service Vehicles, 2000



Source: FTA, Fiscal Year 2000 Trends Report on the Use of Section 5310 Elderly and Person's with Disabilities Program Fund.

rail system as a whole by at least fifteen 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 2000, 52 of 689 key rail stations were ADA accessible. By comparison, in 1994, 13 of 700 key rail stations were accessible and, in 1997, 29 were accessible of a total of 689.

Exhibit 2-23

Urban Transit Operators' ADA Vehicle Fleets, 2000

	ACTIVE VEHICLES	ADA COMPLIANT VEHICLES	ADA AS A PERCENTAGE OF ACTIVE
Rail			
Automated Guideway	49	49	100%
Commuter Rail (*)	5,209	2,468	47%
Heavy Rail	10,260	9,125	89%
Inclined Plane	8	6	75%
Light Rail	1,338	869	65%
Monorail	8	8	100%
Total Rail	**16,872**	**12,525**	**74%**
Non-Rail			
Cable Car	55	15	27%
Ferry Boat	98	79	81%
Motor Bus	65,435	54,624	83%
Trolley Bus	894	595	67%
Other	22,465	9,752	43%
Total Non-Rail	**88,947**	**65,065**	**73%**
Total	**105,819**	**77,590**	**73%**

(*) Excludes Commuter Rail Locomotives

Source: National Transit Database

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 column contains the values reported in the 1999 C&P report, based on 1997 data. Data revisions are shown in the second column. The third column provides comparable values based on 2000 data.

Exhibit 3-1

Comparison of System Conditions Statistics with Those in the 1999 Report

HIGHWAY

STATISTIC	CONDITION	1997 DATA 1999 REPORT	1997 DATA REVISED	2000 DATA
Total System Pavement	Good	n/a	43.2%	43.5%
	Acceptable	n/a	**86.6%**	**86.0%**
Rural Interstate Pavement	Good	n/a	56.9%	68.5%
	Acceptable	n/a	**97.6%**	**97.8%**
Small Urban Intestate Pavement	Good	n/a	51.4%	61.6%
	Acceptable	n/a	**95.8%**	**95.8%**
Urbanized Interstate Pavement	Good	n/a	39.3%	48.2%
	Acceptable	n/a	**90.0%**	**93.0%**
National Highway System Pavement	Good	n/a	46.1%	54.6%
	Acceptable	n/a	**91.8%**	**93.5%**

BRIDGE

STATISTIC	1998 DATA 1999 REPORT	1998 DATA REVISED	2000 DATA
Deficient Bridges	172,572	n/a	167,566
Deficient Bridges On Interstates	55,010	n/a	55,679
Deficient Bridges On Other Arterials	134,225	n/a	137,973

TRANSIT

STATISTIC		1998 DATA 1999 REPORT	1998 DATA REVISED	2000 DATA
Average Urban Bus Vehicle Condition *		3.1	2.96 **	3.07
Average Rail Vehicle Condition*		4.0	3.61***	3.55
Urban Bus Maintenance Facilities	Excellent	3%		9%
	Good	17%		8%
	Adequate	57%		54%
Rail Maintenance Facilities	Excellent	7%		0%
	Good	53%		21%
	Adequate	17%		43%
Rail Maintenance Yards	Excellent	0%		0%
	Good	63%		50%
	Adequate	37%		50%
Rail Stations	Excellent	11%		1%
	Good	46%		33%
	Adequate	15%		50%
Rail Track	Excellent	24%		26%
	Good	49%		45%
	Adequate	10%		12%

* Average Condition. Condtions are rated on ranking of 1 (poor) to 5 (excellent).
** Revised based on an improved methodology of applying data from the National Transit Database to estimated decay curves.
*** Revised based on new surveys of rail vehicle physical conditions and subsequent revision of decay curve function.

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, Small Urban Areas (population less than 50,000), and Urbanized (population greater than 50,000). In previous editions of this report the overall pavement conditions were presented based on the qualitative condition terms "very good," "good," "fair," "mediocre," and "poor." This edition adopts simplified terminology used in the annual 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 these two measures, and the relationship between the new categories are discussed later in the chapter.

In 2000, 86.0 percent of measured roads had acceptable ride quality including 43.5 percent that met the standard for good condition. Since 1997, there was a slight increase in the percentage of miles in the good category. There was also an increase in the percentage of miles in acceptable condition. Pavement condition on the Interstate system improved since 1997. The percentage of rural, small urban, and urbanized Interstates with acceptable ride quality increased by 0.4 percent to 96.6 percent between 1997 and 2000.

The common indicator used to evaluate the condition of the Nation's bridges was the number of deficient bridges. Under this metric, there were two types of deficient bridges: structurally deficient and functionally obsolete. In 1994, 32.5 percent of the Nation's bridges were deficient. In 2000, 28.5 percent of the Nation' bridges were deficient. Of the total number of bridges in 2000, 14.8 percent were structurally deficient while 13.8 percent were functionally obsolete. In urban areas, 31.9 percent of bridges were deficient, while in rural areas 27.6 percent were deficient. Local government agencies own over half of the deficient bridges.

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 29.6 percent. The percentage of deficient bridges on the Interstate system decreased from 24.7 percent to 21.6 percent while the percentage of deficient bridges on other arterials decreased from 27.6 percent to 25.8 percent.

A third indicator of bridge condition is deck area deficiency; this measure is increasingly used by engineers and policy analysts to describe bridge integrity. FHWA's FY 2002 Performance Plan, for example, includes an indicator on deck area deficiency for NHS and non-NHS bridges. As Exhibit 3-34 describes, the nationwide percentage of bridge deck area described as deficient dropped from 30.9 percent in 1996 to 27.9 percent in 2000. Bridges with unknown or unclassified ownership had the largest percentage of deficient deck area (42.8 percent in 2000), followed by privately owned bridges (33.8 percent). Federally owned bridges had the smallest percentage of deficient deck area (25.8 percent in 2000).

In 2000, 27.9 percent of the Nation's bridge deck area was considered deficient. The percentage of deficient bridge deck area decreased on every functional system from 1996 to 2000. Rural Interstate bridges had the smallest deficient deck area in 2000 (about 15 percent), while urban collector bridges had the largest deficient deck area (39.6 percent).

Transit Conditions

The condition of transit vehicles did not change significantly between 1997 and 2000. On a scale of 1 (poor) to 5 (excellent), bus vehicles had an average condition of 3.07 in 2000, up from 2.96 in 1997. The average condition of rail vehicles was 3.55 in 2000, down from 3.61 in 1997. Both the 1997 and 2000 ratings are lower than the 3.80 rating of rail vehicles reported in 1987. The average rail vehicle condition of 4.0 that was reported in the 1999 C& P Report for 1997 was subsequently revised downward to reflect a correction in the decay curve function for rail vehicles, excluding commuter rail. This revision was based on an updated and larger set of condition data collected by FTA in 1999, 2000, and 2001.

The percentage of bus maintenance facilities in adequate or better condition declined to 71 percent in 2000 from 77 percent in 1997. The percentage of rail maintenance facilities in adequate or better condition also fell from 77 percent in 1997 to 64 percent in 2000. The condition of yards has also declined. In 2000, 50 percent of all yards were in good condition and 50 percent were in adequate condition, compared with 63 percent in good condition and 37 percent in adequate condition in 1997. While the percentage of stations estimated to be in adequate or better condition has increased from 77 percent in 1997 to 84 percent in 2000, the percentage in good or better condition has declined from 54 percent in 1997 to 34 percent in 2000. These changes have resulted largely from the application of the newly estimated decay curve based on rail maintenance facility decay curves rather than in a change in the actual condition level of stations. Rail track conditions are estimated to have remained constant since 1997, with 83 percent of all track estimated to be in good or better condition in both 1997 and 2000.

Road Conditions

Pavement Terminology & Measurements

Pavement condition affects costs associated with travel, including vehicle operation, delay, and crash expenses. Poor road surfaces cause additional wear 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. Unexpected changes in surface conditions can lead to crashes, and inadequate road surfaces may reduce road friction, which affects the stopping ability and maneuverability of vehicles.

The pavement condition ratings in this section are derived from one of two measures: International Roughness Index (IRI), and 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 1 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. 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.

States are required to report IRI data for the Interstate system, other principal arterials, rural minor arterials, and the National Highway System regardless of functional system. IRI reporting is recommended for all other functional classifications. The use of IRI data for reporting the status of rural major collectors and urban minor arterials has increased to 59 percent and 49 percent respectively of the miles for each. The total of urban collector miles reported using IRI data has risen to 34 percent. The procedure of reporting pavement condition status by IRI data for all functional classes is increasing.

The FHWA adopted the IRI for the higher functional classifications because this index uses a standardized procedure, is more consistent across jurisdictions, is an objective measurement, and is generally accepted as a worldwide 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, 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 data in this report only go back to 1993, when IRI data began to be collected. Caution should be used when making comparisons with older data from earlier editions of this report and when attempting to make comparisons between PSR and IRI data in general.

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

A. Other principal measures of pavement condition or distress such as rutting, cracking and faulting 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 has been working with AASHTO and States to establish standards for measuring roughness, cracking, rutting, and faulting.

Exhibit 3-3

Pavement Condition Criteria (Old - New)

	IRI RATING		PSR RATING	
OLD CONDITION TERM CATEGORIES	**INTERSTATE**	**OTHER**	**INTERSTATE**	**OTHER**
Very Good	< 60	< 60	$\geq$ 4.0	$\geq$ 4.0
Good	60 to 94	60 to 94	3.5 to 3.9	3.5 to 3.9
Fair	95 to 119	95 to 170	3.1 to 3.4	2.6 to 3.4
Mediocre	120 to 170	171 to 220	2.6 to 3.0	2.1 to 2.5
Poor	> 170	> 220	$\leq$ 2.5	$\leq$ 2.0

	All Functional Classifications	
NEW RIDE QUALITY TERMS*	**IRI RATING**	**PSR RATING**
Good	< 95	$\geq$ 3.5
Acceptable	$\leq$ 170	$\geq$ 2.5

* The threshold for "Acceptable" ride quality used in the 2002 Conditions and Performance 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 meet to be classified as "Acceptable".

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 National Highway System (NHS) mileage should meet pavement standards for "acceptable ride quality." This goal was accomplished in 1999.

The FHWA has adopted a new metric based on the percent of vehicle miles traveled (VMT) on acceptable pavement. This metric of "Ride Quality" places more emphasis on the benefits of good pavements to the users instead of the physical condition of pavements. The *FHWA Fiscal Year 2003 Performance Plan* established the goal to have 92.5 percent of all VMT on the NHS to be on highways rated as acceptable or better ride quality by the year 2003. Exhibit 3-4 shows that in the year 2000, 91.0 percent of the VMT on the NHS were on pavements with acceptable ride quality. This is an increase of 0.4 percent over 1999. The NHS is discussed in more detail in Chapter 24.

Exhibit 3-4

Ride Quality on the National Highway System

	1993	1995	1997	1999	2000
Total VMT on NHS	2,323,656,218	2,773,719,086	3,033,033,380	3,241,301,356	3,312,944,220
Total VMT on NHS Acceptable Pavements	2,091,128,773	2,468,245,187	2,703,120,410	2,937,157,991	3,013,967,870
Total Miles of NHS	142,837	154,204	157,582	158,971	158,802
Total Miles of NHS with Acceptable Ride Quality	127,872	139,408	144,643	147,817	148,538
Percent VMT on NHS Acceptable Pavements	90.0%	89.0%	89.1%	90.5%	90.9%
Percent Miles of NHS Pavement with Acceptable Ride Quality	89.5%	90.4%	91.8%	93.0%	93.5%

Source: Highway Performance Monitoring System.

Please note that the remainder of this chapter retains the traditional approach of describing pavement condition in terms of miles, rather than in terms of VMT.

To be rated acceptable, pavement performance must have an IRI value of less than or equal to 170 inches per mile. Good pavements comprise a subset of acceptable pavements. For a pavement to be rated as good, the IRI value must be less than or equal to 95 inches per mile. The Fiscal Year 2003 Performance Plan applies the same ride quality standard to all NHS routes, including those off the Interstate system. IRI is required to be reported for all NHS routes and is the preferred measure to determine acceptable ride quality.

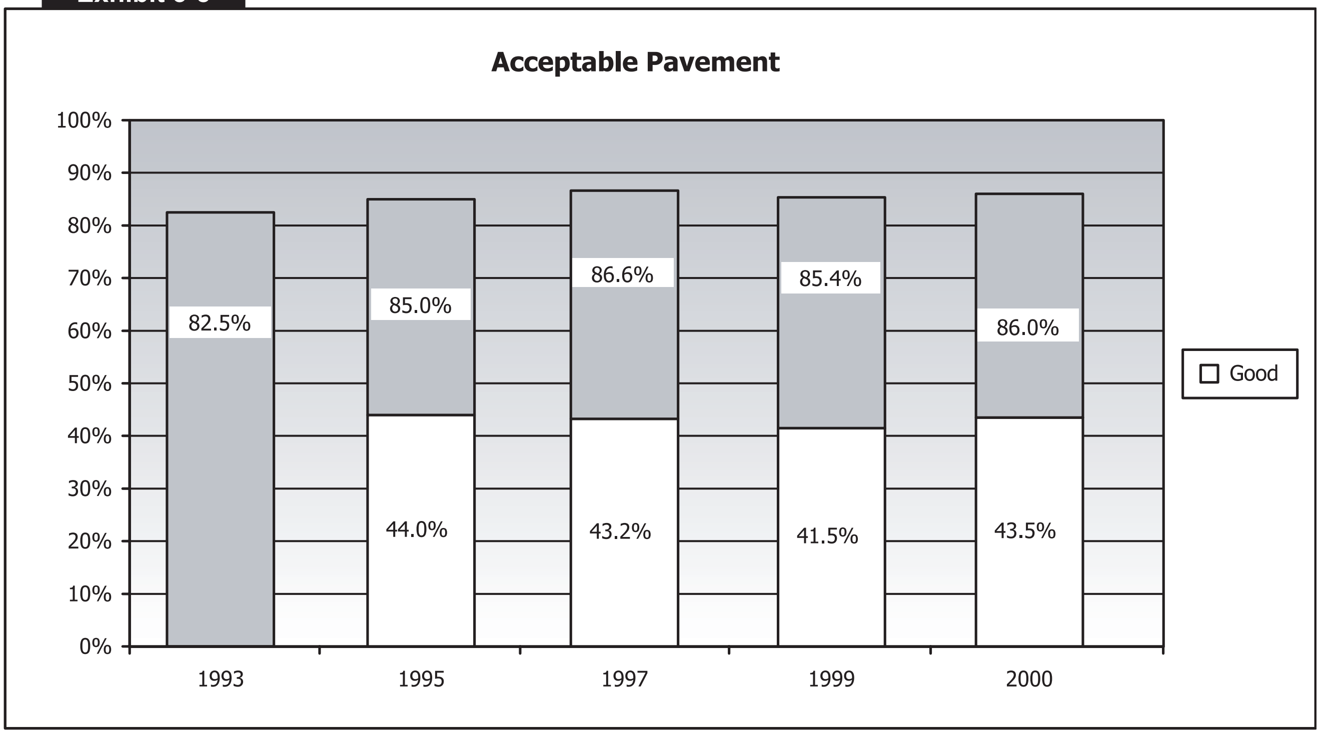
In this chapter, overall ride quality is presented based on the qualitative condition terms good, acceptable, and not acceptable. The correlation between these condition terms to the condition terms used in previous C&P reports and to the IRI or PSR system is presented in Exhibit 3-3.

Overall Pavement Condition

The highway systems covered in this chapter include all mileage except rural minor collectors and local functional classifications. Based on the new metrics for ride quality, 86.0 percent of total road mileage evaluated was rated acceptable in 2000, including 43.5 percent that met the standard for good. *[See Exhibit 3-5]*.

> **Q. Why isn't a percentage shown for the "Good" category in 1993?**
>
> **A.** In 1993, many States were in the process of converting from PSR to IRI reporting, and some anomalies in the overall data were observed. The percentage of pavement meeting the criteria to be classified as good was clearly inconsistent with that reported in subsequent years.

Exhibit 3-5

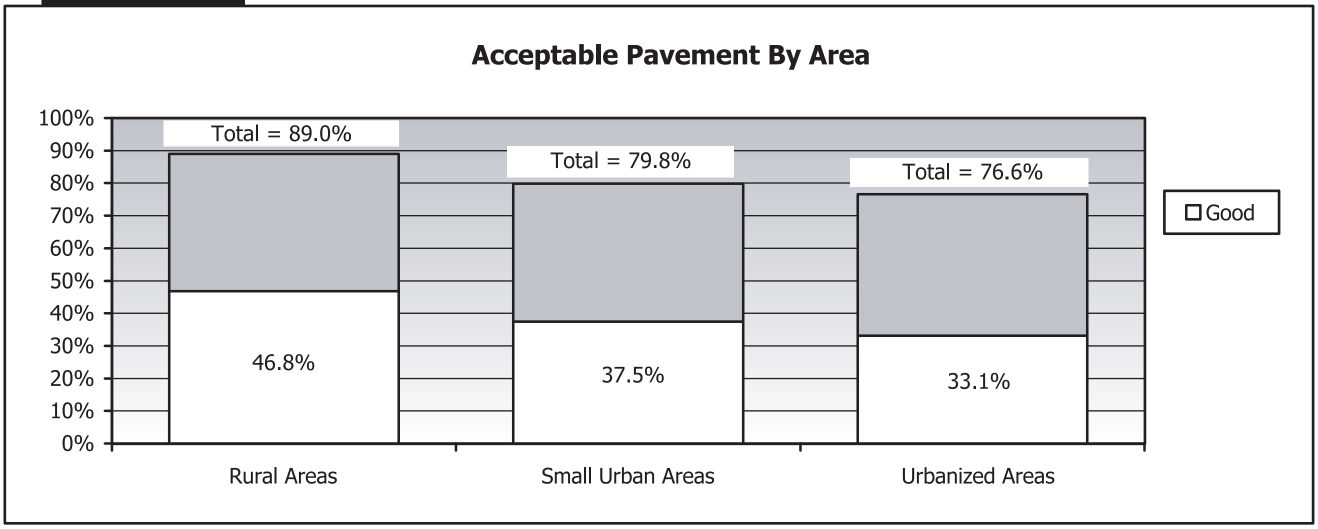


Source: Highway Performance Monitoring System.

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 78.2 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 2000 data, pavement conditions in rural areas are slightly better than those in small urban and urbanized areas. 89.0 percent of total road miles in rural areas are rated acceptable while 79.8 percent of road miles in small urban areas are rated acceptable and 76.6 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, 46.8 percent of rural miles, 37.5 percent of small urban miles, and 33.1 percent of urbanized miles. *[See Exhibit 3-6]*. Note that rural minor collectors and local functional system mileage are not included in these percentages.

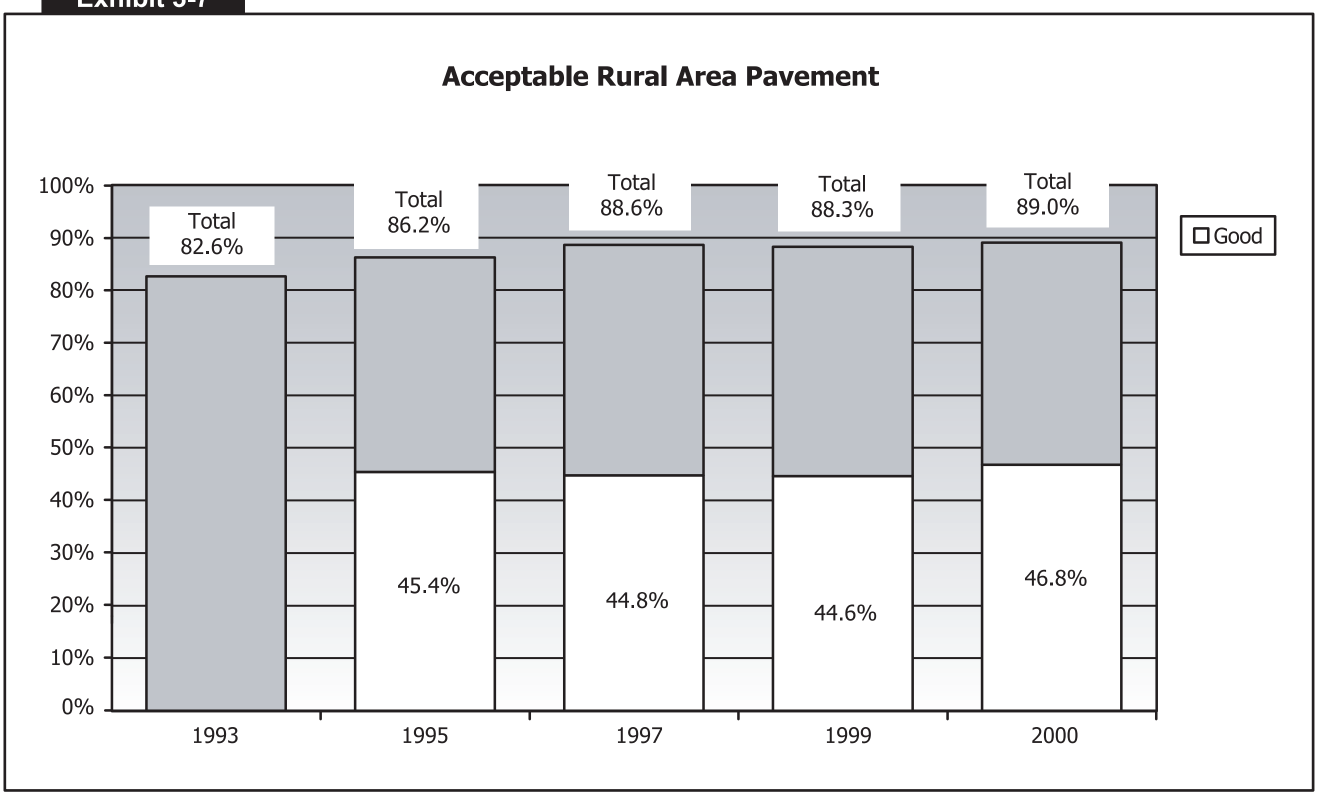
Exhibit 3-6



Source: Highway Performance Monitoring System.

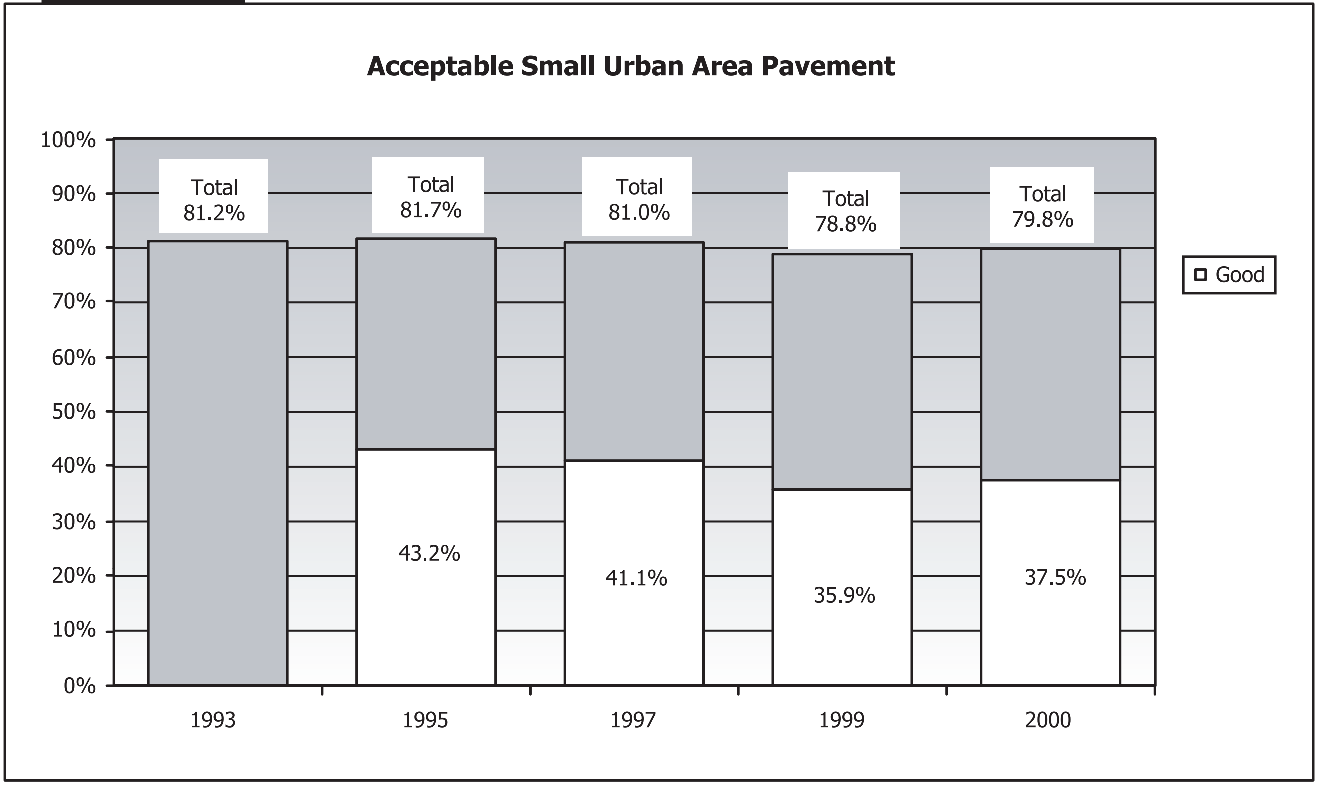
Pavement conditions in rural areas have generally been improving over time. Since 1993, the percentage of road miles in acceptable condition has increased from 82.7 percent to 89.0 percent in rural areas. However, both small urban and urbanized areas have experienced decreases in acceptable pavement miles from 81.2 percent to 79.8 percent and from 82.4 percent to 76.6 percent, respectively, since 1993. Comparable trends can be observed in the percentage of miles rated as good.
[See Exhibits 3-7, 3-8, & 3-9].

Exhibit 3-7



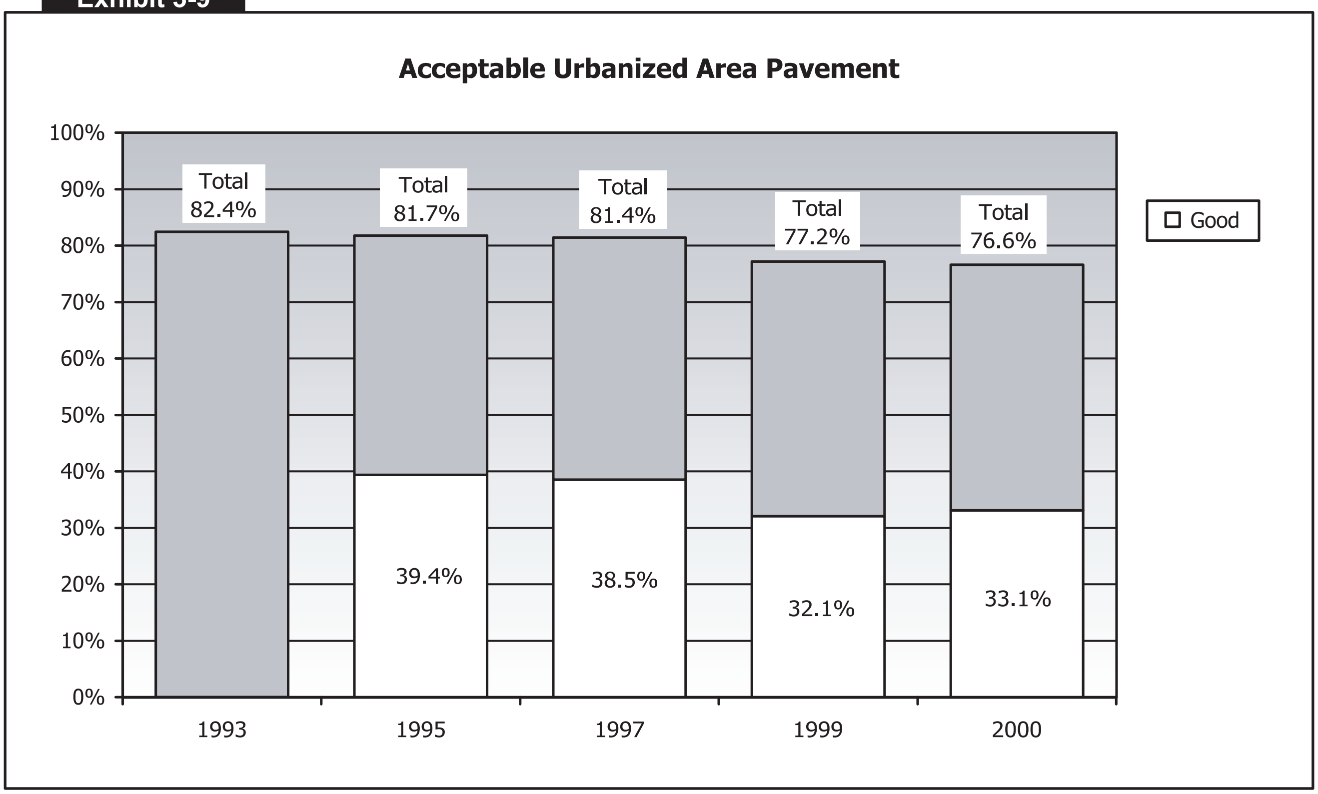
Source: Highway Performance Monitoring System.

Exhibit 3-8



Source: Highway Performance Monitoring System.

Exhibit 3-9



Source: Highway Performance Monitoring System.

Pavement Condition by Functional Classification

As stated in Chapter 2, the functional classification for approximately 68.8 percent of total mileage is "local." Nevertheless, roads classified as "Interstate" have the largest percentage of VMT, followed by other principal arterials, minor arterials, and major collectors. Therefore, ride quality on Interstate routes affects more users than ride quality on lower functional classifications. Interstate mileage in rural areas is 97.8 percent acceptable. In small urban areas, Interstate mileage is 95.6 percent acceptable. In urbanized areas, Interstate mileage is 93.0 percent acceptable.

For minor arterials, rural areas have a lower percentage of acceptable roads and a slightly higher percentage of miles of good roads than compared to urban areas. Urban areas also have a lower percentage of collector roads in acceptable condition and a lower percentage of collector roads miles in good condition when compared to rural 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 1993 to 2000 based on the revised ride quality standards incorporated in this report. The exhibit illustrates that pavement conditions have changed in a variety of ways. For example, since 1993, the percentage of Interstate miles in rural areas classified as acceptable has increased from 93.5 percent to 97.8 percent.

The percentage of Interstate miles in urbanized areas rated as acceptable has increased from 89.8 percent to 93.0 percent. However, during the same time period, the percentage of Other Principal Arterials in urbanized areas listed as acceptable has decreased from 79.3 percent to 67.8 percent.

Combining the rural, small urban, and urbanized Interstate data illustrates that, overall, Interstate pavement performance has improved since 1993. The percentage of all Interstate mileage with "acceptable ride quality" increased from 92.6 percent in 1993 to 96.6 percent in 2000.

One consistent trend is the faster rate of pavement condition improvement in rural areas versus small urban and urbanized areas. Since 1993, 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, two functional classifications—Interstate and Minor Arterials—have seen an increase in acceptable road miles, one functional class—Other Freeway and Expressway—has remained relatively stable, and two functional classes—Other Principal 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 have experienced declines in acceptable road miles—Other Principal Arterials, Minor Arterials, and Collectors. *[See Exhibit 3-10].*

Exhibit 3-10

Ride Quality by Functional System, For Selected Years 1993 - 2000

Percent Acceptable

FUNCTIONAL SYSTEM	1993	1995	1997	1999	2000
Rural Interstate	93.5%	94.5%	95.9%	97.6%	97.8%
Rural Principal Arterial	89.2%	91.4%	93.7%	95.5%	96.0%
Rural Minor Arterial	84.6%	85.1%	89.8%	92.0%	92.1%
Rural Major Collector	75.7%	82.5%	84.0%	79.7%	82.1%
Small Urban Interstate	93.5%	94.4%	95.8%	95.4%	95.8%
Small Urban Other Freeway & Expressway	93.7%	90.2%	91.2%	92.8%	93.7%
Small Urban Other Principal Arterial	85.8%	82.0%	80.5%	81.7%	82.9%
Small Urban Minor Arterial	77.7%	82.5%	82.2%	78.1%	80.0%
Small Urban Collector	74.0%	76.4%	75.9%	68.3%	68.9%
Urbanized Interstate	89.8%	90.0%	90.0%	92.2%	93.0%
Urbanized Other Freeway & Expressway	86.8%	87.6%	87.7%	88.8%	88.3%
Urbanized Other Principal Arterial	79.3%	75.9%	73.2%	67.6%	67.8%
Urbanized Minor Arterial	82.4%	82.1%	82.7%	78.5%	78.3%
Urbanized Collector	82.1%	84.4%	86.4%	80.3%	77.4%

Percent Good

FUNCTIONAL SYSTEM	1993	1995	1997	1999	2000
Rural Interstate		51.8%	56.9%	65.4%	68.5%
Rural Principal Arterial		41.3%	47.5%	54.0%	57.4%
Rural Minor Arterial		41.2%	45.5%	46.9%	47.8%
Rural Major Collector		48.8%	40.8%	33.2%	36.8%
Small Urban Interstate		49.8%	51.4%	58.2%	61.6%
Small Urban Other Freeway & Expressway		41.6%	35.8%	41.3%	43.8%
Small Urban Other Principal Arterial		36.8%	32.7%	33.7%	36.7%
Small Urban Minor Arterial		48.3%	46.5%	38.1%	38.9%
Small Urban Collector		44.3%	45.3%	30.3%	30.7%
Urbanized Interstate		41.4%	39.3%	45.0%	48.2%
Urbanized Other Freeway & Expressway		37.0%	31.4%	35.5%	38.0%
Urbanized Other Principal Arterial		29.3%	26.8%	23.7%	24.0%
Urbanized Minor Arterial		46.2%	46.0%	38.0%	38.4%
Urbanized Collector		45.5%	48.0%	31.5%	32.5%

Source: Highway Performance Monitoring System.

Roadway Alignment

Alignment adequacy affects the level of service and safety of the highway system. There are two types of alignment: horizontal and vertical. Inadequate alignment may result in speed reductions and impaired sight distance. In particular, trucks are affected by inadequate roadway alignment with regard to speed. Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst). Exhibit 3-11 explains the alignment rating system.

Exhibit 3-11

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 only presents rural data. Exhibits 3-12 and 3-13 illustrate that 95.6 percent of rural Interstate miles are classified as Code 1 for horizontal alignment and 92.8 percent are classified as Code 1 for vertical alignment. The share of rural roads classified as Code 4 for horizontal alignment is 7.7 percent, and 6.3 percent are rated Code 4 for vertical alignment. Roadway alignment continues to improve gradually as sections with poor alignment are reconstructed.

Lane Width

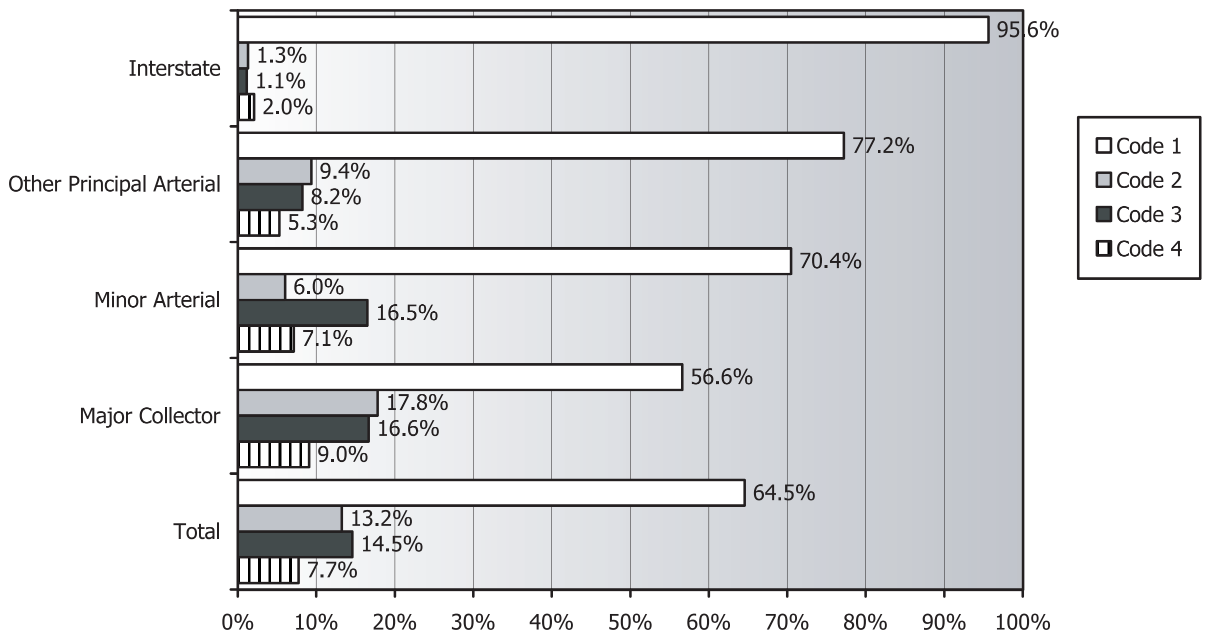
Lane width affects capacity and safety; narrow lanes prevent a road from operating at capacity. As with roadway alignment, lane width is more crucial on functional classifications with the higher travel volumes.

Currently, high-type facilities (e.g. Interstates) are expected to have 12-foot lanes. Exhibits 3-14 and 3-15 illustrate that over 97 percent of Interstate miles meet the 12-foot standard.
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. Since 1993, total rural mileage with lane width greater than or equal to 12 feet increased from 51.6 percent to 52.6 percent while the urban mileage with 12-foot-plus lanes decreased from 67.4 percent to 67.0 percent. Part of the urban decline may be attributable to the reclassification of roads from rural to urban as a result of population growth. [*See Exhibit 3-16*].

Exhibit 3-12

Rural Horizontal Alignment Adequacy



Source: Highway Performance Monitoring System.

Exhibit 3-13

Rural Vertical Alignment Adequacy

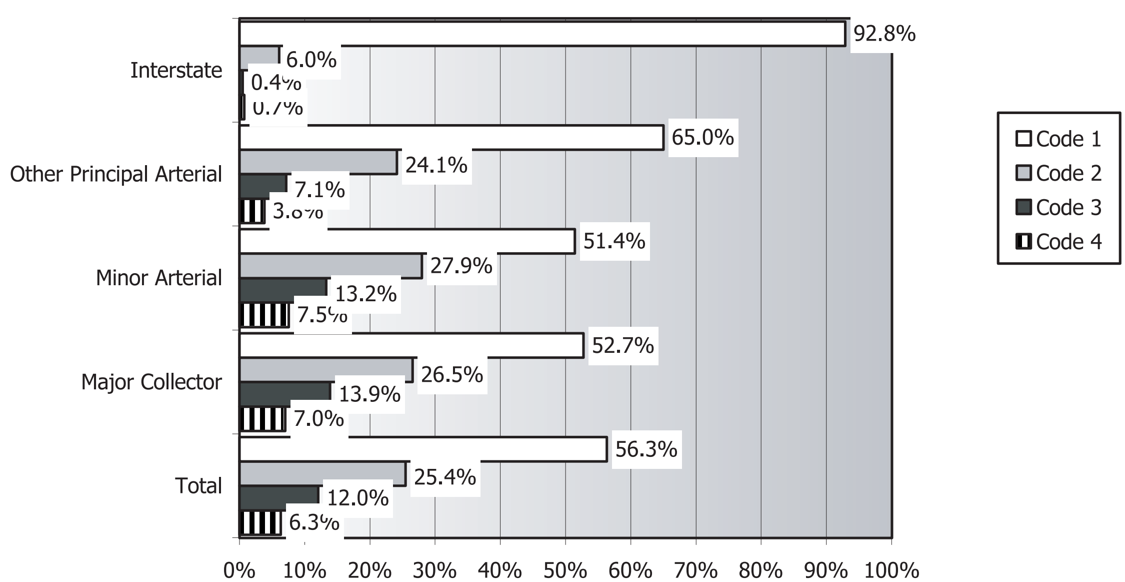
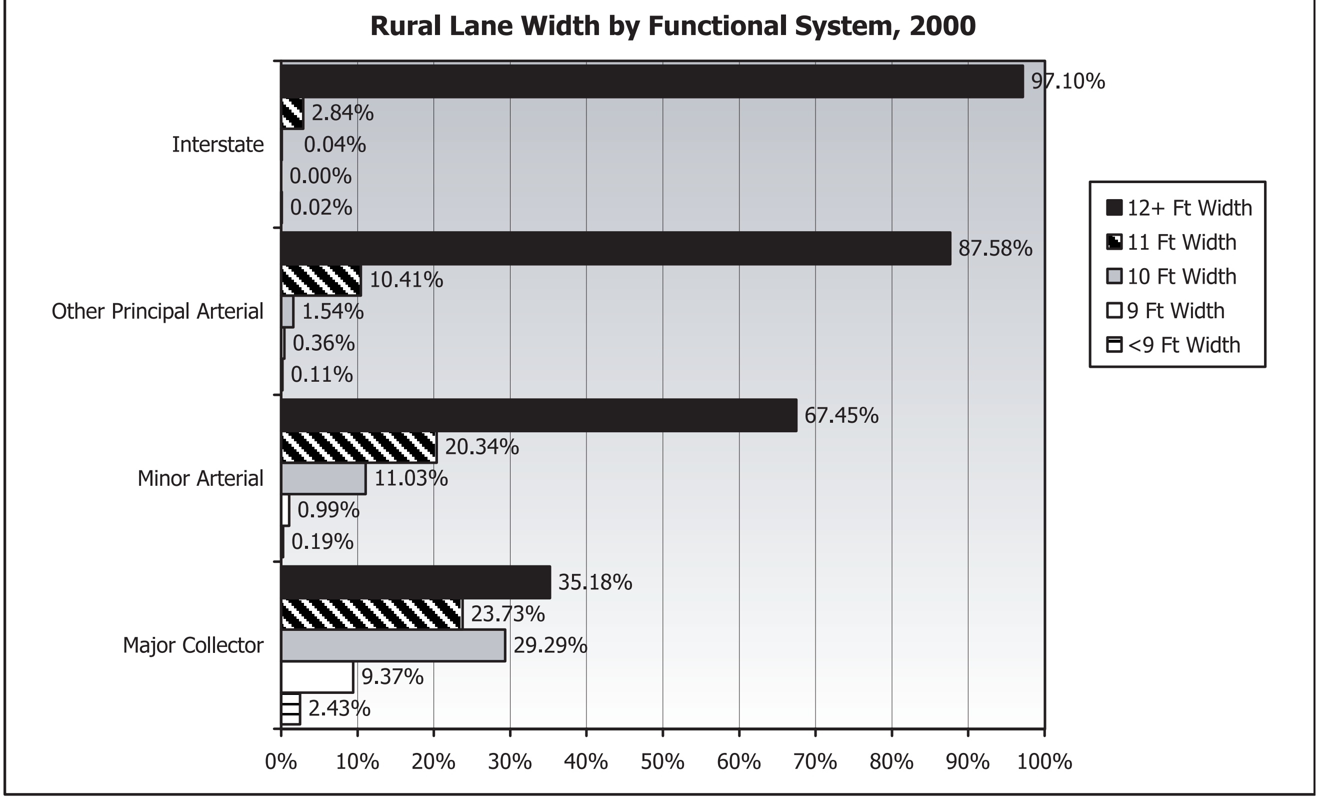
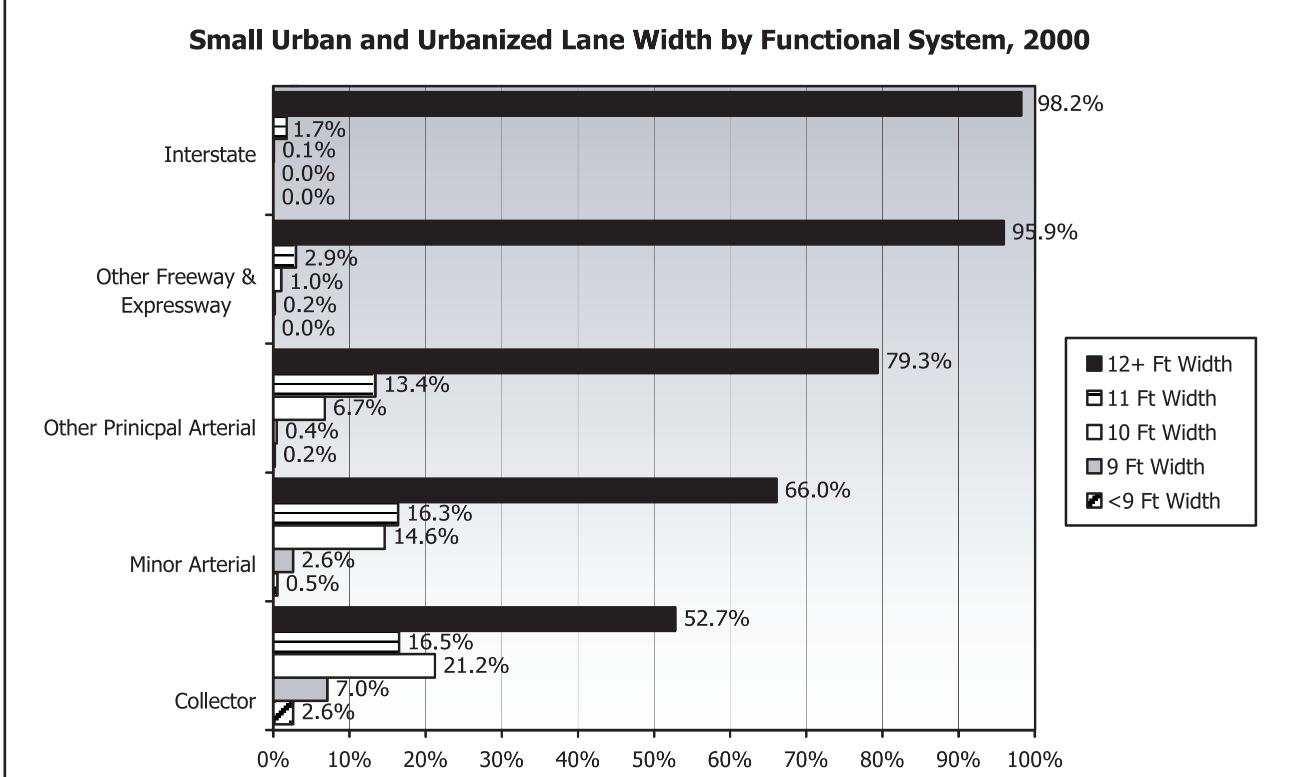


Exhibit 3-14



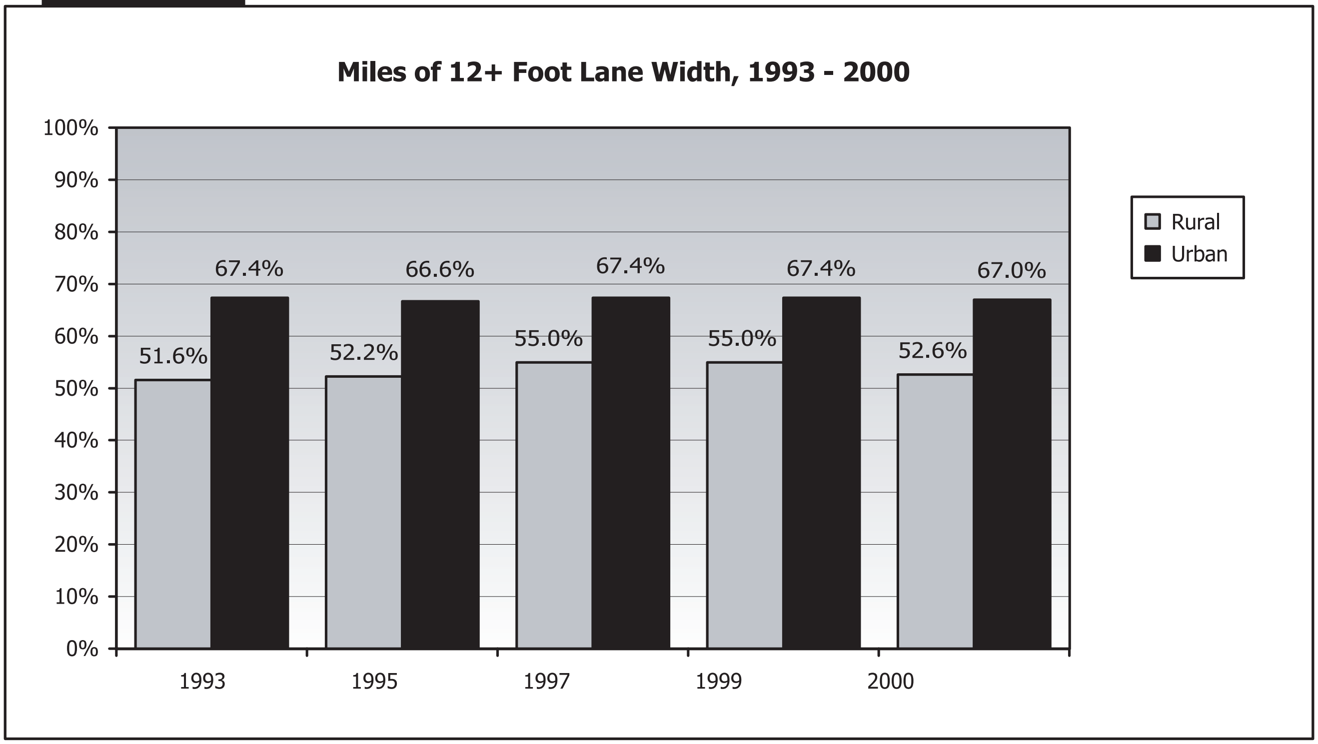
Source: Highway Performance Monitoring System.

Exhibit 3-15



Source: Highway Performance Monitoring System.

Exhibit 3-16



Source: Highway Performance Monitoring System.

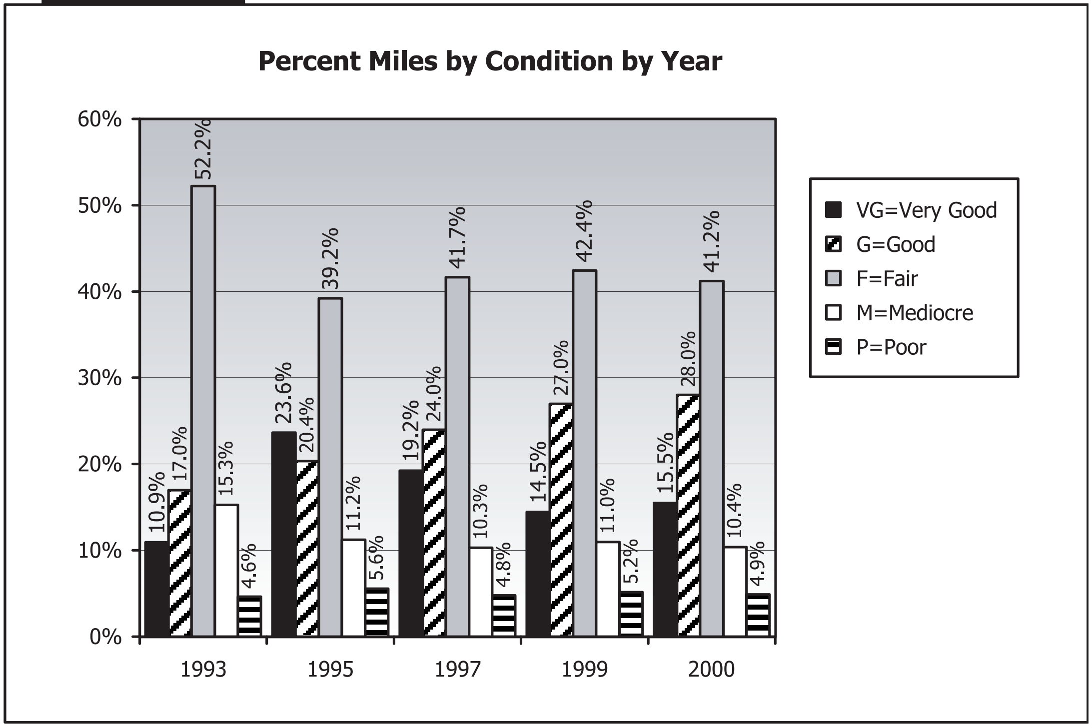
Pavement Condition Based on Old Classification System

In previous C&P reports, the condition of pavement was listed by very good, good, fair, mediocre, and poor. In order to provide reference and a bridge between the rating system in previous reports and the new system, the overall pavement condition based on 2000 HPMS data is shown in Exhibit 3-17.

Following the previous rating system, 15.5% of the miles are in very good condition and 28.0% are in good condition. Since 1997, the percentage of mileage in very good condition fell 1.0 percent while the percentage of mileage in good condition increased 1.0 percent. The percentage of fair pavement decreased from 42.4 percent to 41.2 percent while the percentage of mediocre pavement decreased slightly from 11.0 percent to 10.4 percent. Finally, the percentage of poor pavement decreased slightly from 5.1 percent to 4.9 percent since 1997.

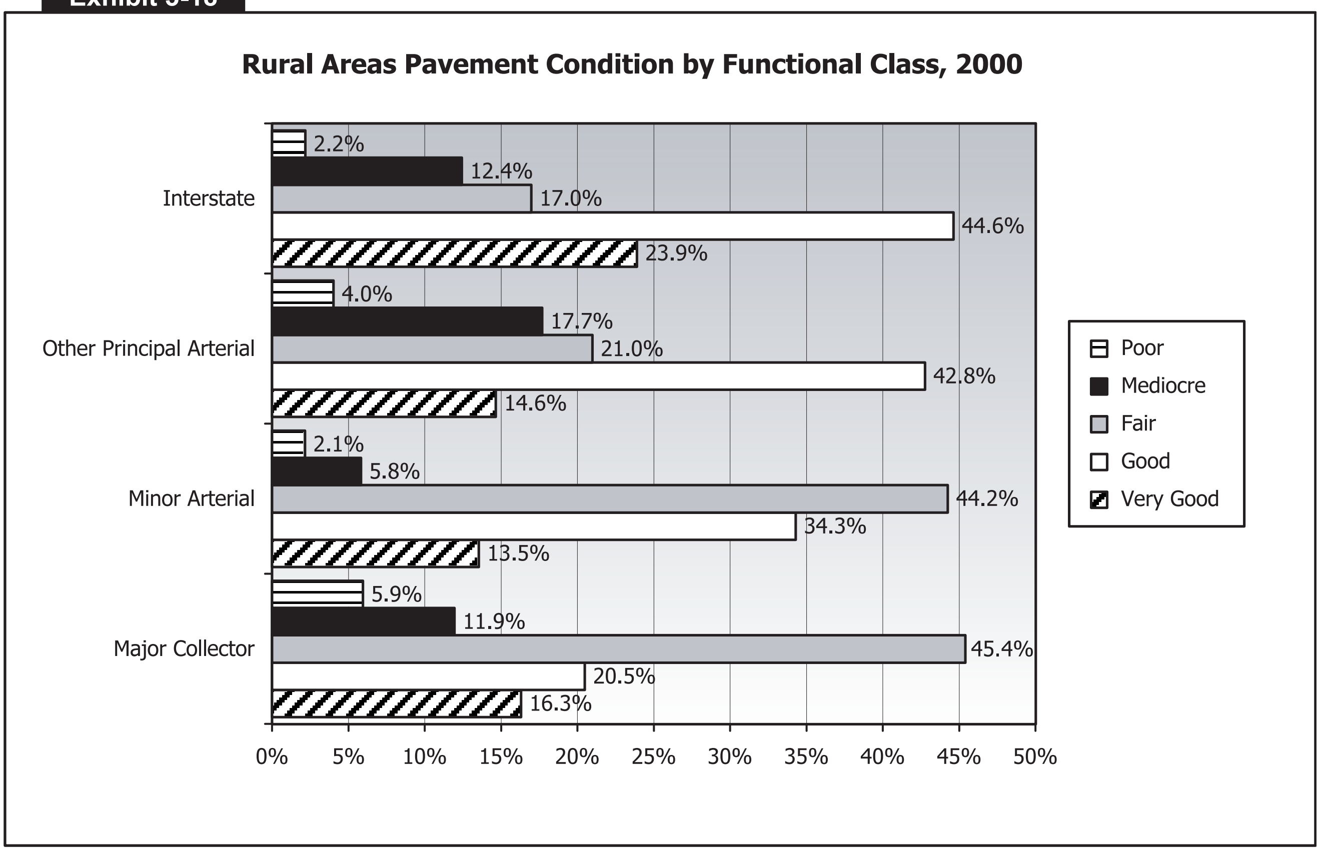
Exhibits 3-18, 3-19, and 3-20 contain the portion of rural, small urban, and urbanized area pavement in the various condition categories, respectively, based on ride quality standards prior to the implementation of the revised standards.

Exhibit 3-17



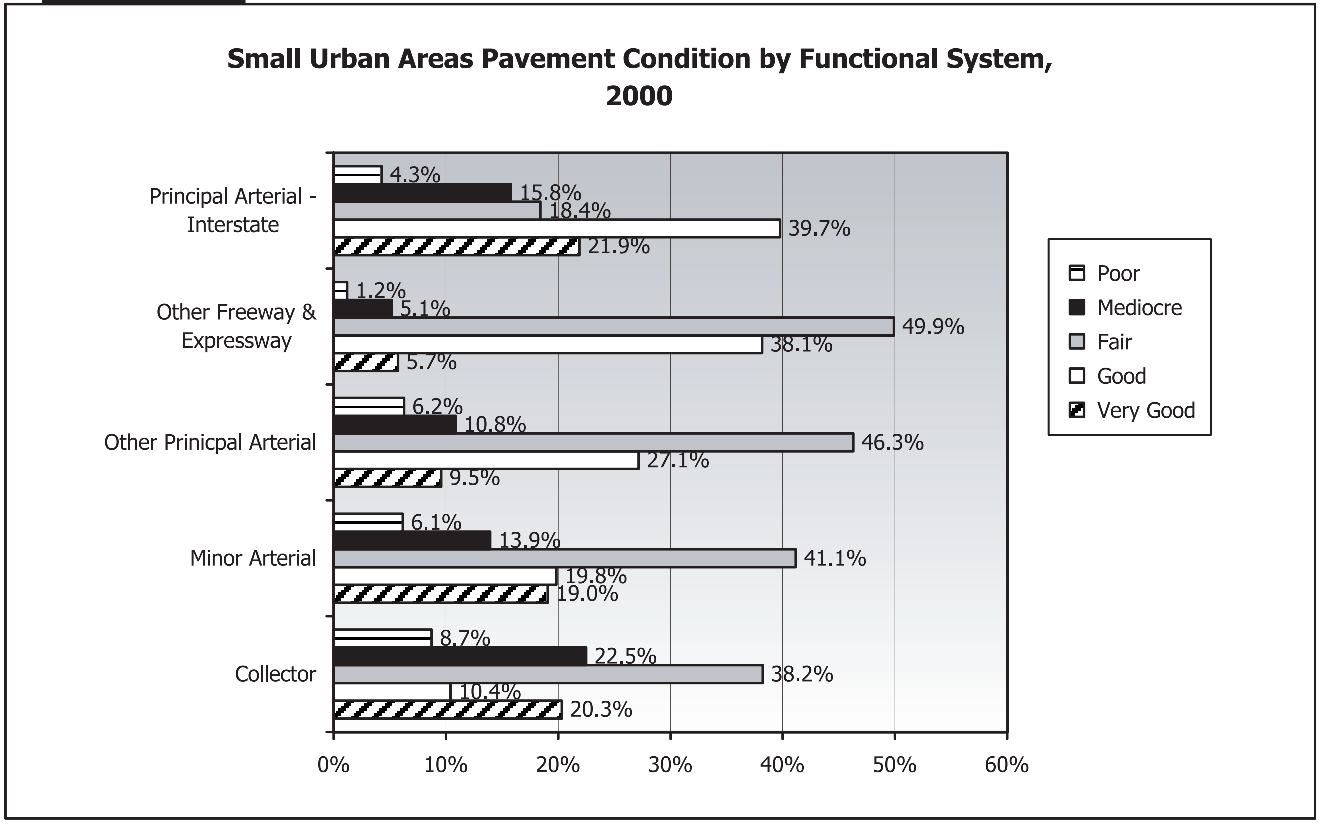
Source: Highway Performance Monitoring System.

Exhibit 3-18



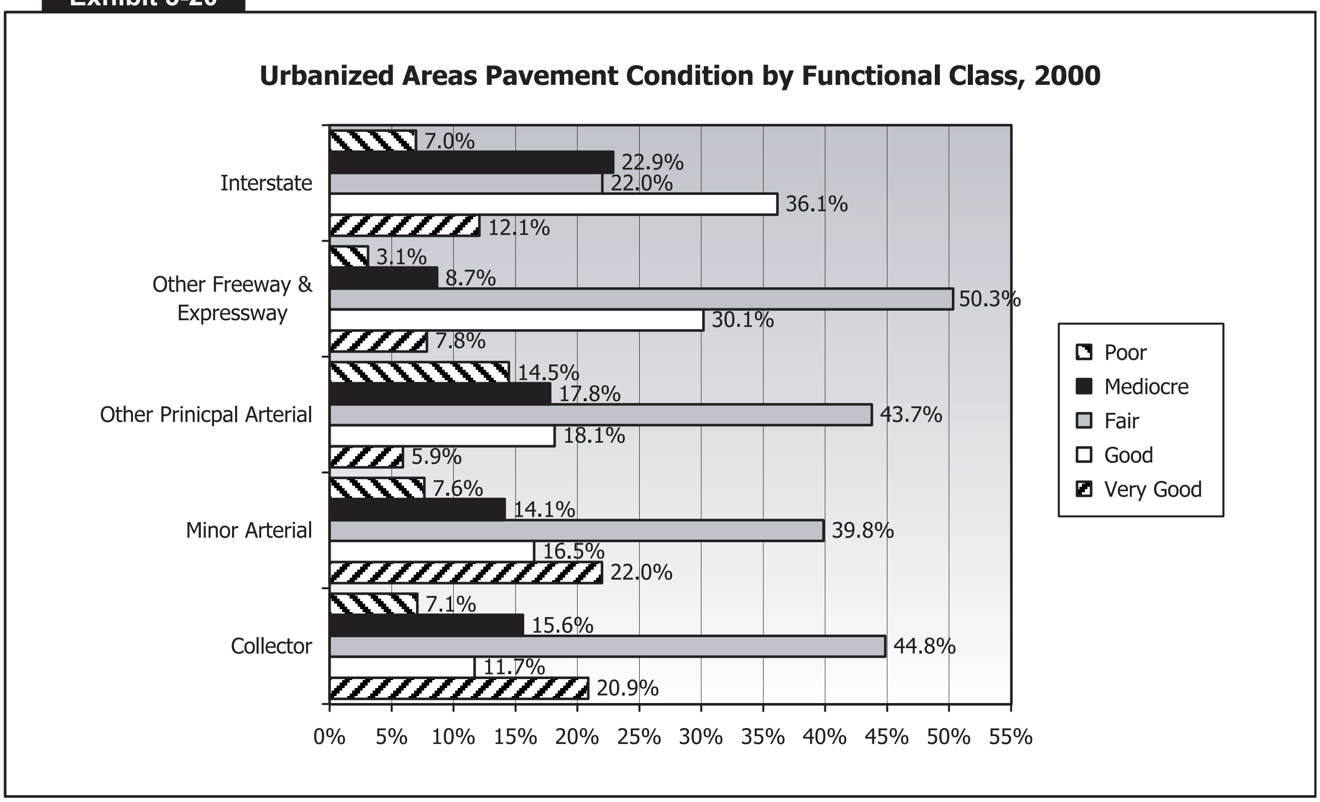
Source: Highway Performance Monitoring System.

Exhibit 3-19



Source: Highway Performance Monitoring System.

Exhibit 3-20



Source: Highway Performance Monitoring System.

Bridge Conditions

Three indicators are examined in this section: bridge condition ratings, the number of deficient bridges, and the percentage of deck area on deficient bridges. Each measure examines bridge conditions from a different perspective. Condition ratings provide a numerical evaluation of the condition of a bridge element. The number of deficient bridges is widely used by policymakers to describe bridge conditions nationwide, but it does not recognize the relative importance, from a mobility perspective, of an individual bridge's contribution to the overall transportation system. The final indicator—the percentage of deck area on bridges classified as deficient—is increasingly used to document the state of bridge conditions; for example, the FY 2002 FHWA Performance Plan includes this measure as its new indicator. This chapter describes deck area on deficient bridges by owner and functional system. Information on National Highway System (NHS) bridges is described in Chapter 24.

Bridge Condition Ratings

The National Bridge Inventory (NBI) contains ratings on the conditions of three major bridge components: the deck, superstructure, and substructure. A bridge deck is the primary surface used for transportation. The deck is supported by the superstructure, which carries the load of the deck and the traffic. 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 substructure elements, such as abutments and piers. Exhibit 3-21 describes bridge condition ratings in greater detail.

Condition ratings are used to describe the existing, in-place status of a component, not its as-built state. Engineers assign condition ratings by evaluating the severity of deterioration or disrepair and the extent to which it is widespread

Exhibit 3-21

Bridge Condition Ratings

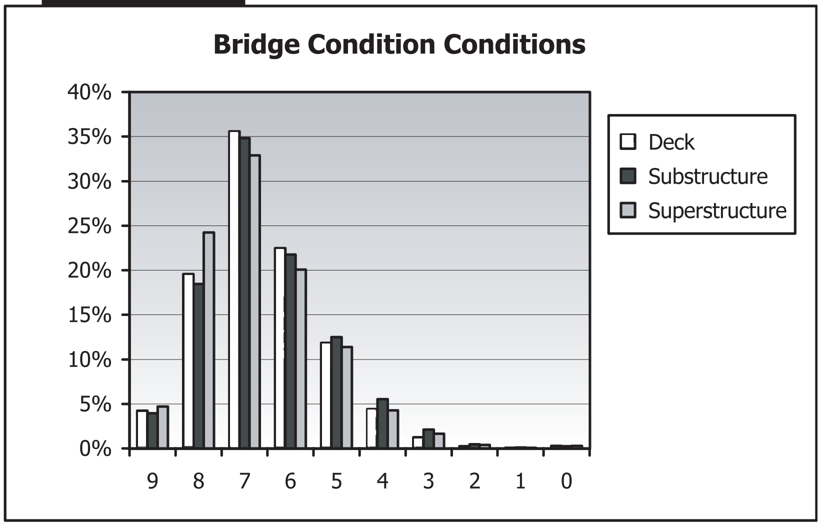
RATING	CATEGORY	DESCRIPTION
9	Excellent Condition	
8	Very Good Condition	
7	Good Condition	No problems noted.
6	Satisfactory Condition	Some minor problems.
5	Fair Condition	All primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	Poor Condition	Advanced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

Source: "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges," December 1995.

throughout the component being rated. A condition rating does not translate directly into an overall rating of a bridge's condition, but it is a good indicator of the quality of specific elements.

Exhibit 3-22 illustrates the distribution of bridge condition ratings. Most bridge components are rated 7 or higher, indicating that they are in good, very good, or excellent condition. Another one-third of all bridge components are rated 5 or 6, indicating fair or satisfactory condition. The remainder of bridge components are rated 4 or lower, indicating a poor or worse condition.

Exhibit 3-22



Source: National Bridge Inventory.

Number of Deficient Bridges

The most commonly-cited indicator of bridge condition is the number of deficient bridges. There are two types of deficient bridges: structurally deficient and functionally obsolete. Bridges are considered structurally deficient if they are restricted to light vehicles, require immediate rehabilitation to remain open, or are closed. A deficient bridge may or may not be dangerous, but it does require significant maintenance, rehabilitation, or sometimes replacement. Bridges are considered functionally obsolete if they have deck geometry, load carrying capacity, clearance, or approach roadway alignment that no longer meets the criteria for the system of which the bridge is a part.

As shown by Exhibit 3-23, about 28.5 percent of the Nation's bridges were deficient in 2000. Of these deficient bridges, about 14.8 percent were structurally deficient and 13.8 percent were functionally obsolete.

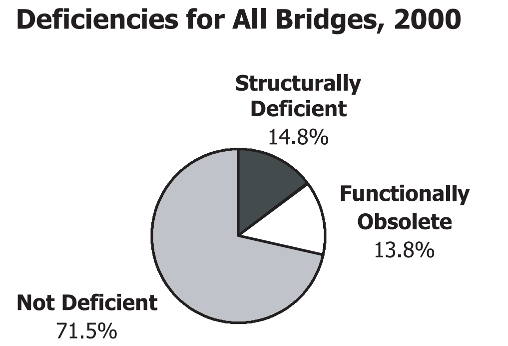
The number of deficient bridges has steadily decreased over the past decade. In 1994, about 32.5 percent of the Nation's bridges were deficient, but that number had dropped by almost 4 percent by 2000. The long-term trend is consistent with expectations in the Federal Highway Administration's 1998 Strategic Plan, which stated that less than 25 percent of the Nation's bridges should be deficient by 2008. Exhibit 3-24 describes the trend data in more detail.

Q. When might a bridge be classified as functionally obsolete?

A. A bridge can become functionally obsolete because of highway improvements on the approaches to the bridge, such as lane additions or the widening of approaching roads. In other cases, a bridge may be classified as functionally obsolete through a redefinition of desired standards.

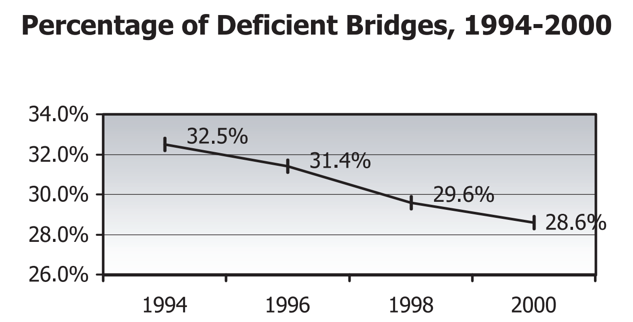
A more specific way of looking at the number of deficient bridges is by owner. As Chapter 2 explained, ownership of bridges is largely divided among State and local governments (47.2 and 50.9 percent, respectively). The remaining bridges, totaling 1.4 percent, are split among the Federal

Exhibit 3-23



Source: National Bridge Inventory.

Exhibit 3-24



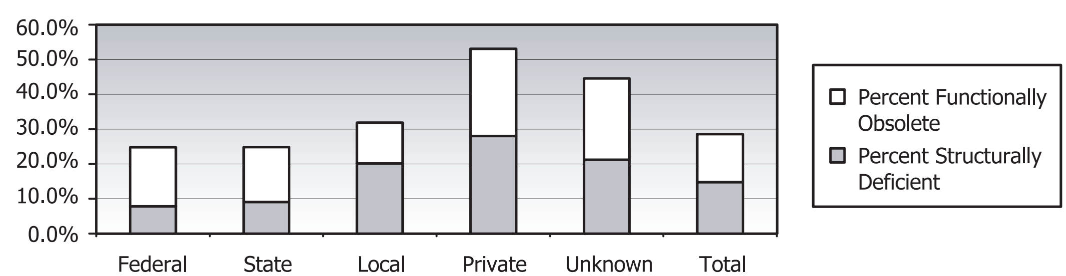
Source: National Bridge Inventory.

Government, private companies, and entities for which ownership is unknown or not coded in the National Bridge Inventory.

Exhibit 3-25 examines bridge deficiencies by owner. This exhibit shows substantial differences by level of government and type of owner. The Federal Government, for example, has the smallest percentage of deficient bridges (24.8 percent), but also owns a relatively small number of bridges (8,221). States have almost the same percentage of deficient bridges (24.9 percent), but have a much larger number of bridges (277,106). About 31.8 percent of the 298,889 bridges owned by local governments are deficient, while 53.1 percent of the Nation's 2,299 private bridges are deficient—the highest percentage of any owner type.

Exhibit 3-25

Bridges: Percent Deficient by Ownership, 2000



	FEDERAL	STATE	LOCAL	PRIVATE	UNKNOWN	TOTAL
Total Bridges	8,221	277,106	298,889	2,299	415	586,930
Total Deficient	2,038	68,832	95,291	1,220	185	167,566
Structurally Deficient	642	25,142	60,196	644	88	86,712
Functionally Obsolete	1,396	43,690	35,095	576	97	80,854

	FEDERAL	STATE	LOCAL	PRIVATE	UNKNOWN	TOTAL
Percent Structurally Deficient	7.8%	9.1%	20.1%	28.0%	21.2%	14.8%
Percent Functionally Obsolete	17.0%	15.8%	11.7%	25.1%	23.4%	13.8%
Total Deficient	24.8%	24.9%	31.8%	53.1%	44.6%	28.6%

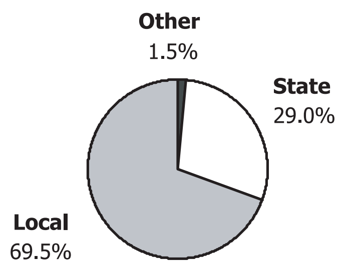
Source: National Bridge Inventory.

Most deficiencies on locally-owned bridges are structural, while most deficiencies on State and Federal bridges involve functional obsolescence. Exhibits 3-26 and 3-27 illustrate this phenomenon. About 69.5 percent of structurally deficient bridges were locally-owned, 29 percent were State-owned, and the remaining 1.5 percent were owned by the Federal Government, private companies, or other entities. Conversely, States owned about 54 percent of all functionally obsolete bridges. Local governments owned 43.4 percent of functionally obsolete bridges, and Federal, private, and other entities owned the remaining 2.6 percent.

Another way of looking at the number of deficient bridges is by rural and urban location. As Chapter 2 noted, 77.5 percent of bridges were in rural communities in 2000. About 27.6 percent of these rural bridges were deficient. At the same time, about 31.9 percent of the nation's urban bridges were deficient; therefore, urban bridges are more likely to be deficient than their rural counterparts.

Exhibit 3-26

Ownership of Structurally Deficient Bridges, 2000



Source: National Bridge Inventory.

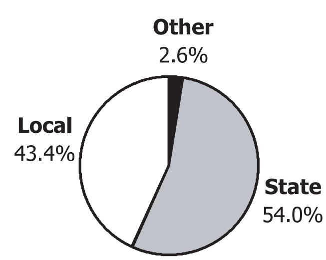
Bridge condition in both urban and rural areas has steadily improved over the past decade. Exhibit 3-28 shows that the number of deficient rural bridges dropped from 31.8 percent in 1994 to 27.6 percent in 2000. More specifically, the number of structurally deficient rural bridges dropped from 20.2 percent in 1994 to 16.2 percent in 2000. The number of functionally obsolete rural bridges decreased less dramatically—from 11.6 percent in 1994 to 11.4 percent in 2000.

Exhibit 3-28 also shows that the number of deficient urban bridges dropped from 35.3 percent in 1994 to 31.9 percent in 2000. The number of structurally deficient urban bridges decreased from 13 percent in 1994 to 9.9 percent in 2000, while the number of functionally obsolete bridges diminished only slightly, from 22.3 percent in 1994 to 22 percent in 2000. The significant drop in urban bridge deficiency, therefore, can largely be attributed to improvements in the structural integrity of bridges in metropolitan areas.

Exhibit 3-29 elaborates on a central conclusion of the previous section: that bridges are more likely to be deficient in urban areas. Bridges on urban Interstates, urban principal arterials, and urban minor arterials have a higher percentage of deficiencies than those on comparable rural functional systems. Local functional class bridges represent a break from this pattern. A larger percentage of rural local functional class bridges are deficient (34.7 percent) than urban local functional class bridges (31.6 percent).

Exhibit 3-27

Ownership of Functionally Obsolete Bridges, 2000

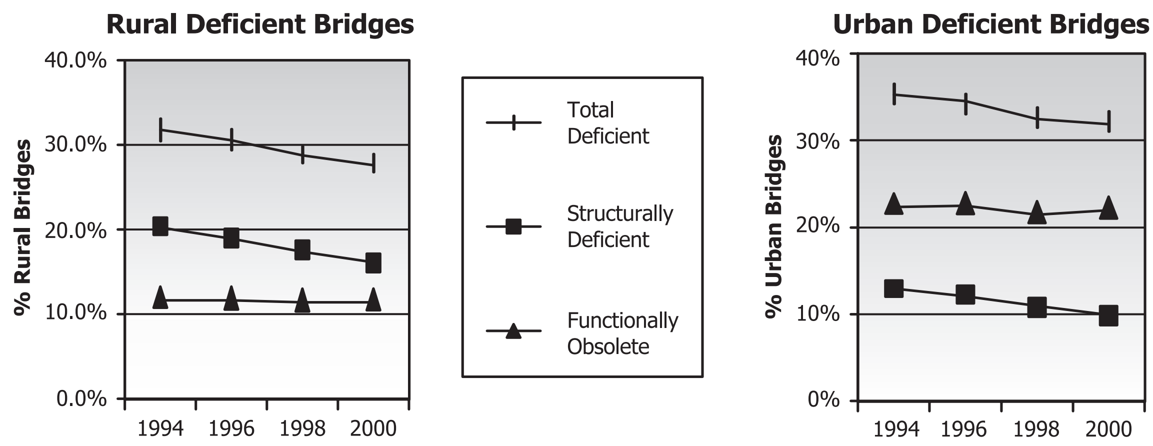


Source: National Bridge Inventory.

The proportion of structurally deficient and functionally obsolete bridges varies by functional system. Generally, the percentage of bridges that are deficient is greater on lower functional systems. Interstate bridges, for example, have the lowest percentage of deficient bridges (16 percent in rural areas and 27 percent in urban areas). Urban minor arterials

Exhibit 3-28

Rural and Urban Bridge Deficiencies, 1994-2000



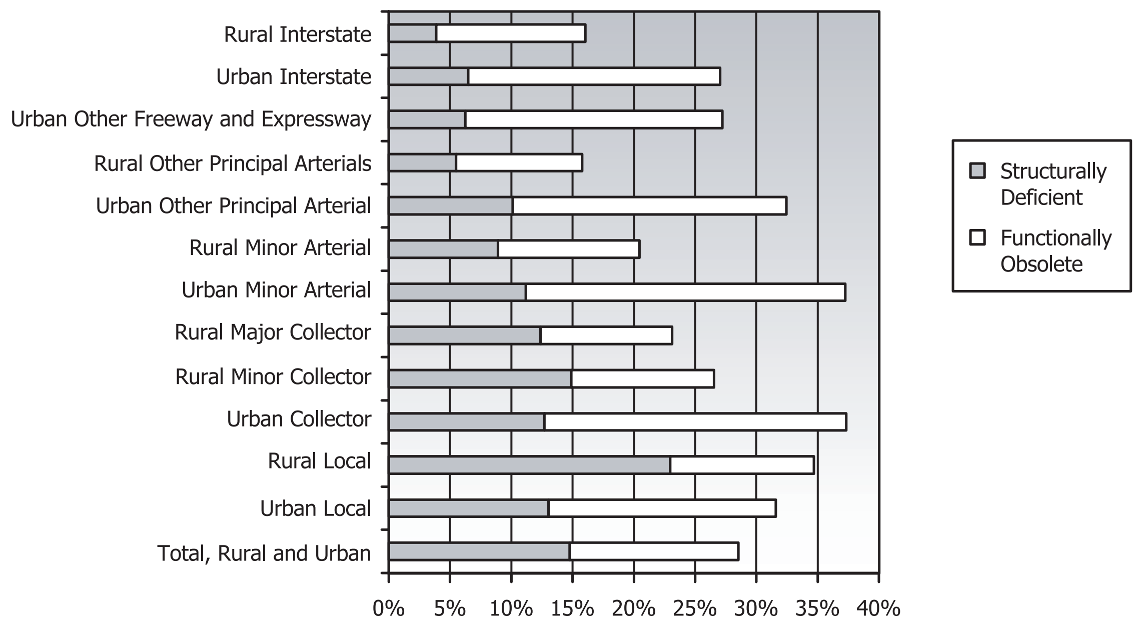
	1994		1996		1998		2000	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Rural Bridges	455,319		456,913		454,664		455,365	
Deficient Bridges	144,799	31.8%	139,545	30.5%	130,911	28.8%	125,523	27.6%
Structurally Deficient	91,991	20.2%	86,424	18.9%	78,999	17.4%	73,599	16.2%
Functionally Obsolete	52,808	11.6%	53,121	11.6%	51,912	11.4%	51,924	11.4%
Urban Bridges	121,141		124,949		128,312		131,781	
Deficient Bridges	42,716	35.3%	43,181	34.6%	41,661	32.5%	42,031	31.9%
Structurally Deficient	15,692	13.0%	15,094	12.1%	14,073	11.0%	13,079	9.9%
Functionally Obsolete	27,024	22.3%	28,087	22.5%	27,558	21.5%	28,952	22.0%
Total Bridges	**576,460**		**581,862**		**582,976**		**587,146**	
Deficient Bridges	187,515	32.5%	182,726	31.4%	172,572	29.6%	167,554	28.5%
Structurally Deficient	107,683	18.7%	101,518	17.4%	93,072	16.0%	86,678	14.8%
Functionally Obsolete	79,832	13.8%	81,208	14.0%	79,500	13.6%	80,876	13.8%

Source: National Bridge Inventory.

and urban collectors have the highest percentage of deficient bridges (37.3 percent for each system). The healthy condition of many higher-level bridges is striking, particularly since these account for a large share of VMT.

Exhibit 3-29

Bridges: Percent Deficient by Functional System, 2000



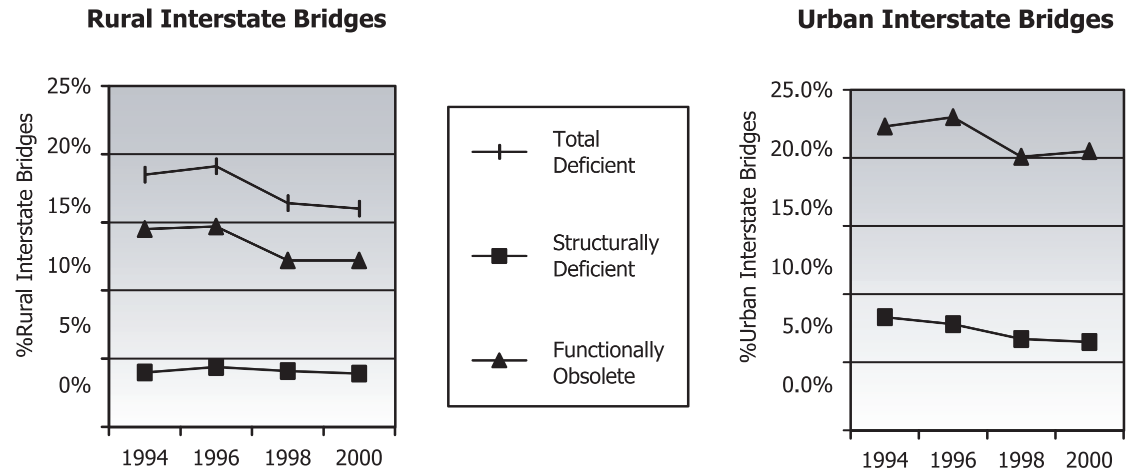
	TOTAL BRIDGES	BRIDGE DEFICIENCIES			PERCENT DEFICIENT		
		STRUCTURAL	FUNCTIONAL	TOTAL	STRUCTURAL	FUNCTIONAL	TOTAL
FUNCTIONAL CLASS							
Rural							
Interstate	27,797	1,076	3,384	4,460	3.9%	12.2%	16.0%
Other Principal Arterial	35,419	1,946	3,642	5,588	5.5%	10.3%	15.8%
Minor Arterial	39,377	3,509	4,551	8,060	8.9%	11.6%	20.5%
Major Collector	95,559	11,839	10,258	22,097	12.4%	10.7%	23.1%
Minor Collector	47,798	7,118	5,567	12,685	14.9%	11.6%	26.5%
Local	209,415	48,111	24,522	72,633	23.0%	11.7%	34.7%
Total Rural	**455,365**	**73,599**	**51,924**	**125,523**	**16.2%**	**11.4%**	**27.6%**
Urban							
Interstate	27,882	1,809	5,727	7,536	6.5%	20.5%	27.0%
Other Freeway and Expressway	16,011	1,000	3,358	4,358	6.2%	21.0%	27.2%
Other Principal Arterial	24,146	2,439	5,396	7,835	10.1%	22.3%	32.4%
Minor Arterial	23,020	2,574	6,002	8,576	11.2%	26.1%	37.3%
Collector	15,038	1,908	3,707	5,615	12.7%	24.7%	37.3%
Local	25,684	3,349	4,762	8,111	13.0%	18.5%	31.6%
Total Urban	**131,781**	**13,079**	**28,952**	**42,031**	**9.9%**	**22.0%**	**31.9%**
Total, Rural and Urban	**587,146**	**86,678**	**80,876**	**167,554**	**14.8%**	**13.8%**	**28.5%**

Source: National Bridge Inventory.

Exhibits 3-30 through 3-33 provide a historical perspective on the level of bridge deficiency by functional classification. Generally, bridge condition has improved on Interstates, other principal arterials, collectors, and local roads over the past decade. The greatest decline in deficiency occurred in the early to mid-1990s, particularly for Interstate bridges. Looking more specifically at the types of deficiency, structural deficiency consistently decreased on the systems profiled in Exhibits 3-30 through 3-33, while functional obsolescence either remained relatively constant or even increased slightly. On collectors, for instance, 16.1 percent of bridges were structurally deficient in 1994, but that number had dropped to 13.2 percent by 2000. At the same time, 11.9 percent of collector bridges were functionally obsolete in 1994, but that number had risen to 12.3 percent by 2000.

Exhibit 3-30

Interstate Bridge Deficiencies, 1994-2000

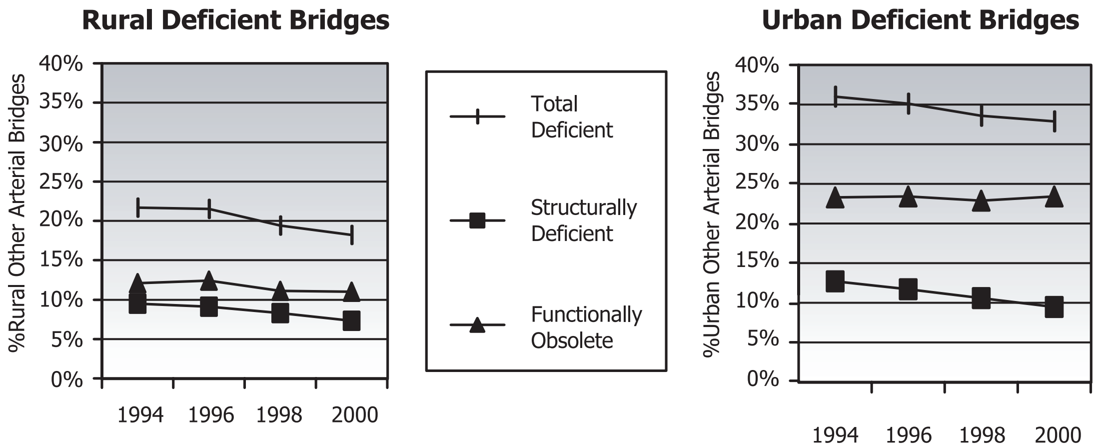


	1994		1996		1998		2000	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Rural Bridges	28,865		28,683		27,530		27,797	
Deficient Bridges	5,342	18.5%	5,479	19.1%	4,504	16.4%	4,460	16.0%
Structurally Deficient	1,162	4.0%	1,249	4.4%	1,135	4.1%	1,076	3.9%
Functionally Obsolete	4,180	14.5%	4,230	14.7%	3,369	12.2%	3,384	12.2%
Urban Bridges	25,861		26,596		27,480		27,882	
Deficient Bridges	7,920	30.6%	8,181	30.8%	7,376	26.8%	7,536	27.0%
Structurally Deficient	2,141	8.3%	2,070	7.8%	1,850	6.7%	1,809	6.5%
Functionally Obsolete	5,779	22.3%	6,111	23.0%	5,526	20.1%	5,727	20.5%
Total Bridges	**54,726**		**55,234**		**55,010**		**55,679**	
Deficient Bridges	13,262	24.2%	13,660	24.7%	11,880	21.6%	11,996	21.5%
Structurally Deficient	3,303	6.0%	3,319	6.0%	2,985	5.4%	2,885	5.2%
Functionally Obsolete	9,959	18.2%	10,341	18.7%	8,895	16.2%	9,111	16.4%

Source: National Bridge Inventory.

Exhibit 3-31

Other Arterial Bridge Deficiencies, 1994-2000



	1994		1996		1998		2000	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Rural Bridges	72,453		72,970		73,324		74,796	
Deficient Bridges	15,693	21.7%	15,693	21.5%	14,216	19.4%	13,648	18.2%
Structurally Deficient	6,914	9.5%	6,622	9.1%	6,060	8.3%	5,455	7.3%
Functionally Obsolete	8,779	12.1%	9,071	12.4%	8,156	11.1%	8,193	11.0%
Urban Bridges	57,012		59,064		60,901		63,177	
Deficient Bridges	20,506	36.0%	20,710	35.1%	20,435	33.6%	20,769	32.9%
Structurally Deficient	7,247	12.7%	6,902	11.7%	6,467	10.6%	6,013	9.5%
Functionally Obsolete	13,259	23.3%	13,808	23.4%	13,968	22.9%	14,756	23.4%
Total Bridges	**129,465**		**132,034**		**134,225**		**137,973**	
Deficient Bridges	36,199	28.0%	36,403	27.6%	34,651	25.8%	34,417	24.9%
Structurally Deficient	14,161	10.9%	13,524	10.2%	12,527	9.3%	11,468	8.3%
Functionally Obsolete	22,038	17.0%	22,879	17.3%	22,124	16.5%	22,949	16.6%

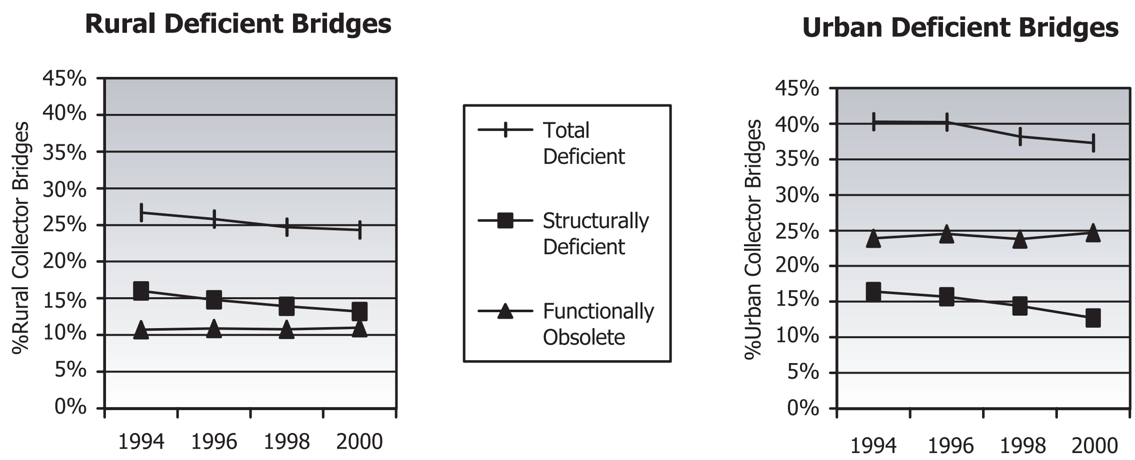
Source: National Bridge Inventory.

Q. Why has the percentage of functionally obsolete bridges not dropped in a similar manner as the percentage of structurally deficient bridges?

A. One reason may be the worsening performance of many systems. Since functional obsolescence indicates that a bridge cannot meet the capacity of the road it serves, increasing congestion would likely make many bridges functionally obsolete.

Exhibit 3-32

Collector Bridge Deficiencies, 1994-2000

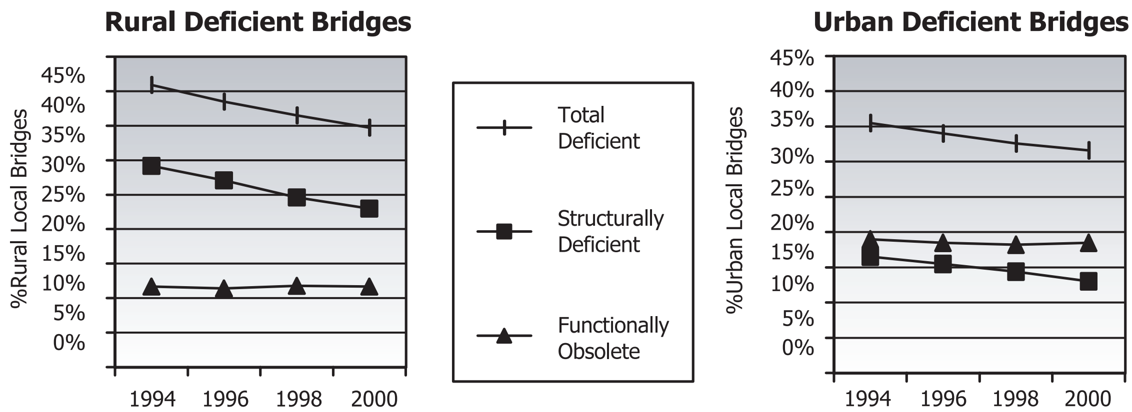


	1994		1996		1998		2000	
TOTAL BRIDGES	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**
Rural Bridges	147,612		144,246		143,140		143,357	
Deficient Bridges	39,398	26.7%	37,158	25.8%	35,368	24.7%	34,782	24.3%
Structurally Deficient	23,645	16.0%	21,375	14.8%	19,919	13.9%	18,957	13.2%
Functionally Obsolete	15,753	10.7%	15,783	10.9%	15,449	10.8%	15,825	11.0%
Urban Bridges	14,702		14,848		14,962		15,038	
Deficient Bridges	5,932	40.3%	5,976	40.2%	5,718	38.2%	5,615	37.3%
Structurally Deficient	2,415	16.4%	2,337	15.7%	2,158	14.4%	1,908	12.7%
Functionally Obsolete	3,517	23.9%	3,639	24.5%	3,560	23.8%	3,707	24.7%
Total Bridges	**162,314**		**159,094**		**158,102**		**158,395**	
Deficient Bridges	45,330	27.9%	43,134	27.1%	41,086	26.0%	40,397	25.5%
Structurally Deficient	26,060	16.1%	23,712	14.9%	22,077	14.0%	20,865	13.2%
Functionally Obsolete	19,270	11.9%	19,422	12.2%	19,009	12.0%	19,532	12.3%

Source: National Bridge Inventory.

Exhibit 3-33

Local Bridge Deficiencies, 1994-2000



	1994		1996		1998		2000	
TOTAL BRIDGES	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**	**NUMBER**	**PERCENT**
Rural Bridges	206,389		211,059		210,670		209,415	
Deficient Bridges	84,366	40.9%	81,215	38.5%	76,823	36.5%	72,633	34.7%
Structurally Deficient	60,270	29.2%	57,178	27.1%	51,885	24.6%	48,111	23.0%
Functionally Obsolete	24,096	11.7%	24,037	11.4%	24,938	11.8%	24,522	11.7%
Urban Bridges	23,566		24,441		24,969		25,684	
Deficient Bridges	8,358	35.5%	8,314	34.0%	8,132	32.6%	8,111	31.6%
Structurally Deficient	3,889	16.5%	3,785	15.5%	3,598	14.4%	3,349	13.0%
Functionally Obsolete	4,469	19.0%	4,529	18.5%	4,534	18.2%	4,762	18.5%
Total Bridges	**229,955**		**235,500**		**235,639**		**235,099**	
Deficient Bridges	92,724	40.3%	89,529	38.0%	84,955	36.1%	80,744	34.3%
Structurally Deficient	64,159	27.9%	60,963	25.9%	55,483	23.5%	51,460	21.9%
Functionally Obsolete	28,565	12.4%	28,566	12.1%	29,472	12.5%	29,284	12.5%

Source: National Bridge Inventory.

Deck Area on Deficient Bridges

A third indicator of bridge condition is deck area on deficient bridges. Engineers and policy analysts are increasingly using this measure to describe the condition of the Nation's bridges. The Federal Highway Administration's FY 2002 Performance Plan, for example, includes this indicator for NHS and non-NHS bridges. This section examines the deck area on deficient bridges by owner and functional system.

As Exhibit 3-34 describes, the nationwide percentage of deck area on deficient bridges dropped from 30.9 percent in 1996 to 27.9 percent in 2000. Bridges with unknown or unclassified ownership had the largest percentage of deck area on deficient bridges (42.8 percent in 2000), followed by privately owned bridges (33.8 percent). Federally owned bridges had the smallest percentage of deck area on deficient bridges (25.8 percent in 2000).

Exhibit 3-35, describes this information by functional system. The percentage of deck area on bridges classified as deficient decreased on every functional system from 1996 to 2000. Urban Collector bridges had the largest percentage (39.6 percent). Using this indicator, the deck area on bridges classified as deficient was consistently larger for urban systems.

Exhibit 3-36 describes the percentage of deck area on deficient bridges in 2000, with data broken down by structural deficiency and functional obsolescence. On almost every functional system, the percentage of deck area on functionally obsolete bridges was far greater than the area for structurally deficient bridges. On urban Interstates, for example, 22.8 percent of the deck area on deficient bridges resulted from functionally obsolete bridges while 8.8 percent can be attributed to those bridges classified as structurally deficient.

Exhibit 3-34

Deficient Bridge Deck Area by Owner, 1996, 1998, and 2000

	Percentage of Deck Area		
FUNCTIONAL SYSTEM	**1996**	**1998**	**2000**
Federal	23.8%	26.4%	25.8%
State	29.4%	26.7%	26.4%
Local	35.2%	34.1%	32.8%
Private	38.1%	35.5%	33.8%
Unknown	49.0%	46.3%	42.8%
Total	**30.9%**	**28.5%**	**27.9%**

Source: National Bridge Inventory.

Exhibit 3-35

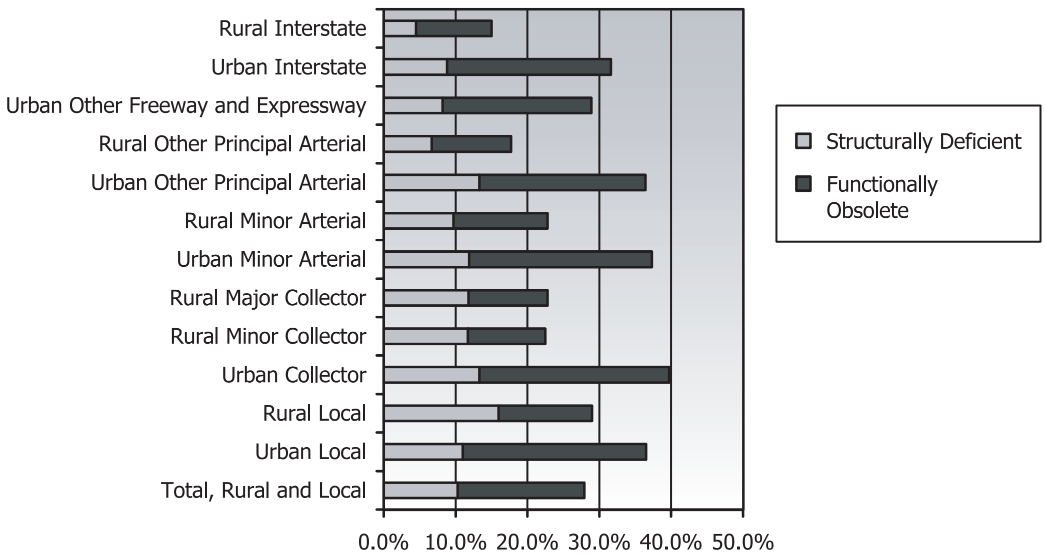
Deck Area on Deficient Bridges by Functional System, 1996, 1998, and 2000

	Percentage of Deck Area		
FUNCTIONAL SYSTEM	**1996**	**1998**	**2000**
Rural			
Interstate	17.9%	15.7%	15.0%
Other Principal Arterial	21.6%	19.0%	17.6%
Minor Arterial	26.1%	23.9%	22.9%
Major Collector	23.9%	22.9%	22.7%
Minor Collector	24.7%	23.2%	22.5%
Local	32.3%	30.3%	29.1%
Subtotal	**24.6%**	**22.7%**	**21.8%**
Urban			
Interstate	34.2%	30.9%	31.6%
Other Freeway and Expressway	32.4%	28.6%	28.9%
Other Principal Arterial	40.9%	38.3%	36.4%
Minor Arterial	40.3%	39.3%	37.3%
Collector	41.6%	39.3%	39.6%
Local	38.5%	36.7%	36.4%
Subtotal	**36.8%**	**34.0%**	**33.6%**
Bridge Total	**30.9%**	**28.5%**	**27.9%**

Source: National Bridge Inventory.

Exhibit 3-36

Deficient Bridge Deck Area by Functional Area, 2000



	Percentage of Deck Area		
	STRUCTURAL	**FUNCTIONAL**	**TOTAL**
Rural			
Interstate	4.5%	10.5%	15.0%
Other Principal Arterial	6.7%	11.0%	17.7%
Minor Arterial	9.7%	13.1%	22.8%
Major Collector	11.8%	11.0%	22.8%
Minor Collector	11.7%	10.8%	22.5%
Local	16.0%	13.0%	29.0%
Total Rural	**10.2%**	**11.6%**	**21.8%**
Urban			
Interstate	8.8%	22.8%	31.6%
Other Freeway and Expressway	8.2%	20.7%	28.9%
Other Principal Arterial	13.3%	23.1%	36.4%
Minor Arterial	11.9%	25.4%	37.3%
Collector	13.3%	26.4%	39.7%
Local	11.0%	25.5%	36.5%
Total Urban	**10.5%**	**23.2%**	**33.7%**
Total, Rural and Urban	**10.3%**	**17.6%**	**27.9%**

Source: National Bridge Inventory.

Transit System Conditions

U.S. transit system conditions can be analyzed by examining the aggregate number and type of transit vehicles in service, their average and condition, the physical condition and age of bus and rail maintenance facilities, and the condition of transit rail infrastructure components such as track, power systems, stations, and structures.

The National Transit Database (NTD) collects information from urban transit operators on fleet size, age distribution of vehicles, vehicle maintenance expenditures, and vehicle utilization, i.e., revenue miles traveled. The NTD data, however, does not provide information on the overall condition of vehicles. The Federal Transit Administration (FTA) has found the condition of vehicles of the same age can vary considerably, depending on factors such as the quality of vehicle maintenance and the geographic location in which the vehicles operate. Vehicles that are well maintained will generally be 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 also deteriorate more rapidly than vehicles that do not operate under those conditions.

FTA conducted extensive studies to estimate the mathematical relationship between the condition of a transit asset—a vehicle, facility, or rail track—and the age of the asset, its usage rate, and, when available, its maintenance history. Initial estimations of these relationships were based on extensive data collected by the Regional Transportation Authority of Northeastern Illinois and the Chicago Transit Authority in the 1990s and mid-1980s. This information was used to estimate the relationship between asset condition, age, and maintenance history over a ten-year period. The results of this study are available in a January 1996 FTA report, *The Estimation of Transit Asset Condition Ratings*.

Improvements to this estimation process have been and continue to be developed. As part of this effort, FTA has undertaken additional engineering surveys. In 1999, engineering assessments were made of the physical conditions of 77 bus maintenance facilities and 572 buses belonging to 31 transit operators. In 1999 and 2000, the physical conditions of 120 rail vehicles at ten different transit operators were also rated, with an emphasis on heavy rail vehicles and facilities. A subsequent survey of rail vehicles and facilities was undertaken in 2001, with inspections of the conditions of 36 rail facilities and 72 rail vehicles of 12 transit operators. This 2001 survey was split fairly evenly between heavy and light rail facilities and vehicles. The data collected by these studies have been used to refine the mathematical relationship used to estimate conditions for buses, heavy and light rail vehicles, facilities, and stations and to update the condition information that is presented in this chapter. No surveys of commuter rail vehicles or facilities were undertaken as a part of this effort. Commuter vehicles and facilities will be surveyed for the next version of this report.

Each vehicle and maintenance facility that was examined in an engineering assessment is assigned an overall level of condition based on a weighted average of the condition level assigned to the subcomponents of each vehicle and maintenance facility. For example, light rail vehicle subcomponents examined include the couplers, frame, bolster, gearbox, pneumatic piping, and the wiring and connections. Vehicles' exterior and interior subcomponents are also rated. Maintenance facility components that are evaluated include the roof structure, heating and ventilation systems, mechanical and plumbing systems, electrical equipment, specialty shops, and work bays. Subcomponents examined include—in the case of the roof structure—the exterior roofing frame, gutters and drainage system, and interior roof frame. In the case of specialty shops, the condition of each type of shop (e.g., machine shop, metal working shop) is evaluated separately. Condition ratings of bus vehicles and bus maintenance facilities are undertaken in a similar fashion.

The physical condition of each asset is rated on a scale of 1 to 5 with 5 being the highest level of condition. This scale corresponds to the Present Serviceability Rating (PSR) formerly used by the Federal Highway Administration (FHWA) to evaluate pavement conditions. A rating level of 5, or "excel-lent," is synonymous with no visible defects, or nearly new condition. At the other end of the scale, a rating level of 1 indicates that the asset is in need of immediate repair and may have a seriously damaged component or components *[See Exhibit 3-37]*.

Exhibit 3-37

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.

Bus Vehicle Conditions

The 1999 C & P Report revised bus vehicle conditions downwards based on survey information on the physical condition and age of bus vehicles collected by the National Bus Condition Assessment. This survey revealed that, on average, the condition of bus vehicles declined much more rapidly in the first five years of operation than was previously believed (from condition level 5 to about 3.25), after which the rate of decline was found to slow substantially with a condition level of 2.5 being reached after about 15 years, and 2.0 after 20 years.

Bus vehicle condition and age information is reported according to bus vehicle type for 1987-2000 in Exhibit 3-38. In 2000, the estimated average condition of the urban bus fleet was 3.07, up from 2.96 in 1997. Average bus vehicle age was reported to be 6.8 years, up slightly from an average age of 6.6 years in 1997. Since 1987, 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)*. Full size buses have consistently been operating at just below the adequate condition level.

Articulated buses have exhibited the most significant changes in condition levels, falling from a condition of 3.08 in 1987 to 2.49 in 1997, increasing to 3.33 in 2000. This fluctuation is most likely the result of a 12-year industry replacement policy and the fact that the bulk of *articulated buses* were purchased in 1983-84. This replacement cycle is also evidenced by a peak in the percentage of overage *articulated buses* at 61 percent in 1997, and subsequent decline to 29 percent in 2000. In all years, mid-sized buses have main-tained an average condition above 3.0 and both small buses and vans have consistently maintained an average condition of more than 3.5.

Urban Bus Maintenance Facilities

Age

The estimated age distribution of urban bus maintenance facilities in 2000 is shown in Exhibit 3-39. This distribution is based on age information collected by the 1999 National Bus Condition Assessment, and applied to the 2000 national bus facility total as reported in the National Transit Database. Ninety-two

Exhibit 3-38

Urban Transit Bus Fleet Count, Age and Condition 1987-2000 (*)

YEAR	1987	1989	1991	1993	1995	1997	1999	2000
Articulated Buses								
Total Fleet	1,712	1,730	1,764	1,807	1,716	1,523	1,967	2,078
Percent Overage Vehicles	0%	0%	13%	16%	33%	61%	46%	29%
Average Age	4.9	6.7	8.2	9.5	10.7	11.8	8.7	6.9
Average Condition	3.08	3.08	2.98	2.88	2.66	2.49	3.10	3.33
Full-Size Buses								
Total Fleet	46,231	46,446	46,660	46,824	46,335	47,149	49,195	49,721
Percent Overage Vehicles	21%	22%	17%	20%	23%	25%	26%	25%
Average Age	8.2	8.4	8.0	8.5	8.6	8.2	8.7	8.5
Average Condition	2.93	2.83	2.93	2.82	2.83	2.86	2.90	2.93
Mid-Size Buses								
Total Fleet	2,821	2,928	3,268	3,598	3,879	5,328	6,807	7,643
Percent Overage Vehicles	10%	14%	23%	24%	23%	18%	14%	15%
Average Age	5.9	6.5	6.7	6.4	6.8	5.6	5.7	5.7
Average Condition	3.03	3.13	3.13	3.14	3.08	3.30	3.30	3.30
Small Buses								
Total Fleet	2,127	2,428	3,415	4,064	5,447	7,081	8,461	9,039
Percent Overage Vehicles	11%	15%	14%	13%	13%	13%	13%	12%
Average Age	3.9	4.1	4.0	4.0	4.0	3.7	4.0	4.2
Average Condition	3.56	3.56	3.56	3.48	3.55	3.56	3.51	3.47
Vans								
Total Fleet	3,241	3,288	6,261	8,353	11,969	13,796	14,539	14,893
Percent Overage Vehicles	30%	21%	22%	22%	21%	22%	5%	6%
Average Age	3.1	2.9	3.0	3.1	3.2	2.3	3.2	3.2
Average Condition	3.78	3.78	3.78	3.59	3.71	3.75	3.71	3.71
Weighted Average Condition	2.98	2.98	2.98	2.88	2.90	2.96	3.03	3.07
Weighted Average Age	7.5	7.7	7.2	7.4	7.3	6.6	7.0	6.8

(*) 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. Bus vehicle conditions have been revised based on an improved methodology of applying NTD data to estimated decay curves. These revisions are very small in magnitude.

Sources: Transit Economic Requirements Model and National Transit Database.

percent of bus maintenance facilities are estimated to be more than 10 years old and 31 percent are more than 30 years old. Individual facility ages may not relate well to condition, since substantive renovations are made to facilities at varying intervals over time.

Exhibit 3-39

Age of Urban Bus Maintenance Facilities

	2000	
AGE (YEARS)	**NUMBER**	**PERCENT**
0-10	40	8%
11-20	202	41%
21-30	98	20%
31+	157	31%
Total	**497**	**100%**

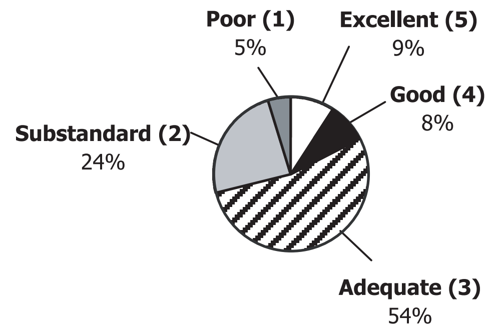
Source: National Bus Condition Assessment.

Condition

In 2000, the condition of bus maintenance facilities was estimated to be 3.23. Exhibit 3-40 provides the estimated condition level distribution of bus maintenance facilities. In 2000, 54 percent of all urban bus maintenance facilities were in adequate condition, 8 percent in good condition, and 9 percent in excellent condition, for a combined total of 71 percent in adequate-or-better condition (declining from 77 percent in 1997). Twenty-nine percent, however, are estimated to be in unacceptable condition—24 percent in substandard condition, and 5 percent in poor condition.

Exhibit 3-40

Percentage Distribution of Conditon of Urban Bus Maintenance Facilities, 2000



CONDITION	NUMBER	PERCENT
Excellent (5)	46	9%
Good (4)	41	8%
Adequate (3)	266	54%
Substandard (2)	121	24%
Poor (1)	23	5%
Total	**497**	**100%**

Source: National Bus Condition Assessment, Transit Economic Requirements Model and National Transit Database.

Rail Vehicle Conditions

The average condition of all rail vehicles except commuter rail has been re-estimated, based on engineering surveys of rail vehicle physical conditions undertaken between 1999-2001, following the completion of the 1999 C & P. The revision in rail vehicle conditions is similar to the one that occurred for bus vehicles in the 1999 Report. Analysis of the rail condition information collected in the survey revealed that rail decay curves follow a similar pattern as those for buses, i.e., rail vehicles decline rapidly during their first 5 years and more slowly thereafter. The conditions for commuter rail vehicles, for which the condition estimation procedures have not been reexamined, remain higher than for other rail vehicles. The conditions level for commuter rail vehicles reported here differs slightly from those in the 1999 C&P Report, based on the application of more comprehensive vehicle information.

In 2000, all rail vehicles were estimated to have an average condition of 3.55, down marginally from an average condition level of 3.71 in 1997. Condition levels in the 1999 Report for heavy and light rail vehicles have been revised downward by approximately one full point, from levels ranging from 4.0 to 4.7 to levels ranging from 3.25 to 3.64. Rail condition estimates are provided in Exhibit 3-41.

Rail vehicles have been, on average, in slightly better condition than bus vehicles between 1987 and 2000, with average condition levels consistently remaining above 3.5. Weighted-average rail vehicle age increased from 15.6 years in 1987, to 20.4 in 1997, to 21.8 years in 2000. The decline in average condition and increase in age has been driven by *commuter rail self-propelled passenger coaches* and *heavy rail vehicles.* The condition of *commuter rail self-propelled passenger coaches* has steadily declined from a condition of 5.0 in 1987 to 4.07 in 2000; the condition of heavy rail vehicles declined more gradually, from 3.59 in 1987 to 3.25 in 2000; the percentage of overage *commuter rail self-propelled passenger coaches* and *heavy rail vehicles* has also increased—for commuter rail self-propelled passenger coaches from 2 percent in 1987 to 61 percent in 2000, and for heavy rail vehicles from 15 percent in 1987 to 40 percent in 2000.

Conditions and ages for other rail vehicle types (*commuter rail locomotive, commuter rail passenger*

Exhibit 3-41

Urban Transit Rail Fleet Count (*), Age and Condition 1987-2000

YEAR	1987	1989	1991	1993	1995	1997	1999	2000
Commuter Rail Locomotives								
Total Fleet	491	451	467	556	570	586	644	591
Percent Overage Vehicles	30%	19%	17%	17%	21%	22%	17%	19%
Average Age	16.9	14.6	15.3	15.6	15.6	16.5	16.1	15.8
Average Condition	4.34	4.47	4.47	4.45	4.48	4.47	4.53	4.51
Commuter Rail Passenger Coaches								
Total Fleet	2,137	2,138	2,226	2,402	2,402	2,470	2,886	2,793
Percent Overage Vehicles	41%	32%	29%	29%	36%	33%	32%	29%
Average Age	19.6	18.0	17.3	18.6	20.1	19.8	18.5	17.7
Average Condition	4.23	4.36	4.36	4.20	4.12	4.09	4.21	4.28
Commuter Rail Self-Propelled Passengers Coaches								
Total Fleet	2,563	2,421	2,529	2,526	2,645	2,681	2,455	2,472
Percent Overage Vehicles	2%	5%	5%	6%	24%	25%	60%	61%
Average Age	13.3	15.0	16.5	18.2	19.7	22.0	24.3	25.2
Average Condition	5.00	4.88	4.74	4.65	4.54	4.36	4.18	4.07
Heavy Rail								
Total Fleet	10,344	10,246	10,170	10,074	10,157	10,173	10,366	10,375
Percent Overage Vehicles	15%	17%	29%	27%	37%	36%	40%	40%
Average Age	15.2	15.4	16.9	17.8	19.3	21.0	22.5	23.00
Average Condition	3.59	3.59	3.49	3.47	3.39	3.31	3.26	3.25
Light Rail								
Total Fleet	879	917	954	943	955	1,132	1,400	1,524
Percent Overage Vehicles	27%	20%	19%	10%	12%	10%	15%	13%
Average Age	17.2	15.6	16.6	14.9	14.8	14.6	18.9	18.4
Average Condition	3.60	3.71	3.60	3.64	3.55	3.63	3.62	3.63
Total Rail								
Weighted Average Condition	3.91	3.91	3.80	3.77	3.70	3.61	3.57	3.55
Weighted Average Age	15.6	15.7	16.8	17.7	19.1	20.4	21.6	21.8

(*) Includes vehicles that are not in active service. Rail fleets sizes reported here are slightly larger than those reported for active rail vehicles in Chapter 2.

Sources: Transit Economic Requirements Model and National Transit Database.

coaches, and *light rail vehicles*), which continue to account for a growing percentage of rail transit vehicles, have remained relatively constant and, in some cases, shown marginal improvement in condition and decrease in age between 1987 and 2000. The percentage of these rail vehicle types that are overage has also declined over this period. In 2000, the average age of *commuter rail locomotives* was 15.8 years and their average condition 4.51. Between 1987 and 2000, their average age fluctuated between 15.3 and 16.9 years and their average condition level between 4.34 and 4.53. The average age and condition of *commuter rail passenger coaches* have also remained relatively constant. Between 1987 and 2000, their average condition fluctuated between 4.09 and 4.36 and their average age between 17.3 and 20.1 years. In 2000, their average condition was 4.28 and average age 17.7 years. In the case of *light rail,* average vehicle condition ranged from 3.55 to 3.71 between 1987 and 2000. Their average age declined from 17.2 years in 1987 to 14.9 years in 1997, subsequently rising to 18.9 years in 1999. The industry standard replacement age for light rail vehicles is 25 years.

Urban Rail Maintenance Facilities

Urban rail maintenance facilities continue to age and their condition has continued to deteriorate, although the average condition remains adequate/ fair. In 2000, urban rail maintenance facilities had an average condition of 3.18. As shown in Exhibit 3-42, almost half of all urban rail maintenance facilities are more than 30 years old, and 85 percent are more than 10 years old. The condition of these facilities, updated based on engineering surveys of 36 rail facilities in 2000 and 2001, is lower than in 1997. About 75 percent of this decline was due to methodological revisions.

Exhibit 3-42

Age of Urban Rail Maintenance Facilities

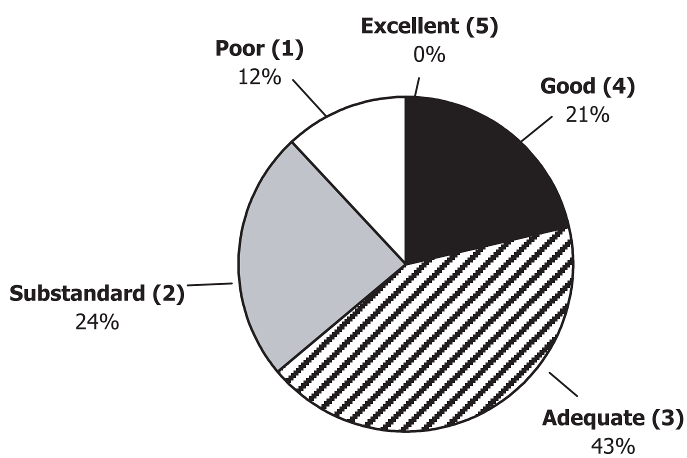
AGE OF FACILITY	2000 NUMBER	2000 PERCENT
0-10	22	15%
10-20	34	23%
21-30	23	15%
31+	71	48%
Total	**150**	**100%**

Source: National Rail Condition Assessment, 2000-2001.

The distribution of the conditions of urban rail maintenance facilities found in the most recent surveys are provided in Exhibits 3-43. Twenty-one percent of all urban rail maintenance facilities were found to be in good or better condition, and 64 percent in adequate or better condition. By comparison, the 1999 C & P Report stated that 60 percent of all urban rail maintenance facilities were in good or better condition and 77 percent in adequate or better condition. The percentage of facilities in substandard or worse condition was also found to have climbed to 36 percent in 2000 from 23 percent in 1997. Again, these changes, in part, reflect revisions to the decay curves and not solely deterioration in condition levels.

Exhibit 3-43

Percentage Distribution of Condition of Urban Rail Maintenance Facilities, 2000



CONDITION	2000 NUMBER	2000 PERCENT
Excellent (5)	0	0%
Good (4)	32	21%
Adequate (3)	64	43%
Substandard (2)	36	24%
Poor (1)	18	12%
Total	**150**	**100%**

Source: National Rail Condition Assessment, 2000-2001.

Other Urban Rail Infrastructure

The condition of urban rail infrastructure other than maintenance facilities and stations is estimated on the basis of decay curves relating condition to age, usage, and maintenance history. This information is based primarily on rail asset information collected by the Chicago Transit Authority (CTA) during the 1980s and 1990s for an Engineering Condition Assessment (ECA). Additional, but considerably more limited, asset condition data was provided by Metra and Pace, two transit operators in the Chicago area. The infrastructure data are based on the dollar amounts spent on different asset types (in constant dollars) rather than a numeric count of the assets. For this reason, condition results are displayed as percentages across condition levels rather than in units. The data collected were used to estimate decay curves for more than 40 different 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. These results supersede those from a previous survey of rail system asset conditions in nine metropolitan areas, *The Status of the Modernization of the Nation's Rail Transit Systems*, June 1992. Conditions results for 1992, reported in Exhibit 3-44, are based on the earlier survey and are, therefore, not entirely comparable to those reported for 1997 and 2000. The 1992 survey was considerably smaller in scope than the one conducted by CTA.

Exhibit 3-44

Physical Condition of U.S. Transit Rail Infrastructure -- Selected Years, 1992-2000

	CONDITION														
	1 POOR			2 SUBSTANDARD			3 ADEQUATE			4 GOOD			5 EXCELLENT		
	1992	1997	2000	1992	1997	2000	1992	1997	2000	1992	1997	2000	1992	1997	2000
Track	0%	7%	7%	5%	10%	10%	32%	10%	12%	49%	49%	45%	14%	24%	26%
Power Systems															
Substations	2%	12%	6%	19%	6%	6%	17%	10%	10%	56%	57%	58%	6%	15%	20%
Overhead Wire	0%	5%	6%	33%	11%	6%	10%	18%	11%	52%	34%	61%	5%	32%	16%
Third Rail	0%	14%	8%	21%	11%	8%	20%	15%	11%	53%	43%	48%	6%	17%	24%
Stations	0%	15%	0%	5%	13%	16%	29%	15%	50%	63%	46%	33%	3%	11%	1%
Structures															
Elevated Structure	na	1%	2%	na	29%	22%	na	12%	16%	na	59%	59%	na	0%	2%
Bridges	0%	na	na	11%	na	na	28%	na	na	54%	na	na	7%	na	na
Elevated Sections	0%	na	na	1%	na	na	72%	na	na	15%	na	na	12%	na	na
Underground Tunnels	0%	9%	12%	5%	19%	11%	34%	18%	19%	51%	47%	46%	10%	7%	12%
Maintenance															
Facilities	2%	6%	12%	34%	17%	24%	12%	17%	43%	35%	53%	21%	17%	7%	0%
Yards	2%	0%	0%	7%	0%	0%	26%	37%	50%	55%	63%	50%	9%	0%	0%

Note: 1997 and 2000 data are from TERM; 1992 data are from "The Status of the Modernization of the Nation's Rail Transit Systems."

Sources: Transit Economic Requirements Model (TERM),"Status of the Modernization of the Nation's Rail Transit Systems," FTA, June 1992.

Track conditions are estimated to have remained constant since 1997, with 83 percent of all track estimated to be in adequate or better condition in both 1997 and 2000. *[See Exhibit 3-44].* The average condition of *power systems* appears to have improved slightly since 1997. In 2000, 88 percent of substations and overhead wire (power system components) were estimated to be in adequate or better condition compared with 82 and 84 percent, respectively, in 1997. The condition of third rail, also a power system component, has improved even more dramatically, with 83 percent estimated to be in adequate or better condition in 2000, compared with 75 percent in 1997.

Station conditions in 2000 have been calculated on the basis of newly estimated decay curves for rail maintenance facilities. While the percentage of stations estimated to be in adequate or better condition has increased from 77 percent in 1997 to 84 percent in 2000, the percentage in good or better condition has declined from 54 percent in 1997 to 34 percent in 2000. These changes have resulted from the application of the newly estimated decay curve rather than in a change in the actual condition level of stations.

The conditions of *structures* (elevated structures and underground tunnels) have also improved. In 2000, 77 percent of this infrastructure was estimated to be in adequate or better condition, compared with 71 to 72 percent in 1997. The condition of *rail yards* has declined. In 2000, 50 percent of all yards were in good condition and 50 in adequate condition compared with 63 percent in good condition and 37 percent in adequate condition in 1997.

Rural Transit Vehicles and Facilities

Data on the conditions of rural vehicles and facilities is available from surveys funded by the Federal Transit Administration and conducted by the Community Transportation Association of America. Rural operators are defined as those operators outside urbanized areas, a different definition than used by the U.S. Census. Two surveys were conducted in 1997 and 2000, with a total of 158 rural transit operators responding. The data collected ranged from June 1997 to June 1999, but have been combined for the purposes of this analysis, as shown in Exhibit 3-45. Data from the last survey, conducted in 1994, was presented in the 1999 Conditions and Performance Report.

Exhibit 3-45

Number of Overage Vehicles and Average Vehicle Age in Rural Transit

	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.

More than 50 percent of the rural transit fleet is overage. According to transit vehicle type, 41 percent of small buses, 34 percent of medium-size buses, 27 percent of full-size buses and 60 percent of vans and other vehicles are overage.

The condition of rural bus maintenance facilities changed minimally between 1992 and 1999 [See Exhibit 3-46]. While the percentage of facilities in good or excellent condition declined marginally, from 82 to 80 percent, the percentage in very poor condition dropped from four percent in 1992 to one percent in 1999.

Special Service Vehicles

There is no current information available on the age and condition of special service vehicles. The last survey of special service vehicle ages was undertaken in 1994. This survey found that 19 percent of all medium buses were overage, 18 percent of all small buses and 43 percent of vans and other vehicles.

Exhibit 3-46

Condition of Rural Bus Maintenance Facilities

CONDITION	PERCENT	
	1999	1992
Excellent	30%	30%
Good	50%	52%
Poor	19%	14%
Very Poor	1%	4%
Total	**100%**	**100%**

Source: Community Transportation Association of America (CTAA).

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 last Conditions and Performance Report in 1999. The first data column contains the values reported in the 1999 report, which were based on 1997 data. Revisions are shown in the second column. The third column reports 2000 values.

Exhibit 4-1

Comparison of Highway and Transit Operational Performance Statistics with Those in the 1999 C&P Report

STATISTIC	1997 DATA: 1999 REPORT	1997 DATA: REVISED	2000 DATA
Percent of Additional Travel Time	N/A	45%	51%
Annual Hours of Traveler Delay per Year	N/A	28.1	31.2
Percent of Travel Under Congested Conditions	N/A	31.7%	33.1%
Daily Vehicle-Miles Traveled (DVMT) per Lane Mile			
Interstates in Urbanized Areas	N/A	14,361	15,310
Other Freeways and Expressways in Urbanized Areas	N/A	11,217	12,210
Other Principal Arterials in Urbanized Areas	N/A	6,092	6,103
Passenger-mile Weighted Average Operating Speed (miles per hour)			
Total	20.3		19.6
Rail	26.1		24.9
Non-Rail	13.8		13.7
Annual Passenger Miles per Capacity-equivalent Vehicle (thousands)			
Bus	400.6		393.2
Heavy Rail	696.3		783.7
Commuter Rail	814.7		914.3
Light Rail	637.6		687.6
Demand Response	170.1		168.8

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

The 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 2000, a trip that would take 20 minutes during non-peak, non-congested conditions would typically require 30.2 minutes if taken during the peak period of travel or 51 percent longer. In 1997, that same trip would have required 29.0 minutes if taken during the peak travel period, 45 percent longer than under non-peak, non-congested conditions.

Annual Hours of Traveler Delay is an indicator of the total time an individual loses due to traveling under congested conditions in a single year. In 2000, the average driver experienced a loss of 31.2 hours due to congestion. This is an increase of 3.1 hours over the amount of annual delay in 1997 or an increase of more than 11 percent over the three-year period.

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 31.7 percent in 1997 to 33.1 percent in 2000. Based on this measure, the average congested period or length of "Rush Hour" has increased more than 18 minutes from 1997 to 2000. 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 2000 was approximately 5.3 hours; however, larger communities have the potential of experiencing average lengths of congested periods of 7 to 8 hours.

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 14,361 to 15,310 between 1997 and 2000. DVMT per lane-mile on Urbanized Other Freeways and Expressways grew from 11,217 to 12,210 over this period.

The highway information presented in this chapter are 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 2003 Performance Plan.

Transit operational performance can be evaluated by examining trends in speed and in vehicle utilization rates based on operating data collected in the National Transit Database (NTD). It can also be evaluated with passenger surveys of travel time, waiting time, and seating conditions collected from nationwide surveys.

The operational performance of transit services appears to have diminished marginally over the last few years, particularly for rail modes. Passenger-mile weighted average operating speeds for all transit services combined fell from 20.3 miles per hour in 1997 to 19.6 miles per hour in 2000. The average operating speed of rail services declined from 26.1 miles per hour in 1997 to 24.9 miles per hour in 2000. Non-rail service operating speeds have remained relatively constant—13.8 miles per hour in 1997 and 13.7 in 2000. Vehicle utilization rates have increased for rail modes—commuter rail, heavy rail and light—but declined for buses and demand response vehicles. Annual passenger miles per capacity-equivalent vehicle, in thousands, increased from 814.7 in 1997 to 914.3 in 2000 for commuter rail; from 696.3 to 783.7 for heavy rail; and from 637.6 to 687.6 for light rail.

The most recent nationwide survey of transit travel for which data are available is the 1995 National Household Travel Survey. This information was also presented in the 1999 C&P report. This survey found that, in general, transit provides more reliable and comfortable service to people with higher income levels.

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.

While congestion is conceptually easy to understand, it has no widely accepted definition. 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. What may be considered congestion in a city of 300,000 may be greatly different than perceived traffic conditions 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 affect 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.

Daily vehicle miles of travel (DVMT) per lane mile is the most basic measure of how much travel is being accommodated on our highway systems, 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 speeds, delay, or user costs. The traditional congestion measure in this report has been volume service flow (V/SF) ratio, 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 only addresses the peak hour and does not measure the duration 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.

The 1999 Conditions and Performance report adopted a measure of hours of delay per 1000 vehicle miles to incorporate the effects of congestion throughout the day, not only during the peak hour of travel. Since that report was issued, the FHWA has revised its methodology for calculating delay, and has adopted new indicators for measuring congestion. This report will focus mainly on these new metrics, Percent of Additional Travel Time, Annual Hours of Delay, and Percent of Travel Under Congested Conditions.

The Concern with Operational Performance

Operational performance is a growing concern because greater demands are being placed on the Nation's highways and streets. Demand for highway travel by American residents is continually increasing:

- The U.S. population is likely to grow between 6 percent and 13 percent between 2000 and 2010, to 300 million. Immigration is at its highest levels since the period between 1911-1920, adding 7.6 million residents from 1991 to 1998.

- Population growth and the resulting demand for travel is concentrated in metropolitan areas. The 280 metropolitan statistical areas reached 229.2 million residents in 2000, representing 81.4 percent of total U.S. population and accounting for about 20 percent of U.S. land area.

- Metropolitan growth is occurring in the suburbs, often out of the reach of public transit. The share of population in the suburbs increased from 44 percent to 47 percent, and the share of jobs in suburbs increased from 37 percent in 1980 to 42 percent by 1990. This increase does not appear to have slowed significantly since 1990.

As population and the number of travelers continue to grow, the amount of travel per person is also increasing.

- Local travel per person grew from 2.9 to 4.3 one-way trips per day from 1977 to 1995. Annual miles traveled per person grew from 9,470 to 14,115.

- Long distance travel per person grew from 2.4 to 3.8 roundtrips per year from 1977 to 1995. Annual distance traveled per person on long-distance domestic travel grew from 1,700 to 3,100 miles.

- About 90 percent of local trips and 79 percent of long-distance trips in 1995 were by personal use vehicles. About 78 percent of commuters drove themselves to work in 1999, up from 72 percent in 1985, while carpooling declined from 14 percent to 9 percent.

Demand for highway travel by American businesses to move freight also continues to increase:

- Between 1993 and 1997, the weight of commodities shipped by truck from U.S. establishments increased 20.6 percent, a compound rate of 4.9 percent per year. As noted in chapter 22, the volume of freight movement is forecast to nearly double by 2020.

- Between 1992 and 1997, the number of trucks (excluding pickups, panels, minivans, sport utility vehicles, station wagons, and all government-owned vehicles) increased 10.8 percent to 5.7 million vehicles. During that time, total miles traveled by trucks increased 35.0 percent to 157 billion miles, a compound rate of 6.2 percent per year. Average miles traveled per truck increased 21.9 percent to 27,800 miles, a compound rate of 4.0 percent per year.

Where growth of vehicle travel has been concentrated, highway capacity is often exceeded, speeds decrease, and travel times lengthen and become less predictable. These decreases in operational performance translate into monetary costs for travelers, shippers, and carriers, as described in Chapter 13.

New Operational Performance Measures

As indicated earlier, the primary operational performance measures used in this chapter will be Percent of Additional Travel Time, Annual Hours of Traveler Delay, and Percent of Travel Under Congested conditions. These measures are also included in the FHWA Fiscal Year 2003 Performance Plan.

Q. How are the new measures for measuring congestion calculated?

A. The FHWA has adopted procedures developed by the Texas Transportation Institute for use in their annual Urban Mobility Study. The values shown in this report and in the FHWA Fiscal Year 2003 Performance Plan differ from those in TTI's annual study due to differences in the scope of the analyses. The FHWA values are a broad measure of the congestion for a large number of urban areas (397 for the year 2000). The TTI study includes a more detailed analysis of 68 major population centers.

Percent of Additional Travel Time

The 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. This measure accounts for the additional time required due to increased traffic volumes on the highway and the additional delay caused by crashes, poor weather, special events, or other non-recurring 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 how the Percent of Additional Travel Time has grown over time. In 2000 an average peak period trip required 51 percent longer than the same trip under non-peak, non-congested, conditions. In 1987, an average 20-minute trip during non-congested periods required 25.8 minutes under congested conditions. The same trip in 2000 required 30.2 minutes or an additional 4.4 minutes. Note that while the values for different years are generally comparable, they are based on data for different numbers of areas in different years as shown in Exhibit 4-2. The same number of communities was used in the determination of the remaining two performance measures.

Exhibit 4-2

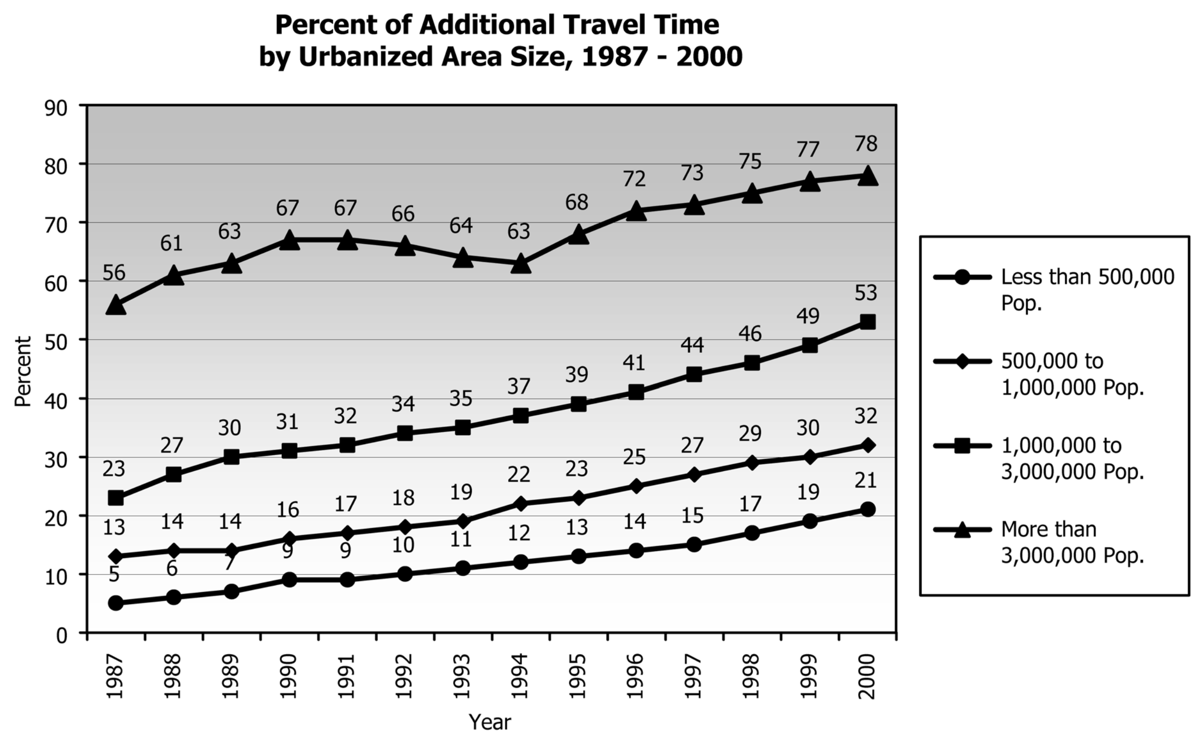
Percent of Additional Travel Time, 1987-2000

YEAR	NUMBER OF URBAN AREAS STUDIED	PERCENT ADDITIONAL TRAVEL TIME
1987	344	29%
1988	360	33%
1989	363	35%
1990	356	37%
1991	371	37%
1992	386	37%
1993	346	38%
1994	360	38%
1995	360	41%
1996	359	43%
1997	399	45%
1998	397	47%
1999	397	49%
2000	397	51%

Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Exhibit 4-3 demonstrates that the additional travel time required due to congestion tends to be higher in larger urbanized areas than smaller ones. However, the largest increase from 1987 to 2000 occurred in urbanized areas with populations between 1,000,000 and 3,000,000, as the Percent of Additional Travel Time increased from 23 to 53 percent. This equates to a 6.0-minute increase (from 24.6 to 30.6 minutes) for an average trip that would require 20 minutes during non-congested periods.

Exhibit 4-3



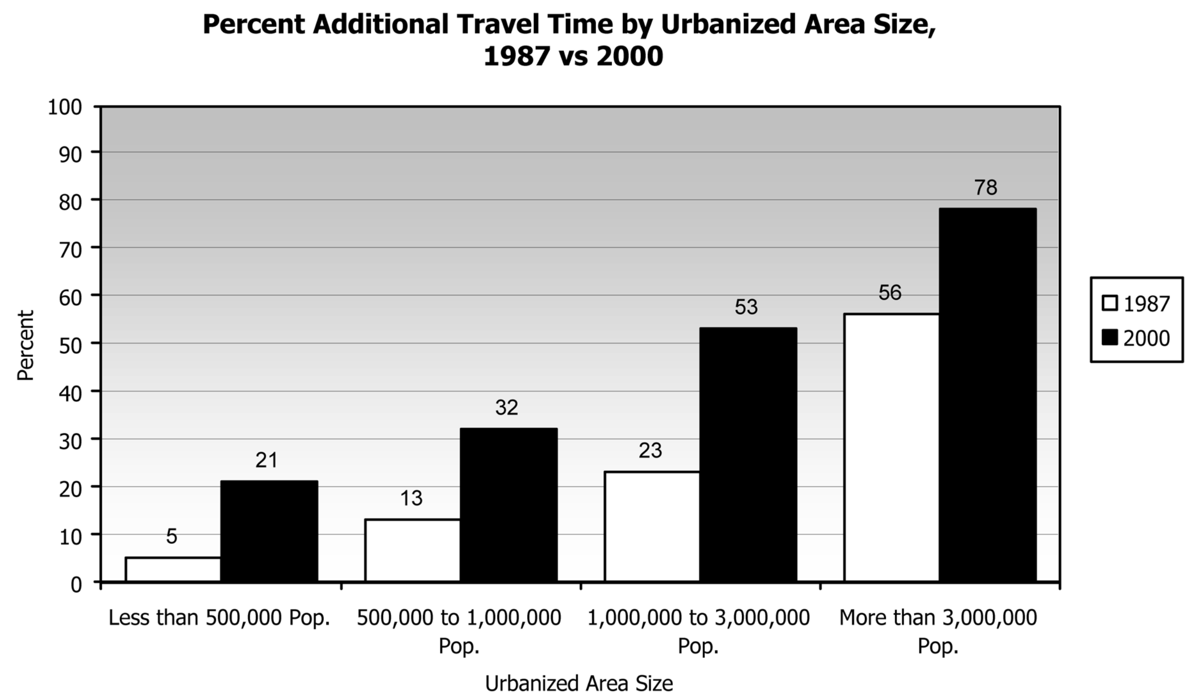
Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Q. What goal was set for the Percent of Additional Travel Time in the FHWA FY 2003 Performance Plan?

A. The goal adopted in the FHWA Performance Plan is to slow the growth of travel time to no more than 1 percentage point per year. This would be lower than the rate of increase experienced since 1987—1.7 percentage points per year.

Exhibit 4-4 directly compares the years 1987 and 2000 to emphasize the impact of increased congestion. The exhibit shows that, in 2000, smaller urbanized areas with a population of less than 500,000 population are experiencing close to the same level of additional travel time due to congestion as urbanized areas with populations of 1,000,000 to 3,000,000 experienced in 1987. This indicates a growing and expanding problem for the Nation's urban highway system.

Exhibit 4-4

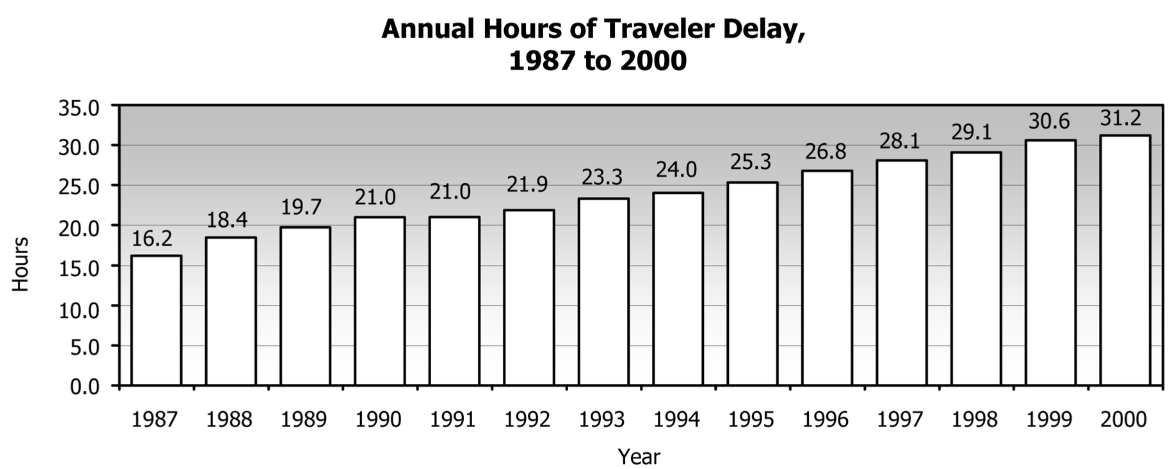


Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Annual Hours of Delay

The annual hours of delay represents the average number of hours that drivers are delayed in traffic per year due to recurring congestion and incidents, such as breakdowns and crashes. Exhibit 4-5 shows that, in 2000, the average driver experienced a loss of 31.2 hours due to congestion. This is an increase of 3.1 hours over the amount of annual delay in 1997 or an increase of more than 11 percent over a three-year period.

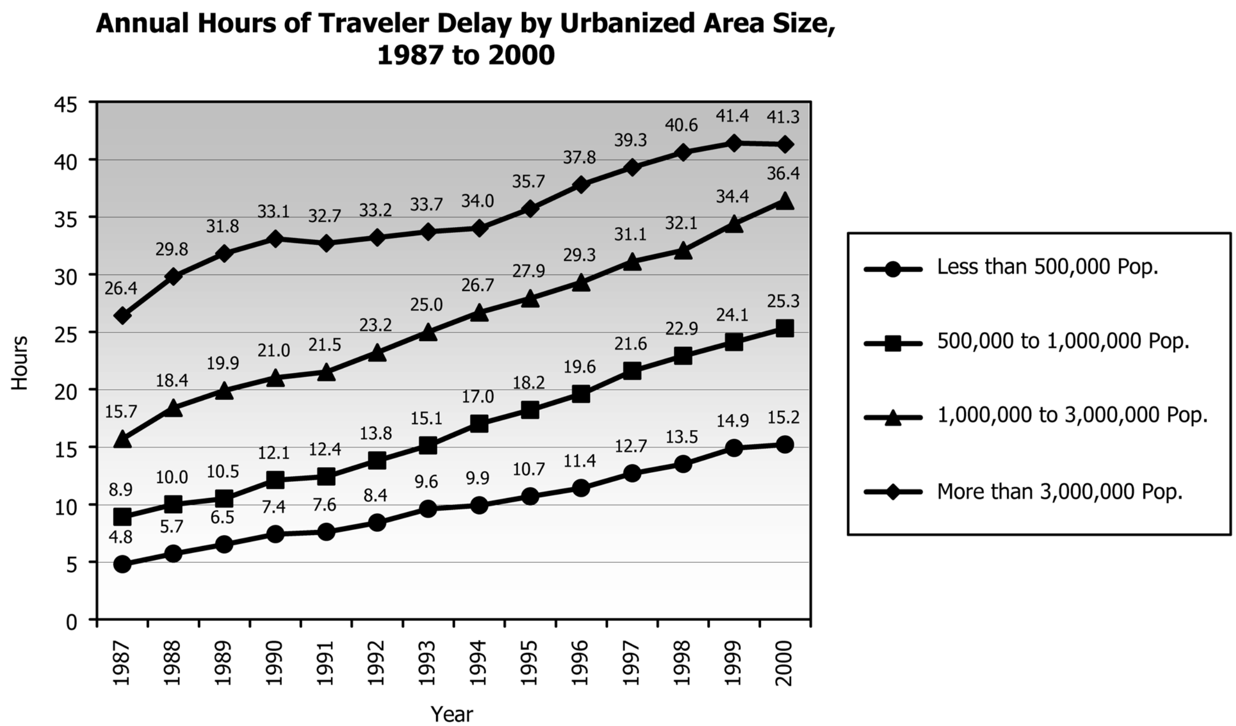
Exhibit 4-5



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Exhibit 4-6 shows that cities over 3 million in population have experienced an increase of 2 hours in the Annual Hours of Delay per traveler since 1997. The average delay per traveler for these cities was 41.3 hours per driver per year in 2000. Cities with populations between 1,000,000 and 3,000,000 experienced the greatest increase in number of hours of annual delay per person, from 31.1 hours in 1997 to 36.4 hours in 2000. This is an increase of 5.3 hours of delay per person per year. Cities with populations of less than 500,000 experienced the greatest percentage growth in Traveler Delay since 1997—from 12.7 hours to 15.2 hours, an increase of almost 20 percent.

Exhibit 4-6



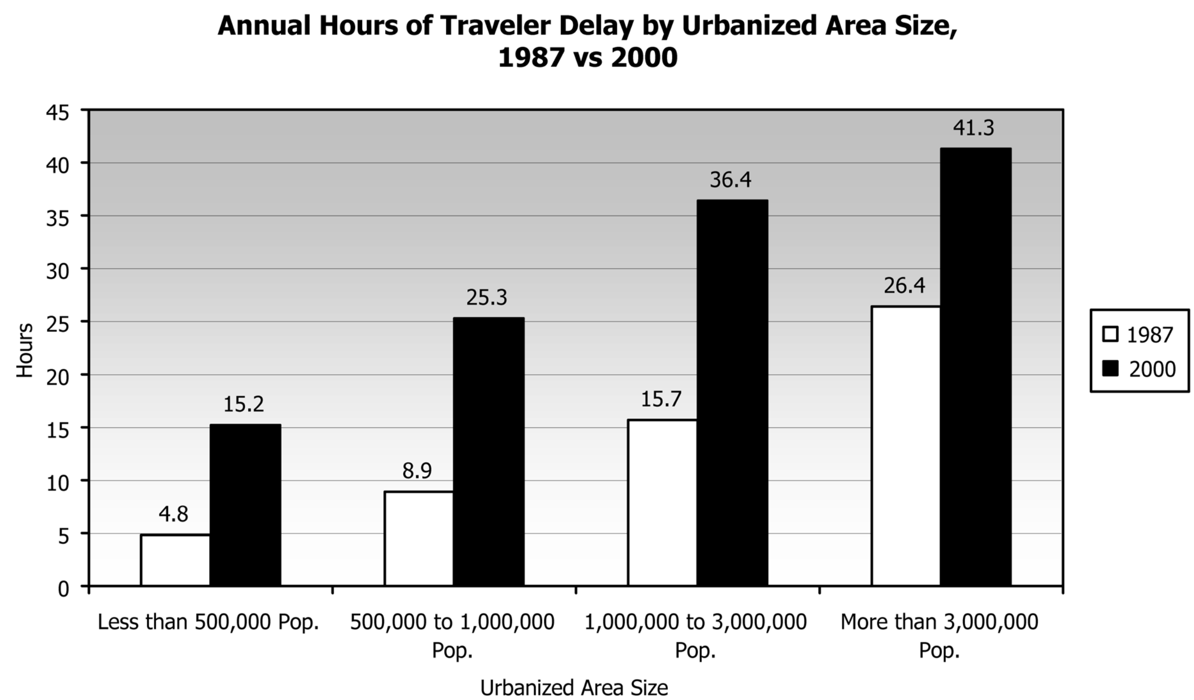
Source: Texas Transportation Institute, 2001 Urban Mobility Study.

The significance of the impact in increased Annual Hours of Delay is shown in Exhibit 4-7. A comparison between the years 1987 and 2000 shows that drivers in cities with populations under 500,000 are experiencing close to the same delays in 2000 as drivers experienced in communities with populations between 1,000,000 and 3,000,000 in 1987. In a span of 13 years, the level of congestion has affected smaller cities to a point equivalent to cities 4 to 6 times their size in 1987, but without the accompanying population growth.

Q. What goal was set for annual hours of traveler delay in the FHWA FY 2003 Performance Plan?

A. The plan observes that delay increased approximately 1-hour per year since 1998. The goal adopted in the FHWA Performance Plan was to slow the growth of delay time by 30 minutes per year.

Exhibit 4-7

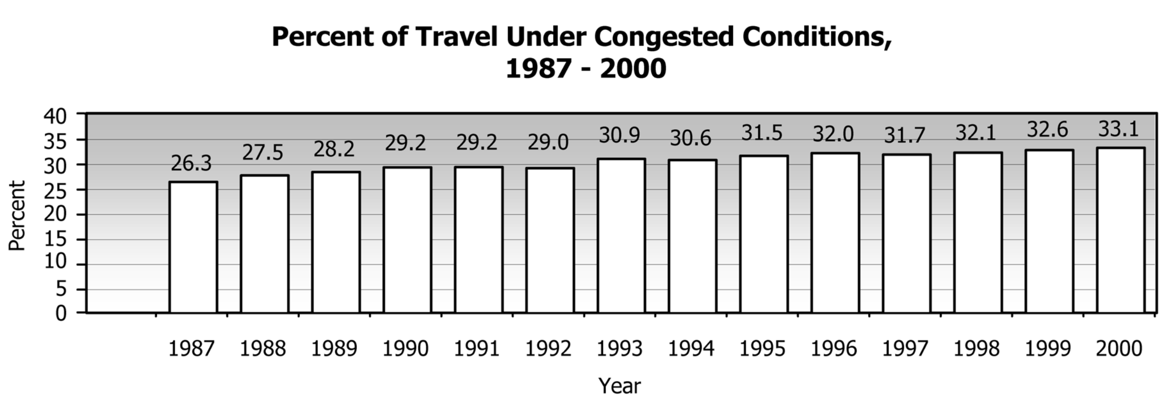


Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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 31.7 percent in 1997 to 33.1 percent in 2000. The average congested travel period has increased from approximately 5 hours in 1997 to approximately 5.3 hours in 2000—an increase in length of 18 minutes.

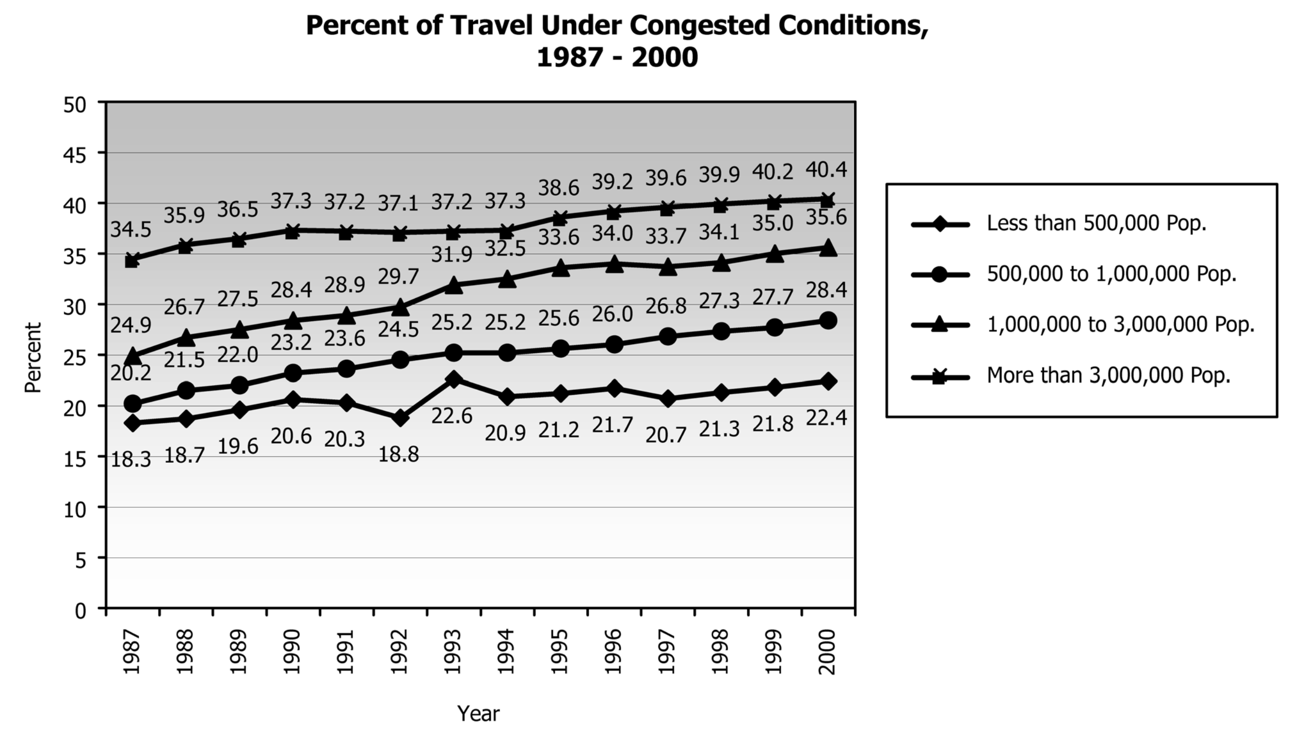
Exhibit 4-8



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Exhibit 4-9 shows that in urban areas with populations greater than 3,000,000, 40.4 percent of daily travel in 2000 was under congested conditions. For urban areas with populations of less than 500,000, the Percent of Congested Travel was 22.4 percent in 2000.

Exhibit 4-9



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

According to work by TTI, periods of recurring congestion are getting longer. What was formerly called "rush hour" can range from approximately 4 hours per day in small metropolitan areas to nearly 8 hours per day in very large metropolitan areas. This indicates that, in some places, recurring congestion is now no longer restricted to the traditional peak commuting periods, but may continue from morning to evening on weekdays. Recurring congestion also occurs on heavily traveled routes on Saturdays and Sundays.

> **Q. What goal was set for the percent of travel under congested conditions in the FHWA FY 2003 Performance Plan?**
>
> **A.** The plan observes that this percentage has increased by approximately 0.5 percent per year in recent years. The goal adopted in the FHWA Performance Plan was to slow the growth of congested travel by 0.2 percent per year.

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, and 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 developing economy.

The Texas Transportation Institute's *2001 Urban Mobility Report* estimates that in the 68 urban areas studied in 1999, drivers experienced 4.48 billion hours of delay and wasted 6.8 billion gallons of fuel. Total congestion cost for these areas, including wasted fuel and time, was estimated to be about $77.8 billion. Almost 58 percent of that cost, or approximately $45.1 billion, was experienced in the 10 metropolitan areas with the most congestion. Exhibit 4-10 shows the 20 urban areas with the highest congestion costs, according to the Texas Transportation Institute.

Exhibit 4-10

Annual Cost of Congestion - Top 20 Urban Areas

	ANNUAL COST DUE TO CONGESTION ($ MILLIONS)			
URBAN AREA	**DELAY**	**FUEL**	**TOTAL**	**RANK**
Los Angeles, CA	10,880	1,690	12,570	1
New York, NY-Northeastern, NJ	8,720	1,025	9,745	2
Chicago, IL-Northwestern, IN	4,135	470	4605	3
San Francisco-Oakland, CA	2,635	420	3,055	4
Detroit, MI	2,530	280	2,810	5
Washington, DC-MD-VA	2,460	270	2,730	6
Houston, TX	2,410	255	2,665	7
Atlanta, GA	2,385	235	2,620	8
Boston, MA	1,940	215	2,155	9
Philadelphia, PA-NJ	1,795	195	1,990	10
Dallas, TX	1,685	180	1,865	11
Seattle-Everett, WA	1,630	230	1,860	12
San Diego, CA	1,570	250	1,820	13
Minneapolis-St. Paul, MN	1,405	160	1,565	14
St. Louis, MO-IL	1,355	140	1,495	15
Miami-Hialeah, FL	1,335	150	1,485	16
Denver, CO	1,270	145	1,415	17
Phoenix, AZ	1,220	165	1,385	18
San Jose, CA	1,080	170	1,250	19
Baltimore, MD	1,035	115	1,150	20

Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Safety Effects of Congestion

Recent newspaper stories about "road rage" highlight the escalating problem of congestion in the United States. Increased congestion levels or the length of time driving in peak congested periods has an impact on the behavior and stress levels of drivers. A recent report completed by the Texas Transportation Institute entitled *Understanding Road Rage: Evaluation of Promising Mitigation Measures* indicates the possibility of increased aggressive driving in congested conditions. The report cited three studies designed to measure the stress levels of drivers under various driving conditions. These indicated a trend towards higher stress levels in drivers when driving in congested conditions as opposed to non-congested conditions. Drivers under greater stress may tend to drive in a more aggressive manner, creating the potential for additional crashes or incidents. Additional study would be needed to verify this hypothesis.

Other Operational Performance Measures:

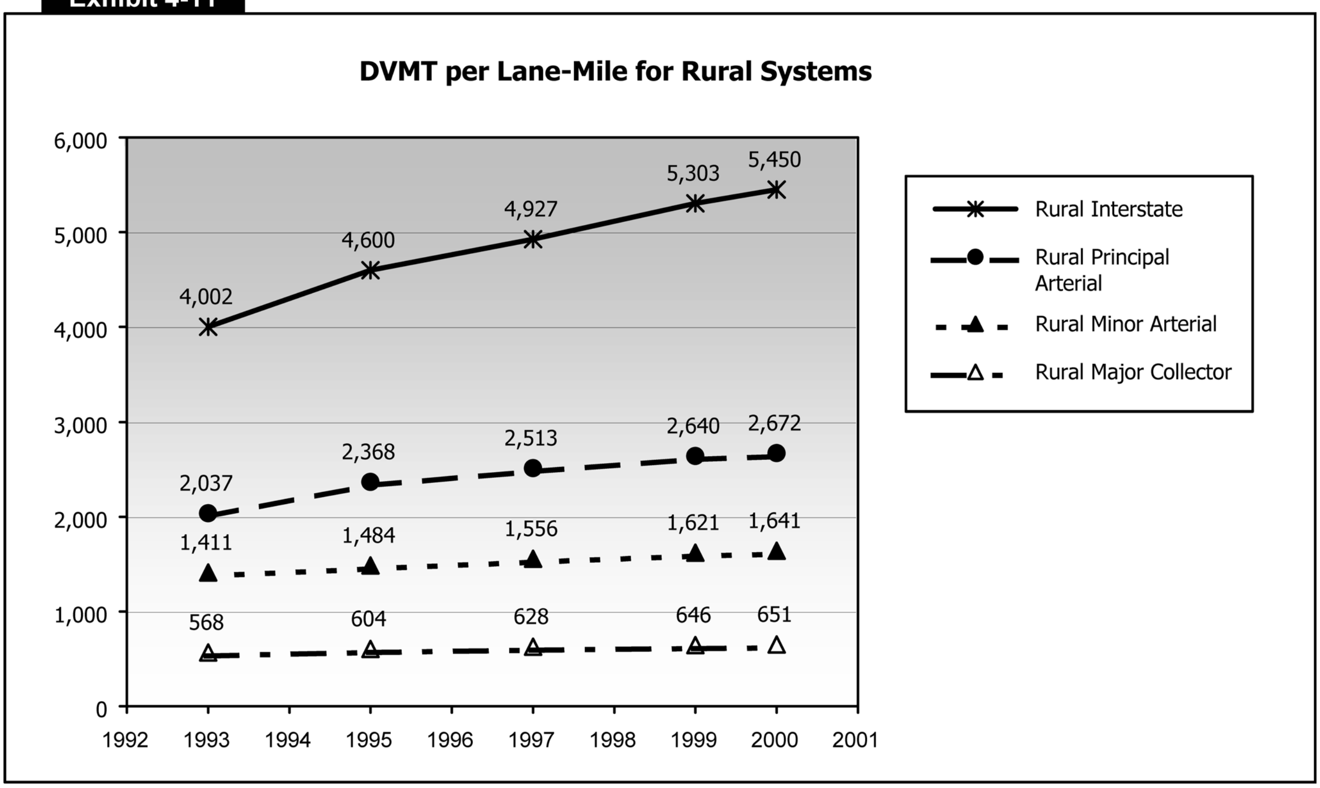
Length of Time of Trip and Average Trip Speed

Whereas the new FHWA operational performance measures suggest that congestion is getting worse on average, the individual traveler's experience of congestion may be very different. The Nationwide Personal Transportation Survey (NPTS) reports from a sample of U.S. households that the average commute took slightly longer in 1995 than in 1983 (21 minutes versus 18 minutes one-way) but was over a greater distance (11.6 miles in 1995 versus 8.5 in 1983). The average commuting speed, including trips by all modes, went from 28 mph in 1983 to 34 mph in 1995. While this trend seems to fly in the face of the increasing congestion, it reflects the fact that the NPTS measures the individual's experience with the system rather than a system-wide indicator. The individual, who may be doing a greater portion of the commute in the outer suburban fringe, could have a higher average speed even though congestion on the roads in the more densely populated areas had increased.

DVMT per Lane-Mile

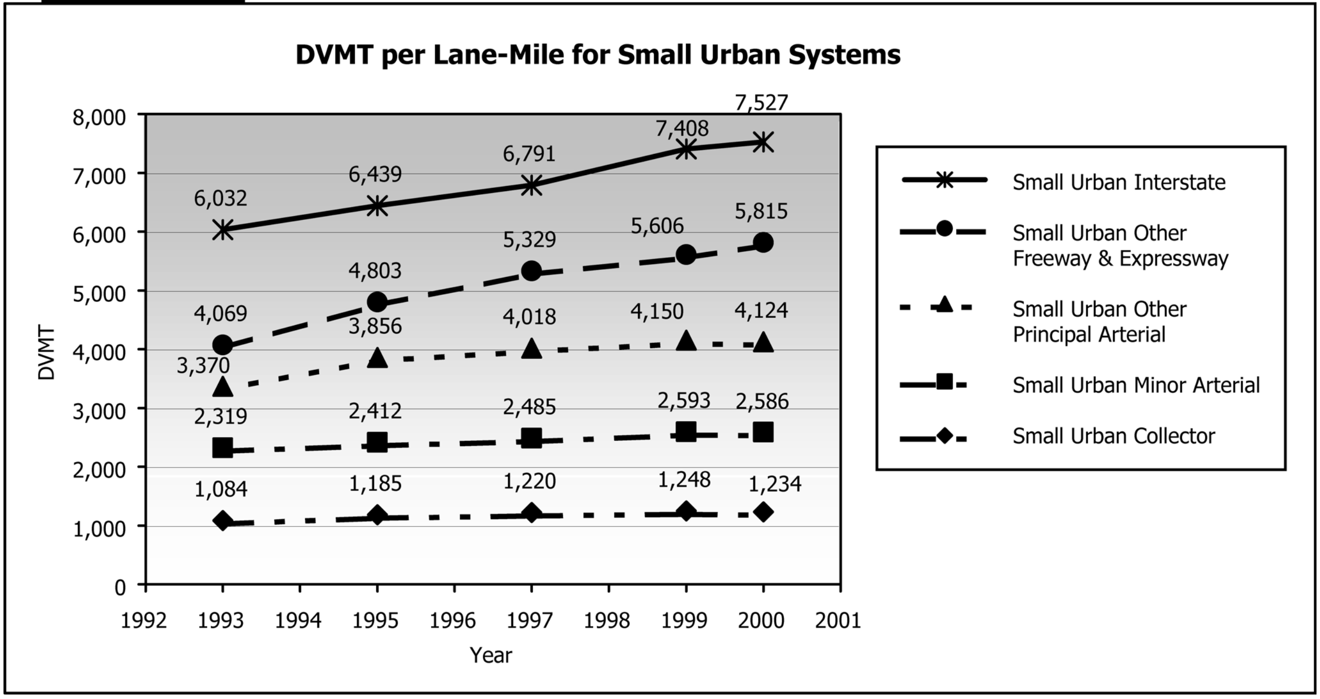
As discussed earlier in this chapter, DVMT per Lane-Mile is a basic measure of travel density that does not fully capture the effects of congestion. However, this measure does provide an indication that the demand for travel is growing faster than the supply of highways. Exhibits 4-11, 4-12 and 4-13 show that the volume of travel per lane mile has increased from 1993 to 2000 on every functional highway system for which data are collected.

Exhibit 4-11



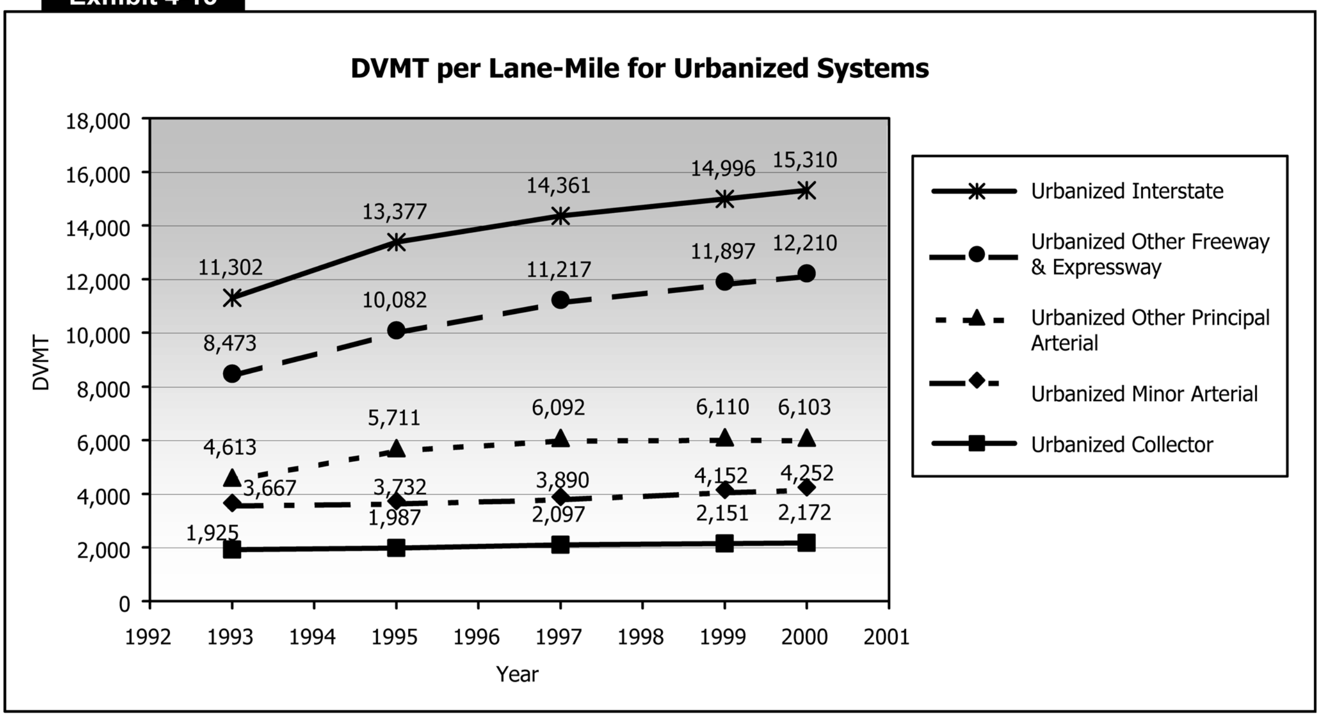
Source: Highway Performance Monitoring System.

Exhibit 4-12



Source: Highway Performance Monitoring System.

Exhibit 4-13



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 saturation 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 other congestion-creating events other than those caused by additional traffic on a facility.

Exhibit 4-14 shows the percentage of peak-hour travel meeting or exceeding a V/SF of 0.80 and 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, 33.4 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.

This measure of congestion severity shows mixed results, as the values for some functional classes have increased since 1997 while others have declined. This indicates that the increases in congestion indicated by broader measures such as the Annual Hours of Traveler Delay, cited earlier, may 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 capture.

Exhibit 4-14

Percent of Peak-Hour Travel Exceeding V/SF Thresholds

	1995		1997		1999		2000	
FUNCTIONAL SYSTEM	**V/SF > 0.80**	**VSF > 0.95**	**V/SF > 0.80**	**VSF > 0.95**	**V/SF > 0.80**	**VSF > 0.95**	**V/SF > 0.80**	**VSF > 0.95**
Rural								
Interstate	9.9%	2.6%	11.0%	3.7%	9.7%	3.0%	10.4%	3.6%
Principal Arterial	6.8%	3.5%	7.0%	3.4%	7.1%	3.9%	7.3%	4.2%
Minor Arterial	4.3%	2.5%	4.2%	1.9%	4.3%	2.2%	4.5%	2.2%
Major Collector	2.8%	1.6%	2.4%	1.4%	2.3%	1.3%	2.3%	1.0%
Small Urban								
Interstate	15.2%	5.7%	13.2%	4.7%	9.2%	3.3%	7.7%	3.2%
Other Freeway & Expressway	12.7%	6.1%	11.3%	6.7%	10.3%	4.4%	12.5%	7.1%
Other Principal Arterial	11.9%	6.8%	11.6%	6.7%	12.8%	7.3%	13.1%	6.3%
Minor Arterial	13.7%	7.2%	13.1%	6.8%	14.4%	8.0%	14.3%	8.2%
Collector	9.6%	6.5%	9.7%	5.6%	10.0%	6.1%	9.9%	5.8%
Urbanized								
Interstate	52.9%	30.7%	55.0%	31.4%	48.4%	25.7%	50.0%	27.0%
Other Freeway & Expressway	46.7%	28.0%	47.5%	27.6%	43.0%	24.0%	46.2%	29.5%
Other Principal Arterial	32.5%	22.2%	29.6%	18.7%	29.5%	17.9%	29.2%	17.3%
Minor Arterial	26.2%	16.9%	25.2%	14.5%	25.2%	15.4%	26.4%	14.9%
Collector	24.1%	16.2%	21.0%	14.0%	20.4%	13.4%	20.2%	14.1%

Source: Highway Performance Monitoring System.

Q. **Why are the percentages shown in Exhibit 4-14 for 1995 and 1997 lower than the values in the 1999 Conditions and Performance Report?**

A. Exhibit 4-14 is based on new capacity estimation procedures procedures based on the 2000 edition of the Transportation Research Board's *Highway Capacity Manual* (HCM). This publication is updated periodically based on new research. One of the elements that has changed over time is the distance drivers are willing to follow another vehicle while driving at free-flow speeds on a facility. Studies of current driver behavior show they are willing to drive at faster speeds at a given density than in the past. Also, they are willing to follow the vehicle ahead more closely without reducing speed. Therefore, the HCM has increased the SF factor, the maximum capacity of freeway lanes from 2000 passenger cars per hour per lane in 1985 to 2300 in 1994 and to 2400 in 1998. That is, more travel can be accommodated in a given travel lane now than in the past. In effect, this change defines away some of the travel identified as "congested" in the 1999 C&P report, which was based on the 1994 HCM.

These periodic modifications to the SF value increase the difficulty of using the V/SF ratio to compare operational performance over time.

Future Research

Measurement of congestion is still a difficult problem. Substantial research has supported the use of delay as the definitive measure of congestion, and 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, we currently have 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 one hour on day one and one and a half hours on day two, 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 Fiscal Year 2003 Performance Plan adopted 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. Data are currently available for 10 cities, but efforts are underway to expand the sample. This measure and other measures currently under development will be refined and applied to additional cities as detectors are deployed and data are accumulated.

Bottlenecks

A November 1999 report prepared by Cambridge Systematics for the American Highway Users Alliance entitled *Unclogging America's Arteries: Prescriptions for Healthier Highways* listed 167 locations in urban areas that it classified as bottlenecks. These were areas where traffic congestion occurs due to 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 18 worst bottleneck locations. Improvements to these locations were estimated to prevent 287,000 crashes including 1,150 fatalities and 141,000 injuries. Major reductions in pollutants were also cited as a benefit. User delay was estimated to be reduced by 71 percent, which translates to approximately 40 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.

Deployment of ITS Systems

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. To obtain valid performance measures from ITS technology, methods are needed to compile sensor data into databases, and to aggregate and analyze the data into useful statistics.

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. When vehicles become too crowded, the quality of a transit trip decreases and may provide an incentive to riders to shift to a different transportation mode.

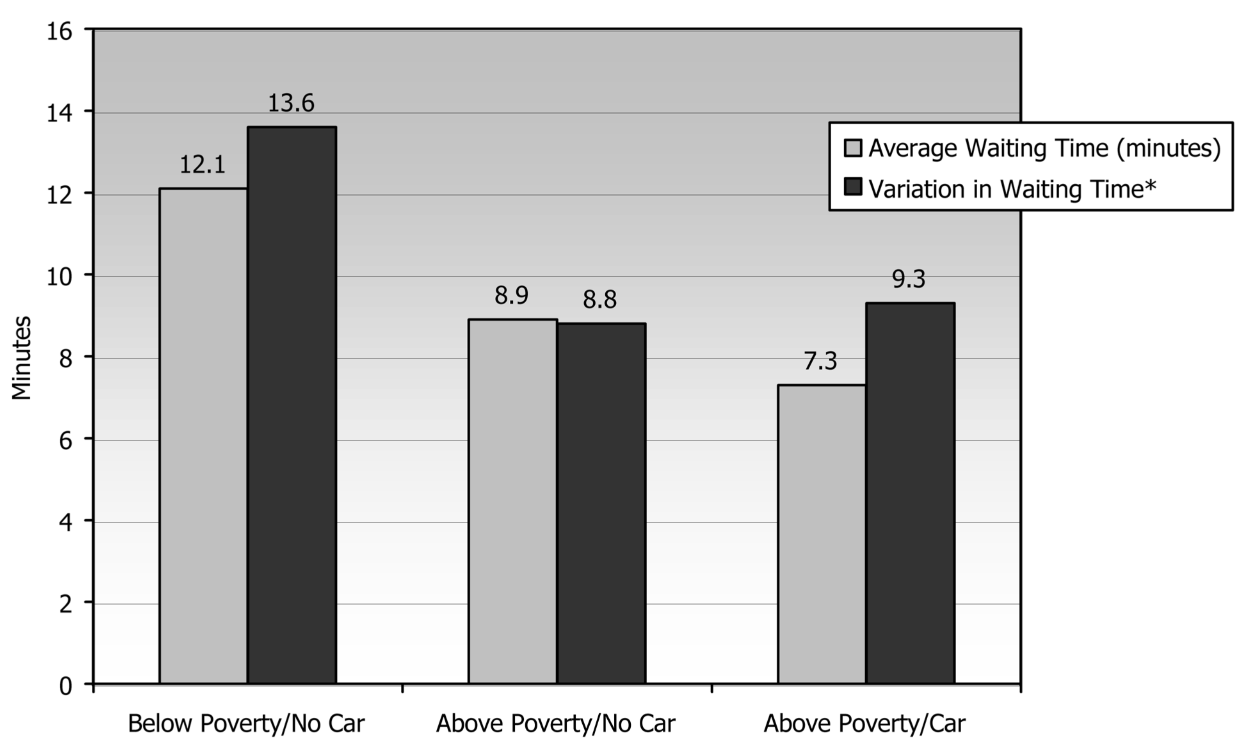
Frequency and Reliability of Services

The frequency of transit services 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.

Exhibit 4-15 shows information on waiting times, from the 1995 Nationwide Personal Transportation Survey by FHWA. This is the most recent nationwide survey providing this information. It does not reflect changes in service levels that may have occurred since TEA-21. Waiting times vary according to the characteristics of the passenger making the trip. Passengers with limited incomes and without

Exhibit 4-15

Transit Passenger Waiting Times and Service Reliability



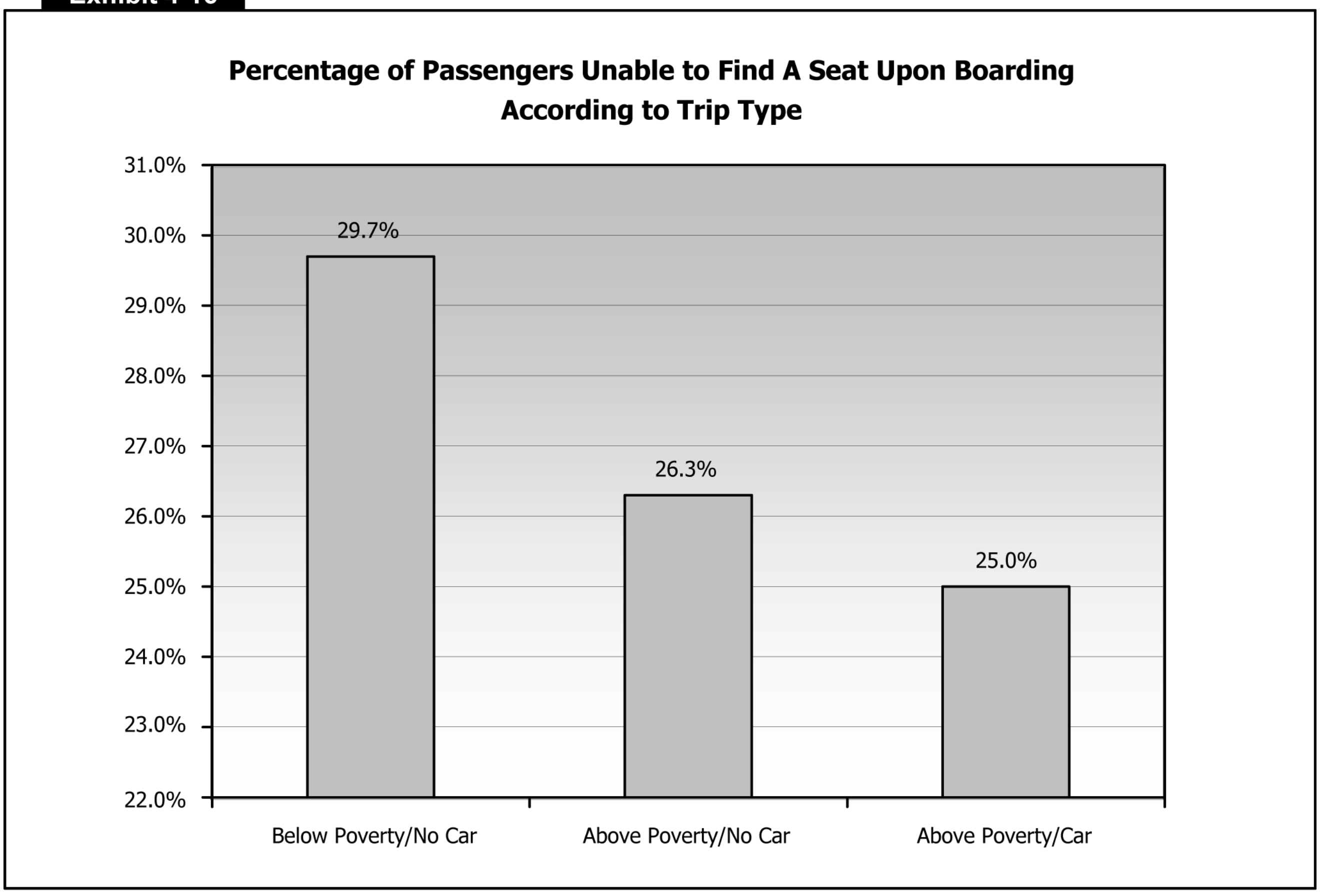
Source: 1995, Nationwide Personal Transportation Survey, FHWA.

access to a private vehicle are the most “dependent” on transit, and are most likely using transit for basic mobility and have fewer alternatives to get to their destination. These riders have, on average, the highest tolerance for delay and unreliability, and experience an average waiting time of 12.1 minutes and variation (standard deviation) in waiting time of 13.6 minutes. Passengers with incomes above the poverty line who have access to a personal vehicle, but who choose to travel by transit, experience the lowest average waiting time of 7.3 minutes and a variation in waiting times of 9.3 minutes. People in this group often use transit to avoid traffic congestion. Riders who have above-poverty incomes but who do not have a car, wait slightly longer for transit service (8.9 minutes), but have a slightly lower degree of variation in the length of time that they wait (8.8 minutes). These riders are often those that benefit from location efficiency, i.e., they live in an area where it is not necessary to have a car because transit is readily available.

Seating Conditions

Transit travel conditions are often crowded. In 1995, 27.3 percent of the people sampled by the Nationwide Personal Transportation Survey were unable to find a seat upon boarding a transit vehicle (Exhibit 4-16). Seats were not available upon boarding for 29.7 percent of trips by passengers with below average incomes and without cars, compared to about 25 percent for trips made by passengers with access to cars and above poverty incomes. The percentage of all passengers unable to find seats during rush hours was even higher, 31.3 percent. Approximately 32 percent of transit trips started during peak hours.

Exhibit 4-16



Source: 1995, Nationwide Personal Transportation Survey, FHWA.

Average Operating Speeds

Average vehicle operating speeds as experienced by passengers are based on the number of miles that transit vehicles travel and the number of hours spent transporting passengers. Based on data from the National Transit Database, the average operating speed for each type of transit vehicle is calculated by dividing vehicle revenue miles by vehicle revenue hours for each type of transit mode. These average modal operating speeds are weighted by the number of passenger miles traveled annually on each type of transit mode to derive passenger-mile weighted average speeds for rail, non-rail, and total transit, as shown below in Exhibit 4-17. This measurement is intended to be passenger oriented, i.e., provide an indicator of the average speed that a passenger will travel on each transit mode rather than the pure operational speed characteristics of a transit mode.

Exhibit 4-17

Passenger-Mile Weighted Average Operating Speed by Transit Mode, 1987 - 2000 (Miles per hour)

	RAIL	NON-RAIL	TOTAL
1987	23.7	13.2	19.3
1988	24.4	13.8	19.1
1989	24.3	13.5	19.1
1990	24.8	13.4	19.2
1991	27.6	13.4	20.4
1992	27.0	13.5	20.3
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
Average	**25.7**	**13.7**	**19.9**

Source: National Transit Database.

The average transit vehicle operating speed declined in 2000 to 19.6 miles per hour, just under the 14-year average of 19.9 miles. The passenger-mile weighted average operating rail speed has declined unevenly since 1991, falling to 24.9 miles per hour in 2000. Rails speeds were highest between 1991 and 1997, ranging between 26.0 to 27.6 miles per hour, up from 24.9 miles per hour in 1990. The passenger-mile weighted average operating speed of non-rail vehicles—which is affected by traffic, road, and safety conditions—has remained relatively constant over the last 14 years, averaging 13.6 miles per hour. Between 1987 and 2000, the passenger-mile weighted average operating speed of rail vehicles has been about 12 miles per hour faster than of non-rail transit vehicles.

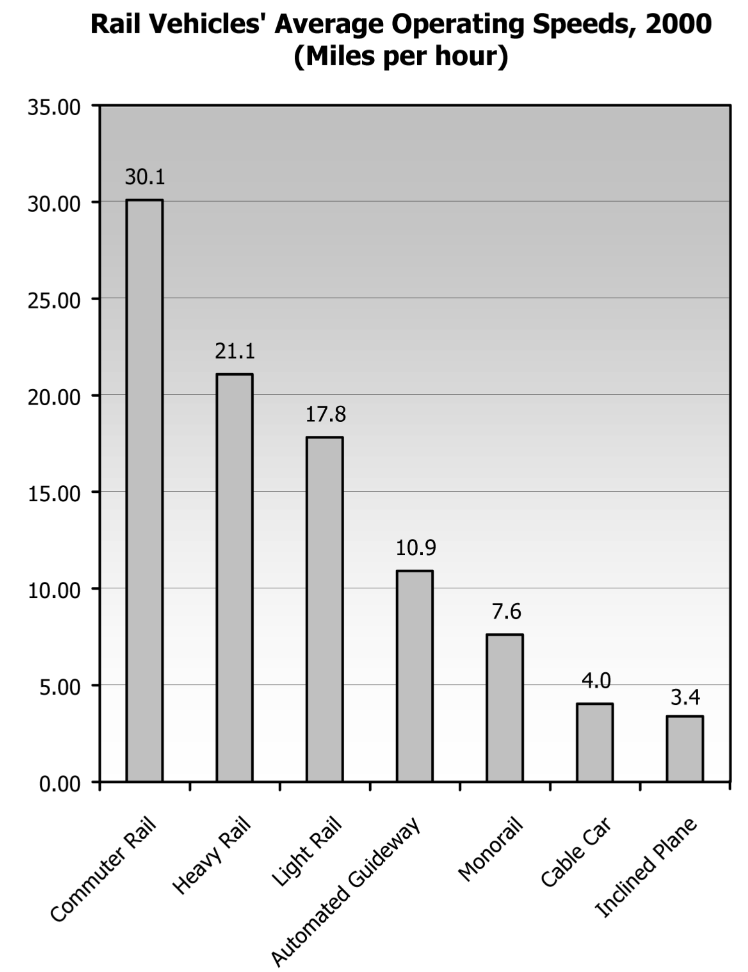
As Exhibit 4-18 shows, the average operating speed of rail vehicles differs considerably from one type to another. Commuter rail provides the fastest service with an average passenger-weighted operating speed of 30.1 miles per hour in 2000. Heavy rail and light rail travel more slowly with average speeds, in 2000, of 21.1 and 17.8 miles per hour. In the same year, the average operating speed for transit vehicles traveling on automated guideways was 10.9 miles per hour; on monorails it was 7.6 miles per hour, on cable cars 4.0 miles per hour, and on inclined planes, i.e., transit vehicles traveling on track a short distance up a steep hill, 3.4 miles per hour.

As shown in Exhibit 4-19, the passenger-mile weighted speeds of non-rail transit vehicles also cover a wide range. Vanpools, which tend to travel long distances on highways, have a faster average operating speed than other non-rail transit vehicles, 36.9 miles per hour in 2000. Buses and ferry boats traveled an average of 10.5 miles per hour. Demand response and publico vehicles were slightly faster at 15.8 and 13.6 miles per hour, respectively. Trolleys were the slowest modes of non-rail transit, traveling at average speeds of 7.4 miles per hour. The only jitney service in the United States providing speed data to FTA operated in San Francisco until 2000. It had an average speed of 7 miles per hour in 1999.

Q. What is publico service?

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

Exhibit 4-18

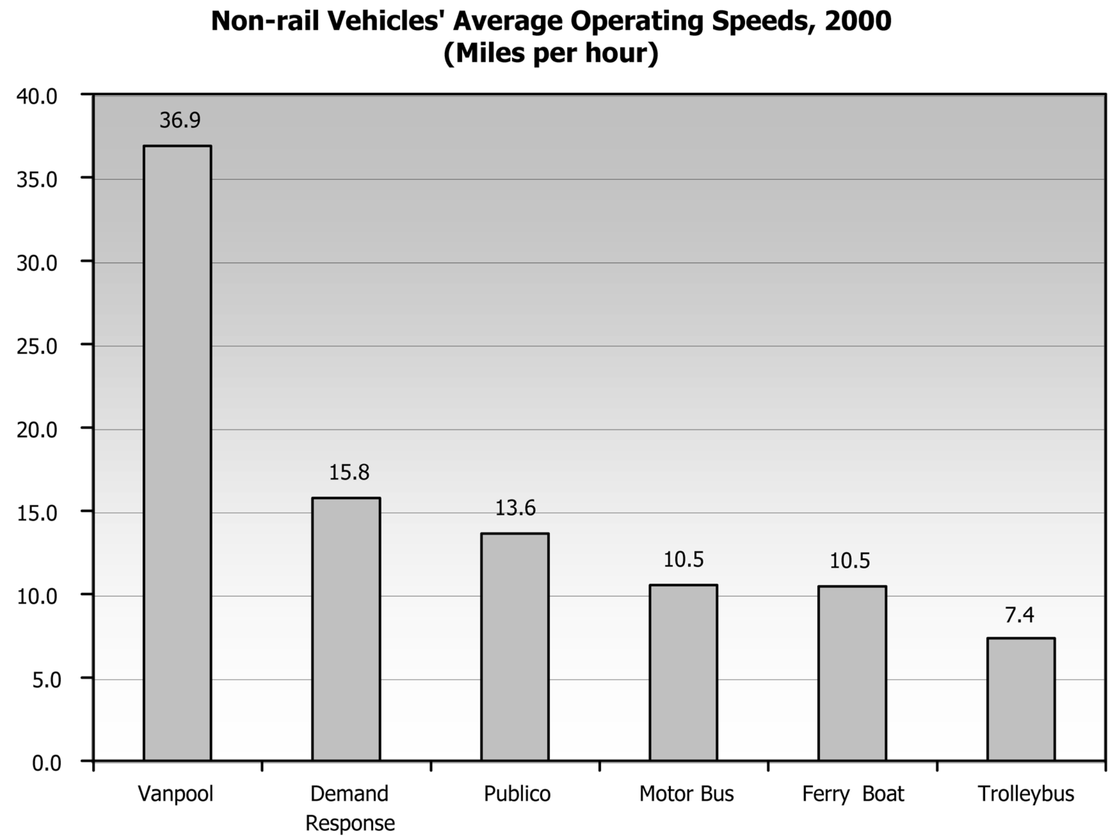


Source: National Transit Database.

Vehicle Utilization

Vehicle utilization is measured as the ratio of the total number of vehicles operated in maximum scheduled service, adjusted by a capacity factor, to the total number of passenger miles traveled annually in each mode.
Vehicle utilization is shown in Exhibit 4-20 and graphed in Exhibit 4-21. Commuter rail has consistently had the highest utilization rate. In 2000, commuter rail utilization reached a new high of 914.3 thousand passenger miles per vehicle, up substantially from 855.2 in 1999, and an average of 828 for the 1990s as a whole. Heavy and light rail per vehicle utilization rates also reached new highs in 2000 of 783.7 and 687.6 thousand passengers, respectively. These levels were well above the average utilization rates experienced in the 1990s. Heavy rail utilization rates also increased in recent years, after a dip in the early 1990s. Light rail has exhibited the largest increase in vehicle utilization, consistently increasing since 1991. Utilization of buses, on the other hand, dropped slightly to 393.2 thousand passenger miles in 2000; the utilization of demand response, including van pools, varied over the 1990s with no discernable trend and was 168.8 thousand passengers in 2000.

Exhibit 4-19



Source: National Transit Database.

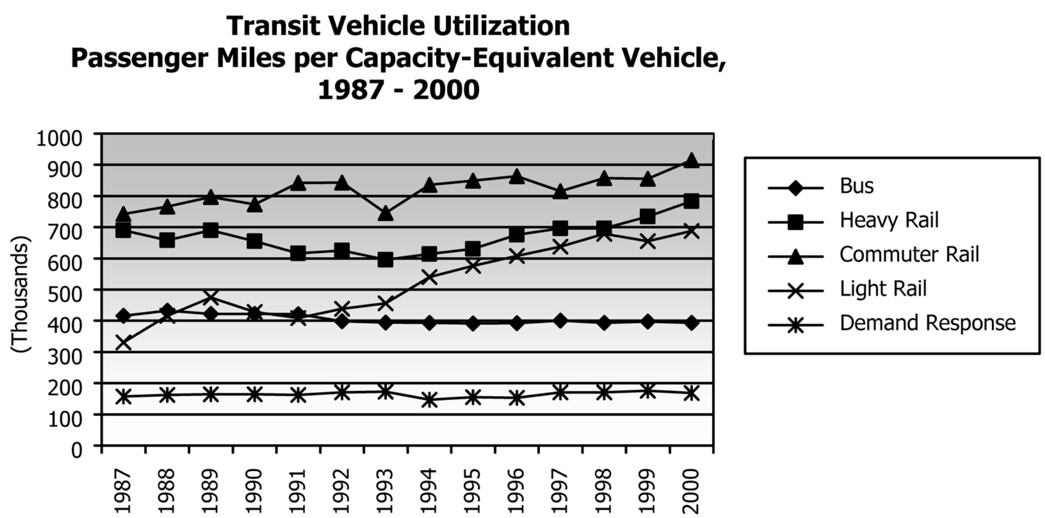
Exhibit 4-20

Transit Vehicle Utilization
Annual Passenger Miles Per Capacity-Equivalent Vehicle by Mode, 1987 - 2000
(Thousands)

	BUS	HEAVY RAIL	COMMUTER RAIL	LIGHT RAIL	DEMAND RESPONSE
1987	415.8	689.7	741.9	330.9	156.6
1988	432.2	657.7	766.1	415.9	162.1
1989	421.9	689.7	796.8	474.8	164.4
1990	421.5	654.6	773.3	427.8	163.9
1991	421.4	616.1	841.4	408.1	162.4
1992	398.9	625.0	842.6	438.6	170.9
1993	394.3	595.1	745.6	455.4	172.7
1994	393.3	613.7	835.7	540.3	146.9
1995	390.7	630.6	849.1	575.7	154.8
1996	392.4	675.4	863.6	607.5	152.6
1997	400.6	696.3	814.7	637.6	170.1
1998	393.4	696.0	857.7	678.4	170.3
1999	397.0	734.5	855.2	654.7	175.4
2000	393.2	783.7	914.3	687.6	168.8

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

Exhibit 4-21



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 20.

Exhibit 5-1 compares key data in this chapter with corresponding safety measures in the 1999 Conditions and Performance Report.

Exhibit 5-1

Comparison of Safety Statistics with Those in the 1999 C&P Report

	1997 DATA		
HIGHWAY SAFETY	**1999 REPORT**	**REVISED**	**2000 DATA**
Number of Fatalities	42,013		41,821
Fatality Rate per 100,000 People	15.69		15.23
Fatality Rate per 100 Million VMT	1.6		1.5
Number of Injuries	3,348,000		3,189,000
Injury Rate per 100,000 People	1,250		1,161
Injury Rate per 100 Million VMT	131		116
TRANSIT SAFETY			
Number of Fatalities	275		292
Fatalities per 100 Million PMT	0.73		0.69
Number of Injuries	56,535		57,457
Injuries per 100 Million PMT	151		135
Number of Incidents	62,009		60,638
Incidents per 100 Million PMT	165		142

Highway fatalities decreased slightly between 1997 and 2000, dropping from 42,013 to 41,821. Although the number of fatalities has fallen sharply since 1966, when Federal legislation first addressed highway safety, there was an increase in the annual number of fatalities between 1994 and 2000. This was largely due to an increase in highway-related fatalities on rural roads.

In 2000, the fatality rate per 100,000 people was 15.23, a decrease from the 1997 fatality rate of 15.69. Similarly, the fatality rate per 100 million VMT dropped from 1.6 in 1997 to 1.5 in 2000. This drop coincided with a significant increase in the number of Vehicle Miles Traveled.

The number of injuries declined from about 3.35 million in 1997 to 3.19 million in 2000. The injury rate per 100,000 people declined from 1,250 in 1997 to 1,161 in 2000, and the injury rate per 100 million VMT dropped from 131 in 1997 to 116 in 2000.

Transit's safety record has continued to improve since 1997. While the total number of fatalities on transit systems increased from 275 in 1997 to 292 in 2000, the fatality rate per 100 million passenger miles traveled (PMT) declined from 0.73 in 1997 to 0.69 in 2000. As with fatalities, total injuries on transit vehicles increased between 1997 and 2000 from 56,535 to 57,457, but the number of injuries per 100 PMT declined from 151 in 1997 to 135 in 2000. Incidents per 100 million PMT declined from 165 to 142 over this same period, and in spite of the increase in transit travel, the total number of incidents declined from 62,009 (1997) to 60,638 (2000).

Highway Safety Performance

This section describes highway safety performance. It includes a look 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). 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.

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 5.5 per 100 million VMT. By 2000, the fatality rate had declined to 1.5 per 100 million VMT. The 2000 fatality rate, in fact, was the lowest on record, and is close to the target of 1.4 per 100 million VMT identified for FY 2003 in the FHWA Performance Plan. This plummeting fatality rate occurred even as the number of licensed drivers grew by more than 88 percent.

The number of traffic deaths also decreased between 1966 and 2000. In 1966, there were 50,894; by 2000, that number had dropped to 41,821. The number of fatalities, however, has not dropped as consistently as the fatality rate. Fatalities reached their highest point in 1973 (54,052), then declined sharply following the implementation of a national speed limit. Fatalities reached their lowest point in 1992 (39,250), but slightly increased between 1992 and 2000. Exhibits 5-3 and 5-4 compare the number of fatalities with fatality rates between 1980 and 2000.

The injury rate also declined between 1988 and 2000, the years for which statistics are available. In 1988, the injury rate was 169 per 100 million VMT; by 2000, the number had dropped to 116 per 100 million VMT (the target in the FHWA Performance Plan for FY 2003 is 107 per 100 million VMT). The number of injuries also decreased between 1988 and 2000, from 3,416,000 to 3,348,000; however, like the number of fatalities, injuries increased between 1992 and 2000.

Exhibits 5-5 and 5-6 describe the number of fatalities and fatality rates by rural and urban functional system between 1994 and 2000. These exhibits are important in describing the recent increase in fatalities and the distinction between fatalities and the fatality rate.

The overall number of fatalities grew between 1994 and 2000, largely because of deaths on rural roads. Between 1994 and 2000, the number of fatalities on rural roads grew from 23,879 to 25,342; at the same time, the number of fatalities declined from 16,837 to 16,479 on urban roads. The fatality rate, however, declined on both rural and urban roads. Although the absolute number of fatalities increased, the fatality rate dropped because there was a significant increase in the number of vehicle miles traveled.

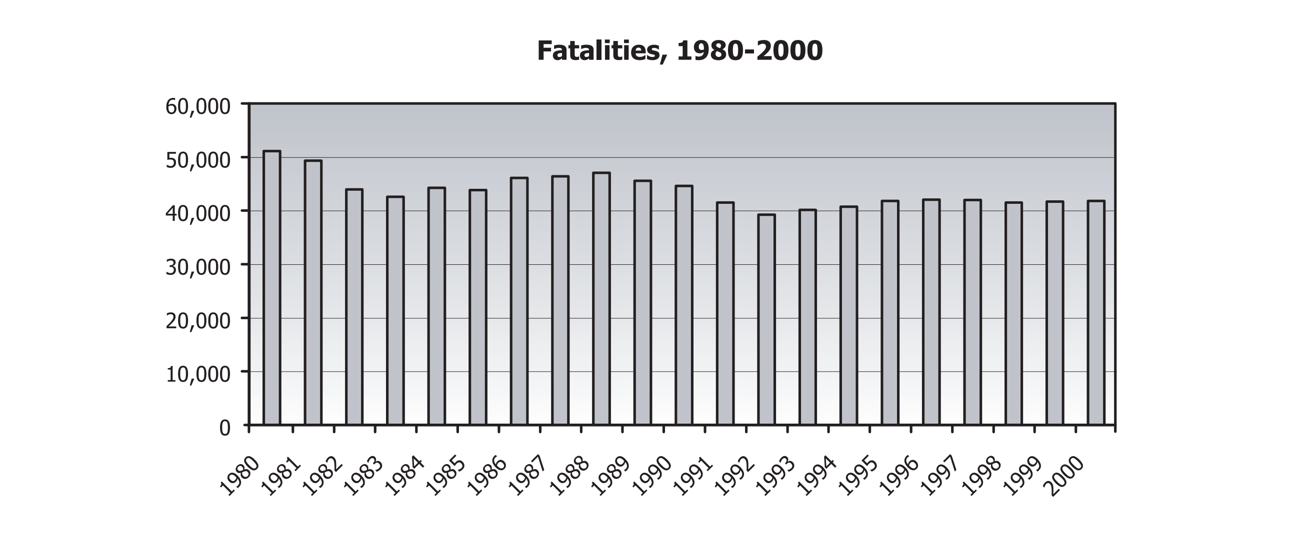
Exhibit 5-2

Summary of Fatality and Injury Rates, 1966-2000

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			
1967	50,724	198,712	25.53	103,172	5.3			
1968	52,725	200,706	26.27	105,410	5.2			
1969	53,543	202,677	26.42	108,306	5.0			
1970	52,627	205,052	25.67	111,543	4.7			
1971	52,542	207,661	25.30	114,426	4.5			
1972	54,589	209,896	26.01	118,414	4.3			
1973	54,052	211,909	25.51	121,546	4.1			
1974	45,196	213,854	21.13	125,427	3.5			
1975	44,525	215,973	20.62	129,791	3.4			
1976	45,523	218,035	20.88	134,036	3.2			
1977	47,878	220,239	21.74	138,121	3.3			
1978	50,331	222,585	22.61	140,844	3.3			
1979	51,093	225,055	22.70	143,284	3.3			
1980	51,091	227,225	22.48	145,295	3.3			
1981	49,301	229,466	21.49	147,075	3.2			
1982	43,945	231,664	18.97	150,234	2.8			
1983	42,589	233,792	18.22	154,389	2.6			
1984	44,257	235,825	18.77	155,424	2.6			
1985	43,825	237,924	18.42	156,868	2.5			
1986	46,087	240,133	19.19	159,486	2.5			
1987	46,390	242,289	19.15	161,816	2.4			
1988	47,087	244,499	19.26	162,854	2.3	3,416,000	1,397	169
1989	45,582	246,819	18.47	165,554	2.2	3,284,000	1,330	157
1990	44,599	249,439	17.88	167,015	2.1	3,231,000	1,295	151
1991	41,508	252,127	16.46	168,995	1.9	3,097,000	1,228	143
1992	39,250	254,995	15.39	173,125	1.7	3,070,000	1,204	137
1993	40,150	257,746	15.58	173,149	1.7	3,149,000	1,222	137
1994	40,716	260,327	15.64	175,403	1.7	3,266,000	1,255	139
1995	41,817	262,803	15.91	176,628	1.7	3,465,000	1,319	143
1996	42,065	265,229	15.86	179,539	1.7	3,483,000	1,314	140
1997	42,013	267,784	15.69	182,709	1.6	3,348,000	1,250	131
1998	41,501	270,248	15.36	184,980	1.6	3,192,000	1,181	121
1999	41,717	272,691	15.30	187,170	1.6	3,236,000	1,187	120
2000	41,821	274,634	15.23	190,625	1.5	3,189,000	1,161	116

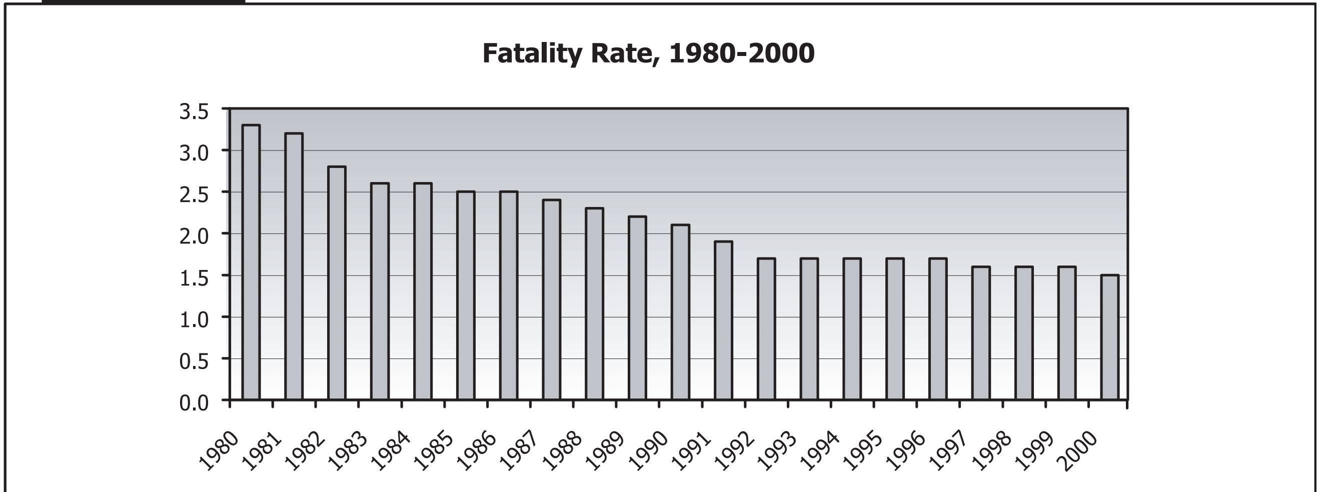
Source: Fatality Analysis Reporting System.

Exhibit 5-3



Source: Fatality Analysis Reporting System.

Exhibit 5-4



Source: Fatality Analysis Reporting System.

The split between urban and rural functional systems shows other differences. Fatality rates declined on every urban functional system between 1994 and 2000. Urban interstate highways were the safest functional system, with a 0.6 fatality rate in 2000. Other freeways and expressways, however, recorded the sharpest decline in fatality rates. The fatality rate for other freeways and expressways in 2000 was about 39 percent lower than in 1994.

Fatality rates remained constant or slightly decreased on rural functional systems between 1994 and 2000; however, rural Interstates registered a slight increase. The rural Interstate fatality rate in 2000 was double that of urban Interstates. Travel speeds tend to be higher on rural Interstates than urban Interstates, making it more likely that crashes would occur.

Exhibit 5-5

Fatalities by Functional System, 1994-2000

FUNCTIONAL SYSTEM	1994	1995	1996	1997	1998	1999	2000
Rural Areas (under 5,000 in population)							
Interstate	2,577	2,676	2,967	3,083	3,167	3,300	3,429
Other Principal Arterial	5,143	4,999	5,329	5,471	5,485	5,385	5,236
Minor Arterial	4,230	4,436	4,246	4,345	4,300	4,352	4,319
Major Collector	6,156	6,262	6,062	6,004	5,956	5,933	5,783
Minor Collector	1,603	1,609	1,576	1,748	1,788	1,792	1,879
Local	4,170	4,587	4,461	4,513	4,548	4,855	4,696
Subtotal Rural	**23,879**	**24,569**	**24,641**	**25,164**	**25,244**	**25,617**	**25,342**
Urban Areas (5,000 and over in population)							
Interstate	2,159	2,192	2,338	2,304	2,299	2,372	2,507
Other Freeway and Expressway	1,929	1,819	1,549	1,303	1,291	1,373	1,422
Other Principal Arterial	4,986	5,075	5,568	5,450	5,322	5,107	5,157
Minor Arterial	3,602	3,757	3,678	3,542	3,359	3,227	3,335
Collector	1,224	1,221	1,217	1,169	1,044	1,039	1,036
Local	2,937	3,184	3,074	3,081	2,942	2,982	3,022
Subtotal Urban	**16,837**	**17,248**	**17,424**	**16,849**	**16,257**	**16,100**	**16,479**
Total Highway Fatalities	**40,716**	**41,817**	**42,065**	**42,013**	**41,501**	**41,717**	**41,821**

Source: Fatality Analysis Reporting System.

Exhibit 5-6

Fatality Rates by Functional System, 1994-2000 (per 100 Million VMT)

FUNCTIONAL SYSTEM	1994	1995	1996	1997	1998	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Interstate	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.2%
Other Principal Arterial	2.5	2.3	2.4	2.4	2.3	2.2	2.1	-2.4%
Minor Arterial	2.8	2.9	2.7	2.7	2.6	2.6	2.5	-1.6%
Major Collector	3.4	3.4	3.2	3.0	2.9	2.9	2.8	-2.7%
Minor Collector	3.3	3.2	3.2	3.3	3.3	3.1	3.2	-0.4%
Local	4.0	4.4	4.1	3.9	3.8	3.9	3.7	-1.0%
Subtotal Rural	**2.6**	**2.6**	**2.6**	**2.5**	**2.4**	**2.4**	**2.3**	**-1.7%**
Interstate	0.7	0.6	0.7	0.6	0.6	0.6	0.6	-1.7%
Other Freeway and Expressway	1.3	1.2	1.0	0.8	0.8	0.8	0.8	-6.3%
Other Principal Arterial	1.4	1.4	1.5	1.4	1.4	1.3	1.3	-1.0%
Minor Arterial	1.3	1.3	1.2	1.2	1.1	1.0	1.0	-3.6%
Collector	1.0	1.0	1.0	0.9	0.8	0.8	0.8	-3.0%
Local	1.5	1.6	1.5	1.4	1.3	1.3	1.3	-1.9%
Subtotal Urban	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	**-2.5%**
Total Highway Fatality Rate	**1.7**	**1.7**	**1.7**	**1.6**	**1.6**	**1.6**	**1.5**	**-1.7%**

Source: Fatality Analysis Reporting System.

Only a small percentage of crashes are severe enough to kill passengers. Exhibit 5-7 describes the number of crashes by severity between 1994 and 2000. In 2000, about 67 percent of crashes resulted in property damage only.

Exhibit 5-7

Crashes by Severity, 1994-2000

YEAR	CRASH SEVERITY						TOTAL CRASHES	
	FATAL		INJURY		PROPERTY DAMAGE ONLY			
	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	**6,624,000**	100.0
1998	37,107	0.6	2,029,000	32	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	**37,409**	**0.6**	**2,070,000**	**32.4**	**4,286,000**	**67.0**	**6,394,000**	100.0

Source: Fatality Analysis Reporting System.

Safety belt use has been an important cause for the drop in fatalities and injuries since the 1960s. This trend is described extensively in Chapter 20.

Cost of Highway Crashes

Although the number of highway crashes has dropped sharply over the past three decades, highway safety remains a significant public health problem. Crashes also have significant economic impacts. Exhibit 5-8 describes economic costs, including medical bills and property damage, by crash type.

Exhibit 5-8

Average Cost by Crash Type ($2000 converted from $1998)

Rural	$113,216
Urban	$42,745
Alcohol-Related	$202,272
No Alcohol	$48,875
Pedestrian	$375,347
Pedalcyclist	$108,987
Other	$52,280
Combination Trucks	$106,154
Medium/Heavy Single Trucks	$67,769
Light Trucks	$56,223
Motorcycles	$219,484
Passenger Van	$52,592
Passenger Cars	$51,600

Source: FHWA Office of Research, Development, and Technology.

Types of Highway Fatalities

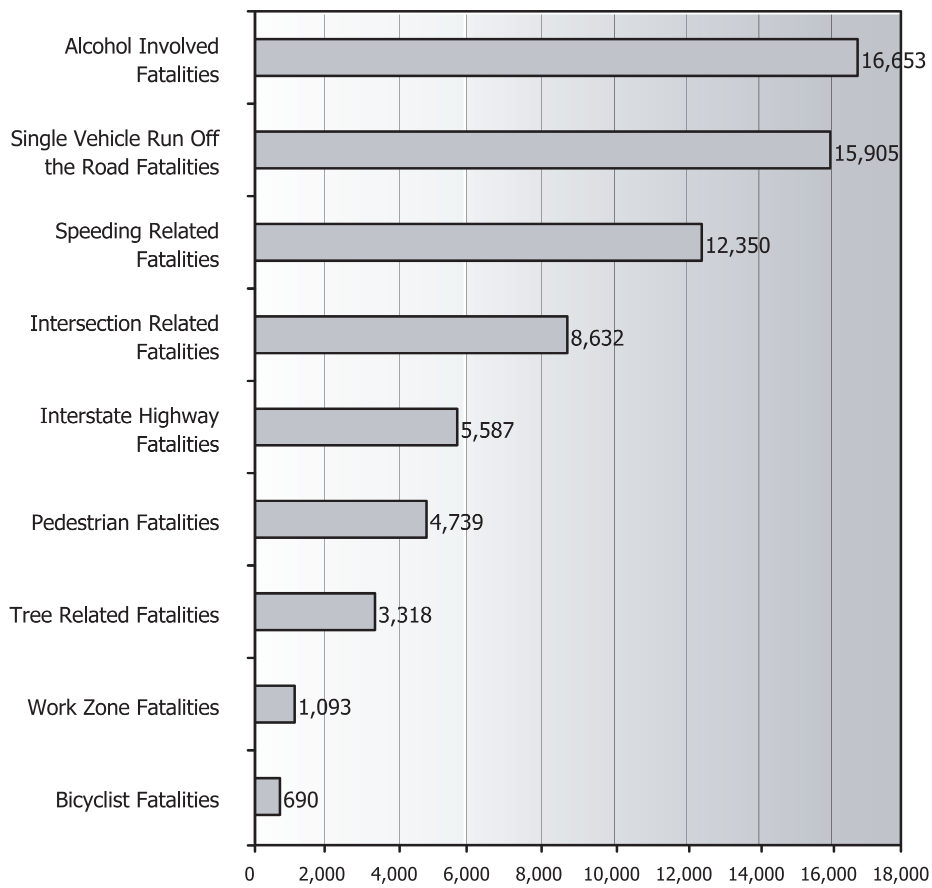
Exhibit 5-9 describes the types of highway fatalities in 2000. The three most common fatalities were related to alcohol-impaired driving, single vehicle run off the road crashes, and speeding. Many of the fatalities shown in Exhibit 5-9 involve a combination of factors—speeding and alcohol, for example—so these should not necessarily be viewed in isolation; in other words, the exhibit counts multiple factors.

Alcohol-impaired driving is a serious public safety problem in the United States. NHTSA estimates that alcohol was involved in 40 percent of fatal crashes and 8 percent of all crashes in 2000. The 16,653 fatalities in 2000 represent an average of one alcohol-related fatality every 32 minutes.

Exhibit 5-10 describes the number of fatalities attributable to alcohol between 1993 and 2000. The number of fatalities dropped from 17,473 in 1993 to 16,653 in 2000, although the pattern of alcohol-related fatalities has been uneven—declining between 1995 and 1999, then increasing between 1999 and 2000.

Exhibit 5-9

Highway Fatalities by Type, 2000



Source: Fatality Analysis Reporting System.

There are three main groups involved in alcohol-impaired driving. The largest group, 21- to 34-year-old young adults, was responsible for 31 percent of all fatal crashes in 2000. 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. Fatally injured drivers with a blood alcohol concentration greater than 0.10 grams per deciliter were six times as likely to have a prior conviction for driving while intoxicated than fatally injured sober drivers. Finally, underage drinkers are disproportionately overrepresented in impaired driving statistics. Not only are they relatively new drivers, but they are also inexperienced drinkers.

The second largest category of highway fatalities involves single vehicle run off the road crashes. In 2000, 15,905 fatalities

Exhibit 5-10

Alcohol-Related Fatalities, 1993-2000

1993	1994	1995	1996	1997	1998	1999	2000
17,473	16,580	17,247	17,218	16,189	16,020	15,976	16,653

Source: Fatality Analysis Reporting System.

occurred when drivers lost control and ran off the road.

> **Q.** **What is the distribution of speed-related fatalities among functional systems?**
>
> **A.** About 13.9 percent of fatalities were on Interstates, 38.7 percent were on other arterial roads, 24.3 percent were on collector roads, and 23.1 percent were on local roads.

Another type of highway fatality is related to speeding. In 2000, over 12,000 lives were lost in speeding-related crashes, and over 700,000 people were injured. Although much of the public concern about speed-related crashes focuses on high-speed roadways, speeding is a safety concern on all roads. Almost half of speed-related fatalities occur on lower functional systems.

The estimated annual economic costs of speed-related crashes exceeded $24.4 billion in 2000. That 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. In 2000, 34 percent of male drivers between the ages of 15 to 20 who were involved in fatal crashes were speeding at the time of the crash.

Research completed by NHTSA shows the correlation between speeding and alcohol consumption in fatal crashes. In 2000, 23 percent of underage *speeding* drivers involved in fatal crashes were intoxicated. By contrast, only 10 percent of underage *nonspeeding* drivers involved in fatal crashes were intoxicated.

Many speeding crashes also occur during bad weather. Speeding was a factor in 27 percent of the fatal crashes that occurred on dry roads in 2000 and in 34 percent of those that occurred on wet roads. Speeding was a factor in 48 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. Half of all urban crashes and one-third of rural crashes occur at intersections. Older drivers and pedestrians are particularly at risk at intersections; half of the fatal crashes for drivers aged 80 years and older and about 30 percent of pedestrian deaths among people aged 65 and older occured at intersections.

A growing safety problem involves crashes in construction and maintenance work zones. The number of fatalities in work zones increased from 868 in 1999 to 1,093 in 2000. Speeding was involved in 27 percent of these fatalities.

Crashes by Vehicle Type

Exhibit 5-11 describes the number of occupant fatalities by vehicle type from 1993 to 2000. The number of occupant fatalities that involved passenger cars decreased from 21,566 in 1993 to 20,492 in 2000. Occupant fatalities involving light and large trucks, motorcycles, and other vehicles all increased during this period. Exhibit 5-12 describes the number of occupant injuries by vehicle type from 1993 to 2000.

Exhibit 5-11

Fatalities for Vehicle Occupants by Type of Vehicle, 1993-2000

TYPE OF VEHICLE	1993	1994	1995	1996	1997	1998	1999	2000
Passenger Cars	21,566	21,997	22,423	22,505	22,199	21,194	20,862	20,492
Light Trucks	8,511	8,904	9,568	9,932	10,249	10,705	11,265	11,418
Large Trucks	605	670	648	621	723	742	759	741
Motorcycles	2,449	2,320	2,227	2,161	2,116	2,294	2,483	2,862
Other Vehicles	425	409	392	455	420	409	447	714
Total	**33,556**	**34,300**	**35,258**	**35,674**	**35,707**	**35,344**	**35,816**	**36,227**

Source: Fatality Analysis Reporting System.

Exhibit 5-12

Injuries for Vehicle Occupants by Type of Vehicle, 1993-2000

TYPE OF VEHICLE	1993	1994	1995	1996	1997	1998	1999	2000
Passenger Cars	2,265,000	2,364,000	2,469,000	2,458,000	2,341,000	2,201,000	2,138,000	2,052,000
Light Trucks	601,000	631,000	722,000	761,000	755,000	763,000	847,000	887,000
Large Trucks	32,000	30,000	30,000	33,000	31,000	29,000	33,000	31,000
Motorcycles	59,000	57,000	57,000	55,000	53,000	49,000	50,000	58,000
Other Vehicles	4,000	4,000	4,000	4,000	6,000	4,000	7,000	10,000
Total	**2,961,000**	**3,086,000**	**3,282,000**	**3,311,000**	**3,186,000**	**3,046,000**	**3,075,000**	**3,038,000**

Source: Fatality Analysis Reporting System.

The number of occupant fatalities in light trucks increased sharply between 1993 and 2000. Fatalities in these vehicles increased from 8,511 in 1993 to 11,418 in 2000, or an average annual increase of 4.9 percent. There were 887,000 light truck occupants injured in 2000.

The number of occupant fatalities in large trucks increased 22.5 percent from 605 in 1993 to 741 in 2000. There were 31,000 large truck occupants injured in 2000. These statistics, however, tell only part of the story. Large trucks are overrepresented in fatal crashes. Large trucks represent 4 percent of the Nation's registered vehicles, 7 percent of traffic volume, and 13 percent of all fatal crashes.

Q. How safe are highway-rail grade crossings?

A. Crashes at highway-rail grade crossings declined from 648 in 1990 to 369 in 2000—a 43 percent drop. While crashes are extremely rare, the results are likely to be catastrophic when they occur. Several States continue to experience problems at crossings.

The number of motorcyclists who died in crashes increased 16.9 percent from 2,449 in 1993 to 2,862 in 2000. There were 58,000 motorcycle injuries in 2000. Exhibit 5-13 describes the number of motorcycle occupants killed or injured per registered vehicle between 1993 and 2000.

Exhibit 5-13

Motorcycle Occupants Killed or Injured Per Registered Vehicle, 1993-2000

YEAR	REGISTERED VEHICLE	MOTORCYCLE OCCUPANTS KILLED	MOTORCYCLE OCCUPANTS INJURED
1993	3,977,856	2,449	59,000
1994	3,756,555	2.32	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

Source: Fatality Analysis Reporting System.

Motorcycle crashes are frequently speed-related. In 2000, for instance, about 38 percent of all motorcycle fatalities were speed-related. Speed was two times more likely to be a factor in fatal motorcycle crashes than in passenger car or light truck crashes. Studies have also shown that alcohol was more likely to have been a factor in motorcycle crashes than passenger car or light truck crashes.

Crashes by Age Group

Another important way of examining highway crashes is by demographic segment. Exhibit 5-14 describes the number of drivers, by age, involved in fatal crashes in 2000.

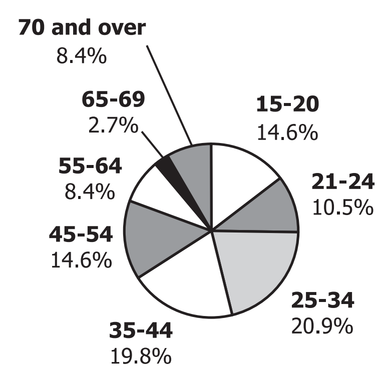
Drivers between the ages of 15 and 20 constitute 8.7 percent of the driving population, but 14.6 percent of total fatalities. In 2000, almost 30 percent of the drivers killed in this age group had been drinking. Drivers in the next oldest age category, those between 21 and 24 years, made up 5.2 percent of the driving population and 10.5 percent of the total number of fatal crashes.

On the other end of the spectrum, drivers aged 70 and older were involved in 8.4 percent of fatal crashes in 2000. 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.

This is largely due to the nature of driving among many older Americans. Older drivers tend to take shorter trips. They usually avoid driving during bad weather and at night; in 2000, for instance, 81 percent of fatalities

Exhibit 5-14

Age of Drivers Involved in Fatal Crashes, 2000



Source: Fatality Analysis Reporting System.

involving older Americans occurred during the daytime. 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 three times as likely to be the one that was struck.

There were 18.5 million drivers aged 70 and older in 1999, a 39 percent increase from the number in 1989. 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.

Reportable transit safety incidents include all collisions and any other type of occurrence (e.g., derailment) that results in injury or death, or fire or property damage in excess of $1,000. Property damage includes damage to transit vehicles and facilities and to other non-transit vehicles that are involved in the incident. 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 on transit or while boarding, alighting, or waiting for transit vehicles to arrive.

Incidents, injuries, and fatalities in absolute terms and per 100 million passenger miles traveled (PMT) for all transit modes are provided in Exhibit 5-15. In absolute terms, transit incidents were 36 percent lower in 2000 than in 1990 and 2 percent lower than in 1997. Injuries in 2000 were 7 percent higher than in 1990, and 2 percent higher than in 1997; fatalities in 2000 were 11 percent lower than in 1990, and 6 percent higher than in 1997. When adjusted for changes in the level transit usage, incidents per 100 million PMT fell from 251 in 1990, to 165 in 1997, to 142 in 2000, a decrease of 14 percent between 1997 and 2000. Injuries per 100 million PMT increased from 148 in 1990, to 151 in 1997, decreasing to 135 in 2000, a decrease of 11 percent between 1997 and 2000. Fatalities per 100 million PMT decreased from 0.89 in 1990, to 0.73 in 1997, to .69 in 2000, a decrease of 6 percent between 1997 and 2000.

Exhibit 5-15

Annual Transit-Related Incidents, Injuries, and Fatalities, 1990-2000
Directly Operated Service

YEAR	INCIDENTS		INJURIES		FATALITIES	
	TOTAL	PER 100 MILLION PMT	TOTAL	PER 100 MILLION PMT	TOTAL	PER 100 MILLION PMT
1990	91,773	251	53,844	148	325	0.89
1991	87,346	245	51,625	145	296	0.83
1992	73,795	210	54,518	155	277	0.79
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

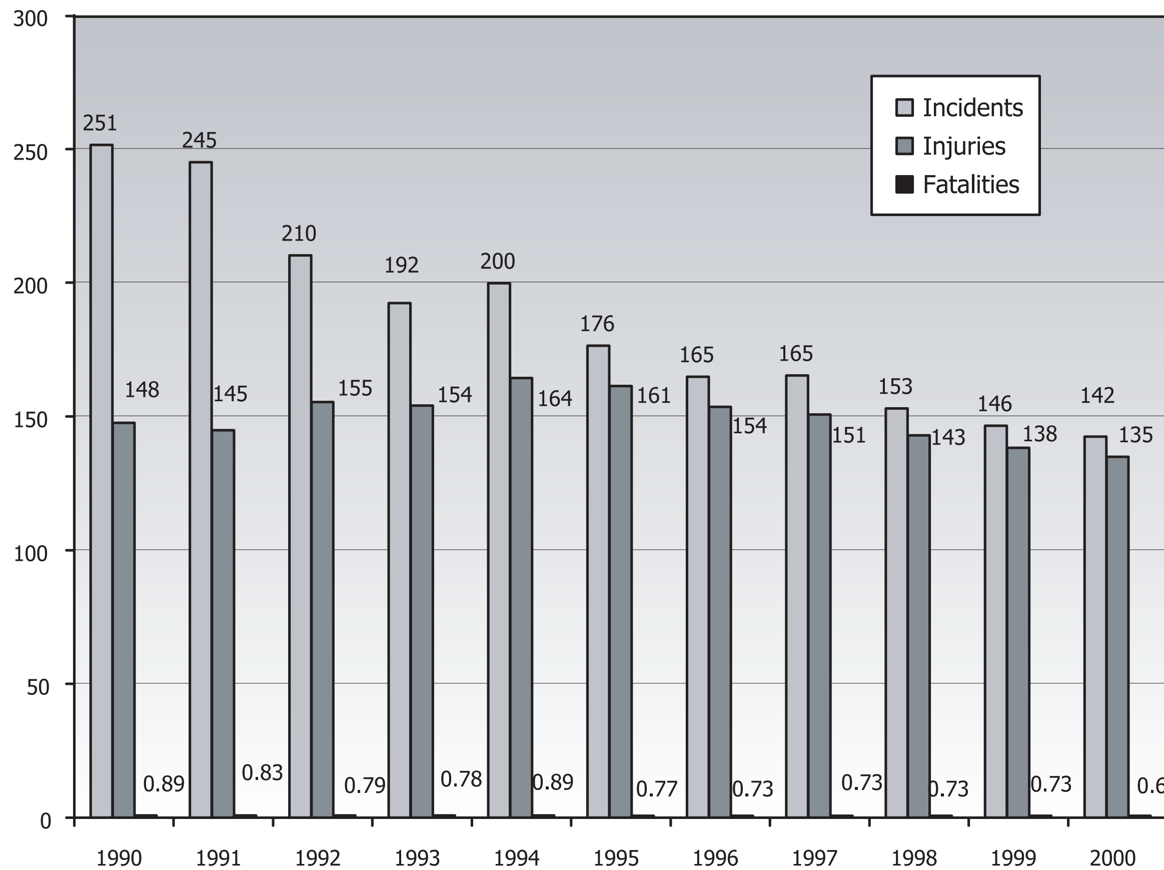
Note: includes all modes (MB, TB, HR, CR, LR, DR, AG, VP, CC, FB, IP, JT) and all incidents, injuries and fatalities including those not directly associated with the operation of transit vehicles (suicides, personal casualties in parking lots and stations)

Source: National Transit Database/Safety Management Information Statistics

Annual safety information from 1990 through 2000 is shown in Exhibit 5-16.

Exhibit 5-16

Transit-Related Incidents, Injuries and Fatalities per 100 Million Passenger Miles Traveled, 1990-2000



Source: National Transit Database/Safety Management Information Statistics.

Exhibit 5-17 shows incident, injury, and fatality annual rates per 100 PMT for the five largest transit modes. These rates span the averages for all modes as reported in Exhibit 5-15. Changes in occurrences on bus, heavy rail, and commuter rail modes, which combined accounted for 96 percent of total PMT in 2000, have the largest effect on the averages reported in Exhibit 5-15. The information provided in Exhibit 5-17 is graphed in Exhibits 5-18, 5-19 and 5-20.

Transit vehicles that share the roadway with other non-transit vehicles have higher incident and injury rates than transit vehicles that travel on fixed guideways. Incident and injury rates have consistently been the highest for demand response vehicles. Buses consistently have had incident and injury rates above rail transit modes, but substantially below demand response vehicles. Incidents and injury rates have been the lowest for commuter rail vehicles.

Although buses have relatively high 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. *[See Exhibits 5-18, 5-19 and 5-20].*

Exhibit 5-17

Transit-Related Incidents, Injuries, and Fatalities
Annual Rates Per 100 Million Passenger Miles by Mode, 1990-2000
Directly Operated Service Only (Purchased Transportation not included)

INCIDENTS

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bus	409	378	314	277	296	264	252	242	243	232	235
Heavy Rail	114	142	144	147	150	136	119	126	110	95	92
Commuter Rail	51	47	47	33	42	38	34	44	30	31	24
Light Rail	282	257	217	168	170	148	141	115	101	99	99
Demand Response	1,790	1,435	946	766	801	785	964	627	633	757	881

INJURIES

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bus	224	218	237	233	257	254	248	234	240	232	230
Heavy Rail	89	89	97	103	109	106	96	102	90	75	78
Commuter Rail	34	33	37	24	32	31	27	34	21	22	20
Light Rail	221	189	181	139	142	152	168	106	96	107	100
Demand Response	709	611	581	511	549	627	662	482	551	646	817

FATALITIES

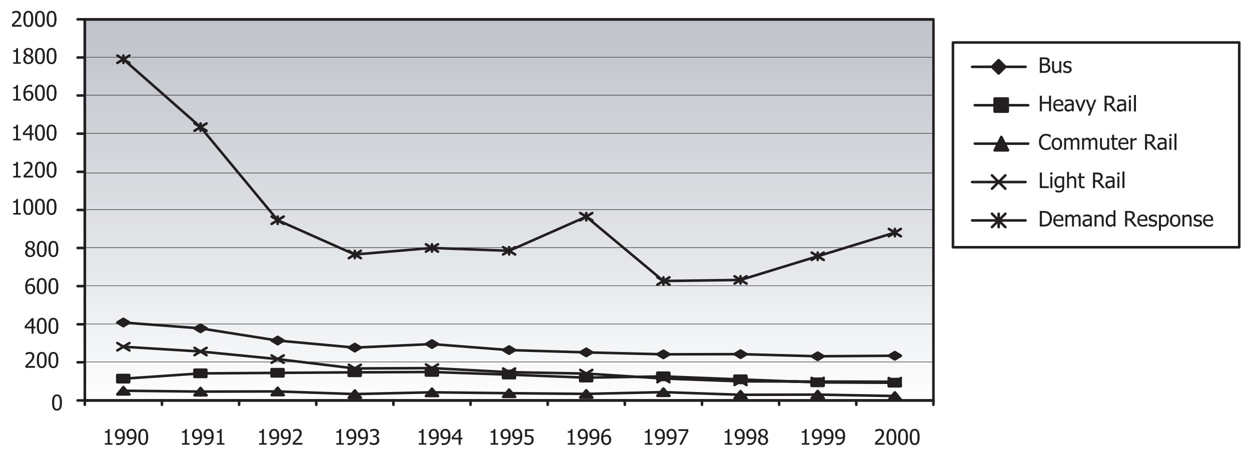
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bus	0.63	0.50	0.59	0.51	0.65	0.50	0.63	0.65	0.64	0.57	0.51
Heavy Rail	0.98	0.95	0.85	0.81	0.80	0.75	0.64	0.64	0.44	0.65	0.56
Commuter Rail	1.44	1.34	1.17	1.35	1.52	1.21	1.01	1.13	1.16	1.16	0.99
Light Rail	0.88	1.97	1.00	2.13	1.56	1.75	0.63	0.29	2.06	1.43	2.24
Demand Response	0.00	2.95	0.00	1.57	1.52	4.04	8.26	3.00	2.07	0.48	3.77

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).

Source: National Transit Database/Safety Management Information Statistics.

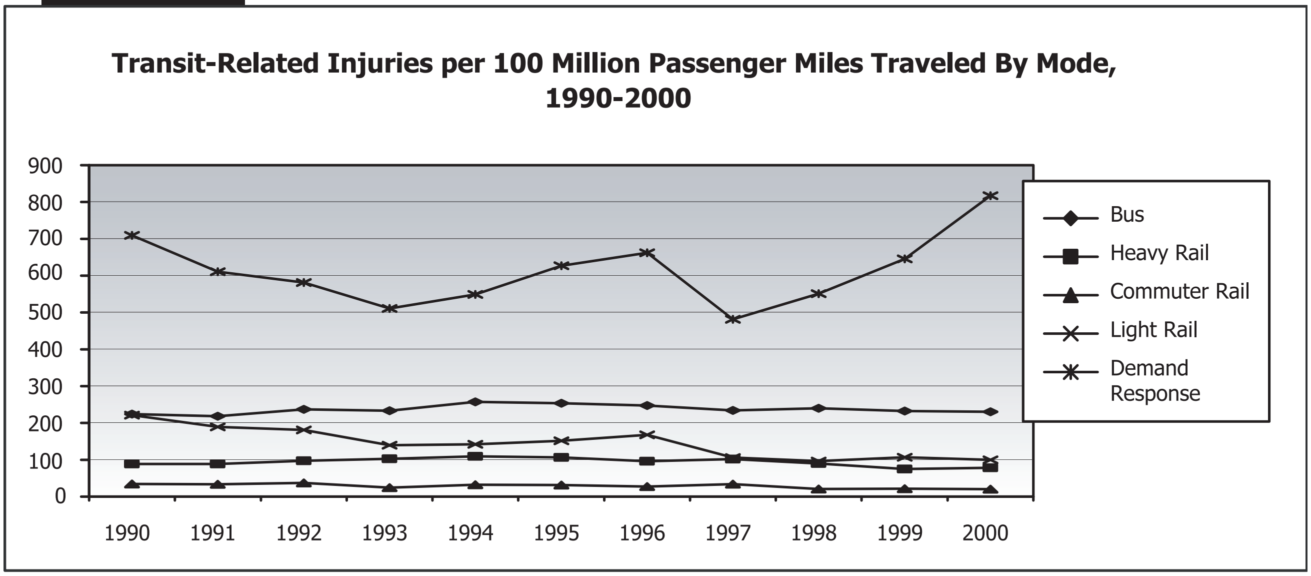
Exhibit 5-18

Transit-Related Incident Rates per 100 Million Passenger Miles Traveled By Mode, 1990-2000



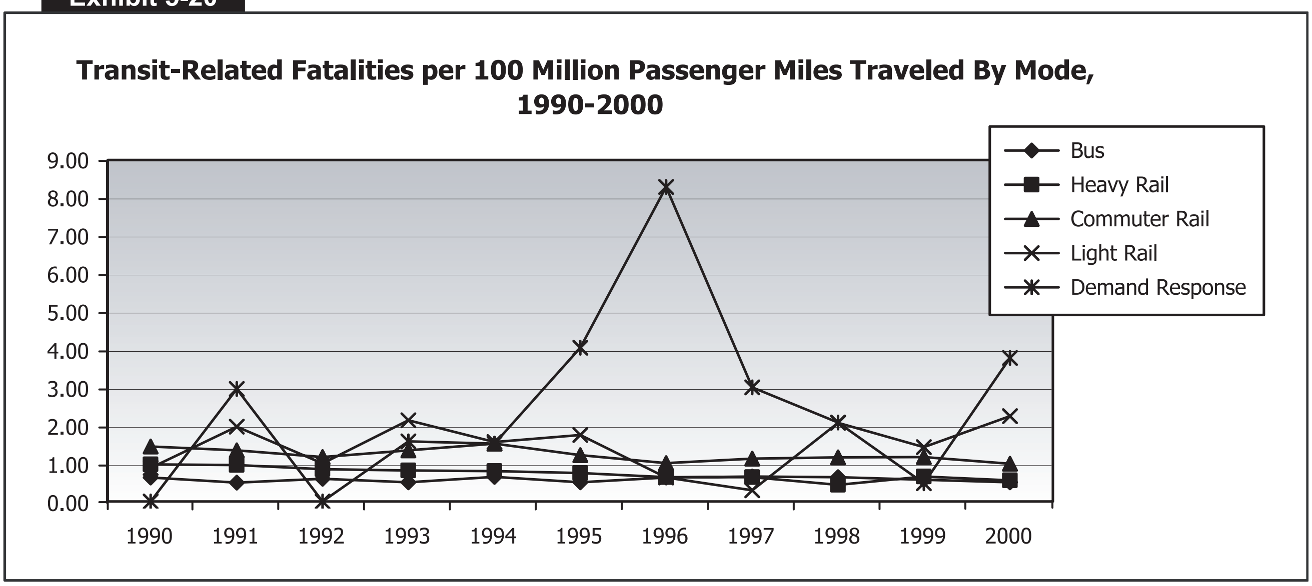
Source: National Transit Database/Safety Management Information Statistics.

Exhibit 5-19



Source: National Transit Database/Safety Management Information Statistics.

Exhibit 5-20



Source: National Transit Database/Safety Management Information Statistics.

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 1999 C&P report, which were based on 1997 data. Where the 1997 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2000 data.

Exhibit 6-1

Comparison of Highway and Transit Finance Statistics with Those in the 1999 C&P Report

STATISTIC	1997 DATA 1999 REPORT	1997 DATA REVISED	2000 DATA
Total Funding for Highways (all govts.)	$106.5 bil	107.4 bil	$128.7 bil
Total Funding for Transit	$26.0 bil		$30.8 bil
Total Public Funding for Transit	$17.5 bil		$21.0 bil
Percent of Public Funding for Transit Funded by Federal Government	27%		25%
Total Highway Expenditures (all govts.)	$101.3 bil	$102.0 bil	$127.5 bil
Percent of Total Highway Expenditures Funded by Federal Government	20.8%		21.7%
Total Highway Capital Outlay (all govts.)	$48.7 bil	$48.4 bil	$64.6 bil
Percent of Total Highway Capital Outlay Funded by Federal Government	41.1%	41.6%	39.9%
Percent of Total Highway Capital Outlay Used for System Preservation	47.6%		52.0%
Total Transit Capital Outlay	$7.6 bil		$9.0 bil
Percent of Total Transit Capital Outlay Funded by Federal Government	54%		47%
Percent of Total Transit Capital Outlay Used for Rail	66%		63%
Total Highway-User Revenues (motor-fuel and vehicle taxes and tolls)	$89.9 bil		$100.6 bil
Highway-User Revenues used for roads	$64.7 bil	$66.3 bil	$81.0 bil
Total Transit Fares and Other System-Generated Revenue	$8.4 bil		$9.8 bil

Highways and Bridges

All levels of government generated $128.7 billion in 2000 to be used for highways and bridges. Of this total, $1.3 billion was placed in reserves for future expenditures, so cash outlays for highways and bridges in 2000 totaled $127.5 billion. Highway expenditures increased 25.0 percent between 1997 and 2000. Highway expenditures grew more quickly than inflation over this period, rising 14.4 percent in constant dollar terms (based on the FHWA Construction Bid Price Index for highway capital outlay, and the Consumer Price Index for all other types of highway expenditures). Since 1997, highway capital expenditures by all level of government grew 33.7 percent to $64.6 billion in 2000. The Federal government contributed $25.8 billion (39.9 percent) of total highway capital expenditures.

It is interesting to note that, despite the increases in Federal highway funding under the Transportation Equity Act for the 21st Century (TEA-21), the Federal share of highway funding has fallen from 1997 to 2000, as the combined capital spending of State and local governments has grown more quickly. The Federal share of highway capital outlay had ranged from 41 to 46 percent between 1987 and 1997. However, in 1998, the Federal share of highway capital outlay fell below 40 percent for the first time since 1959, and it has remained below that level ever since.

In 2000, 52.0 percent of highway capital outlay was used for system preservation, up from 47.6 percent in 1997. Highway user revenues (the total amount generated from motor-fuel taxes, motor-vehicle taxes and fees, and tolls) rose 11.9 percent from $89.9 billion in 1997 to $106 billion in 2000. Of this total, $81.0 billion (80.5 percent) was used for highway programs.

Transit

Transit is funded by Federal, State, and local governments, as well as with system generated revenues. Overall total transit funding increased by 18.7 percent between 1997 and 2000. Although Federal funding for transit increased to $5.3 billion in 2000, 10.9 percent higher than in 1997, Federal funds accounted for only 17 percent of total expenditures on transit in 2000, down from 18 percent in 1997. This decrease in the Federal share was driven by dramatically increased investments by State and local governments in transit, as well as increases in system-generated revenue. Between 1997 and 2000, States and local governments increased their funding in transit by 23.6 percent to $15.7 billion. In 2000, State governments provided 18 percent of total transit funding, and local governments provided 33 percent of total funding. System-generated revenue jumped by 16 percent to $9.8 billion in 2000, and accounted for 32 percent of total transit funding 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 1997 and 2000, the Federal share of total capital expenditures for transit fell from 54 percent in 1997 to 47 percent in 2000.

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 $128.7 billion in 2000 to be used for highways and bridges. Actual cash expenditures for highway and bridge purposes totaled only $127.5 billion in 2000; the remaining $1.3 billion was placed in reserves by various governmental units for future expenditure on highways or bridges. The $3.3 billion shown as placed in reserves in the Federal column indicates that the cash balance of the Highway Account of the Federal Highway Trust Fund (HTF) grew by that amount during 2000.

Exhibit 6-2

Revenue Sources for Highways, 2000
(Billions of Dollars)

	FEDERAL	STATE	LOCAL	TOTAL	PERCENT
User Charges					
Motor-Fuel Taxes	$25.1	$28.7	$1.0	$54.8	42.5%
Motor-Vehicle Taxes and Fees	$4.6	$15.5	$0.7	$20.8	16.2%
Tolls	$0.0	$4.7	$0.7	$5.4	4.2%
Subtotal	**$29.7**	**$49.0**	**$2.3**	**$81.0**	**62.9%**
Other					
Property Taxes and Assessments	$0.0	$0.0	$6.4	$6.4	4.9%
General Fund Appropriations	$1.2	$4.1	$11.9	$17.2	13.4%
Other Taxes and Fees	$0.1	$2.4	$2.8	$5.4	4.2%
Investment Income and Other Receipts	$0.0	$2.7	$4.8	$7.5	5.8%
Bond Issue Proceeds	$0.0	$8.2	$3.1	$11.2	8.7%
Subtotal	**$1.4**	**$17.5**	**$28.9**	**$47.7**	**37.1%**
Total Revenues	**$31.1**	**$66.4**	**$31.3**	**$128.7**	**100.0%**
Funds Drawn from or (Placed in) Reserves	($3.3)	$0.6	$1.5	($1.3)	-1.0%
Total Expenditures Funded During 2000	**$27.7**	**$67.0**	**$32.7**	**$127.5**	**99.0%**

Source: Highway Statistics 2000, Table HF-10.

Highway-user charges, including motor-fuel taxes, motor-vehicle taxes and fees, and tolls were the source of 62.9 percent of the $128.7 billion of total revenues for highways and bridges in 2000. The remaining 37.1 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.

The degree to which highway programs are funded by highway-user charges differs widely among the different levels of government. At the Federal level, 95.6 percent of highway revenues came from motor-fuel and motor-vehicle taxes in 2000. 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, 75.5 percent, of highway revenues at the State level in 2000. Bond issue proceeds were another significant source of funding, providing 12.3 percent of highway funds at the State level. The remaining 14.0 percent of State highway funding came from general fund appropriations, other State taxes and fees, investment income, and other miscellaneous revenue sources.

Many States do not permit local governments to impose motor-fuel and motor-vehicle taxes, or they cap them at relatively low levels. Therefore, at the local government level, only 7.5 percent of highway funding was provided by highway-user charges in 2000. Local general funds, property taxes, and other taxes and fees were the source of 67.5 percent of local highway funding. Bond issue proceeds provided 9.8 percent of local highway funding, while investment income and miscellaneous receipts provided the remaining 14.0 percent.

Q. **Were all revenues generated by motor-fuel taxes, motor-vehicle taxes and fees, and tools in 2000 used for highways?**

A. No. The $81.0 billion identified as highway-user charges in Exhibit 6-2 represents only 80.5 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 2000 by all levels of government totaled $100.6 billion.

In 2000, $8.3 billion of highway-revenues was used for transit, and $11.3 billion was used for other purposes, such as ports, schools, collection costs, and general government activities. The $0.6 billion shown as Federal highway-user revenues used for other purposes includes fuel tax proceeds deposited into the Leaking Underground Storage Tank (LUST) fund, as well as the portion of gasohol tax receipts that is retained by the general fund for deficit reduction.

Exhibit 6-3

Disposition of Highway-User Revenue By Level of Government, 2000

	FEDERAL	STATE	LOCAL	TOTAL
Portion used for:				
Highways	$29.7	$49.0	$2.3	$81.0
Transit	$5.2	$2.1	$1.0	$8.3
Other	$0.6	$10.5	$0.2	$11.3
Total Collected	**$35.5**	**$61.6**	**$3.5**	**$100.6**

Source: Highway Statistics 2000, Table HF-10

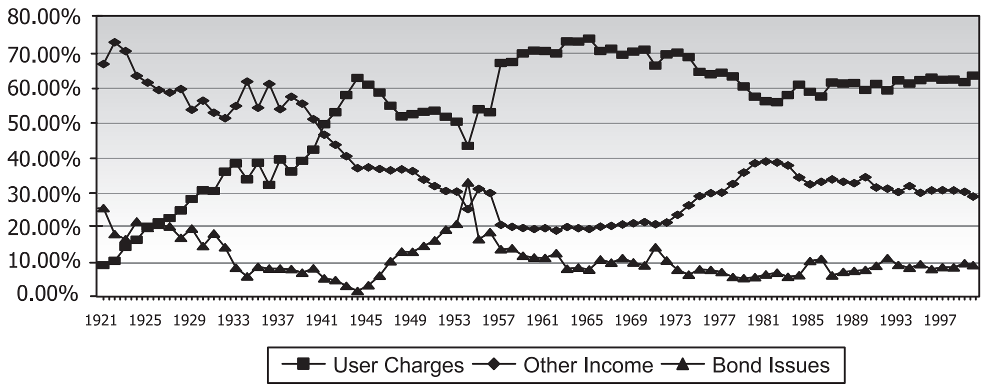
The $5.2 billion shown as Federal highway-user revenues used for transit includes $4.6 billion deposited into the Transit Account of the HTF, as well as $0.6 billion that was deposited in the Highway Account of the HTF that States elected to use for transit purposes. Flexible funding provisions that allow States to reprogram certain highway program funds for transit purposes are discussed in the Transit section of this chapter.

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.

Exhibit 6-4

Highways Revenue Sources by Type, All Units of Government 1921-2000



Billions of Dollars

Year	USER CHARGES: Fuel and Vehicle Taxes	USER CHARGES: Tolls	OTHER CURRENT INCOME: Property Taxes	OTHER CURRENT INCOME: General Fund Approps.	OTHER CURRENT INCOME: Other Taxes and Fees	OTHER CURRENT INCOME: Investment Income and Other	Bond 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
1994	$51.5	$3.8	$4.8	$12.4	$4.3	$7.0	$7.3	$91.3
1995	$55.4	$3.9	$4.9	$13.2	$3.7	$6.6	$8.6	$96.3
1996	$59.7	$4.4	$5.1	$14.7	$4.0	$7.1	$7.8	$102.8
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	$5.4	$6.4	$17.2	$5.4	$7.5	$11.2	$128.7

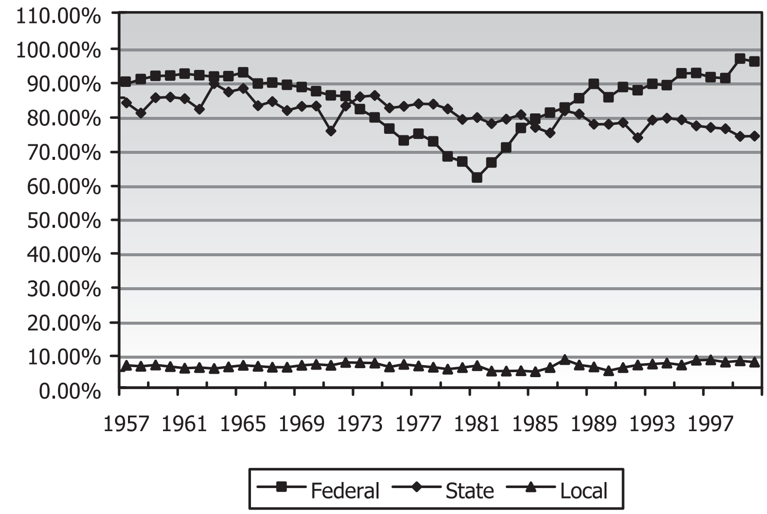
Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics Tables HF-10A and HF-10, various years.

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, and have dropped to an all-time low of 4.8 percent of total highway revenues in 1999. 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 since1971.

Since the passage of the Federal-Aid Highway Act of 1956 and the establishment of the Federal Highway Trust Fund, motor-fuel and vehicle tax receipts have consistently provided a majority of the combined revenues raised for highway and bridge programs by all levels of government.

Exhibit 6-5

Percent of Highway Revenue Derived From User Charges, for each Level of Government, 1957-2000



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%
1994	88.7%	79.0%	7.3%	60.7%
1995	92.1%	78.5%	6.6%	61.6%
1996	92.2%	76.7%	8.0%	62.3%
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	95.6%	73.7%	7.5%	62.9%

Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics, various years Tables HF-10A and HF-10.

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.

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 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.

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 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.

Exhibit 6-5 shows that the share of State government highway funding contributed by highway user charges has declined over time. From 1997 to 2000, the percentage dropped from 76.3 percent to 73.7 percent. Over the same period, States grew more reliant on debt financing, as bond proceeds grew from 10.2 percent to 12.3 percent.

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 the early to middle 1990s, the share of local government highway funding derived from highway user charges rose, reaching a level of 8.1 percent in 1997. However, this pattern has reversed itself, and the share dropped to 7.5 percent in 2000.

Highway Expenditures

Exhibit 6-2 indicates that total expenditures for highways in 2000 equaled $127.5 billion, and identifies the portion of this total funded by each level of government. Exhibit 6-6 classifies this total by type of expenditure and by the level of government. The "Federal," "State," and "Local" columns in this table indicate which level of government made the direct expenditures, while the "Funded by…" columns indicate 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 $27.7 billion (21.7 percent) of total highway expenditures of $101.3 billion in 1997, the majority of the Federal government's contribution to highways consists of grants to State and local governments. Direct Federal spending on capital outlay, maintenance, administration, and research amounted to only $2.3 billion (1.8 percent). The remaining $25.4 billion was in the form of transfers to State and local governments.

State governments combined $24.4 billion of Federal funds with $52.1 billion of State funds and $1.3 billion of local funds to make direct expenditures of $77.9 billion (61.1 percent). Local governments combined $1.0 billion of Federal funds with $14.9 billion of State funds and $31.4 billion of local funds to make direct expenditures of $47.3 billion (37.1 percent).

Types of Highway Expenditures

Current highway expenditures can be divided into two broad categories: non-capital and capital. Non-capital highway expenditures include maintenance of highways, highway and traffic services, administration, highway law enforcement, highway safety, and interest on debt. Highway capital outlay consists of those expenditures associated with highway improvements, including land acquisition and other right-of-way costs; preliminary and construction engineering; new construction, reconstruction, resurfacing, rehabilitation, and restoration costs of roadways, bridges, and other structures; and installation of traffic service facilities such as guardrails, fencing, signs, and signals. Bond retirement is not part of current expenditures, but it is included in the figures cited for total highway expenditures in this report.

Exhibit 6-6

Direct Expenditures for Highways, by Expending Agencies and by Type Billions of Dollars, 2000

	FEDERAL	STATE	LOCAL	TOTAL	PERCENT
CURRENT EXPENDITURES					
Capital Outlay					
Funded by Federal Government	$0.3	$24.4	$1.0	$25.8	20.2%
Funded by State or Local Govt's	$0.0	$23.2	$15.7	$38.9	30.5%
Subtotal	**$0.3**	**$47.6**	**$16.7**	**$64.6**	**50.7%**
Non-Capital Expenditures					
Maintenance	$0.2	$9.1	$14.9	$24.2	19.0%
Highway and Traffic Services	$0.0	$3.8	$2.9	$6.8	5.3%
Administration	$1.8	$5.5	$3.0	$10.3	8.1%
Highway Patrol and Safety	$0.0	$5.7	$5.0	$10.7	8.4%
Interest on Debt	$0.0	$3.0	$2.0	$5.1	4.0%
Subtotal	**$1.9**	**$27.2**	**$27.9**	**$57.1**	**44.8%**
Total, Current Expenditures	**$2.3**	**$74.8**	**$44.6**	**$121.7**	**95.5%**
Bond Retirement	**$0.0**	**$3.1**	**$2.7**	**$5.7**	**4.5%**
Total All Expenditures					
Funded by Federal Government	$2.3	$24.4	$1.0	$27.7	21.7%
Funded by State Governments	$0.0	$52.1	$14.9	$67.0	52.6%
Funded by Local Governments	$0.0	$1.3	$31.4	$32.7	25.7%
Grand Total	**$2.3**	**$77.9**	**$47.3**	**$127.5**	**100.0%**

Source: Highway Statistics 2000, Table HF-10.

As shown in Exhibit 6-6, all levels of government spent $64.6 billion on capital outlay in 2000, or 50.7 percent of total highway expenditures. Highway capital outlay expenditures are discussed in more detail later in this chapter.

Current non-capital expenditures consumed $57.1 billion (44.8 percent), while the remaining $5.7 billion (4.5 percent) went for bond redemption. Most Federal funding for highways goes for capital items. Non-capital expenditures are funded primarily by State and local governments. In 2000, State and local non-capital expenditures were close to equal, as State governments spent $27.2 billion while local governments spent $27.9 billion. The majority of maintenance expenditures occurred at the local government level, or $14.9 billion (61.6 percent) of the $24.2 billion total.

Historical Expenditure and Funding Trends

Exhibits 6-7 and 6-8 provide historical perspective for the 2000 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 25.0 percent increase (from $102.0 billion to $127.5 billion) in total highway spending by all levels of government between 1997 and 2000. Capital outlay by all levels of government increased by 33.7 percent from $48.4 billion to $64.6 billion.

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, reaching 50.7 percent in 2000. This was the first time this percentage had exceeded 50 percent since 1975.

Exhibit 6-8 shows that the portion of total highway funding provided by the Federal government rose from 20.8 to 21.7 percent from 1997 to 2000. It is interesting, however, to note that the Federal share of capital funding dropped from 41.6 to 39.9 percent over this same period. While Federal cash expenditures for capital purposes increased 28.3 percent from 1997 to 2000, State and local capital investment increased even faster (37.1 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 are 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?

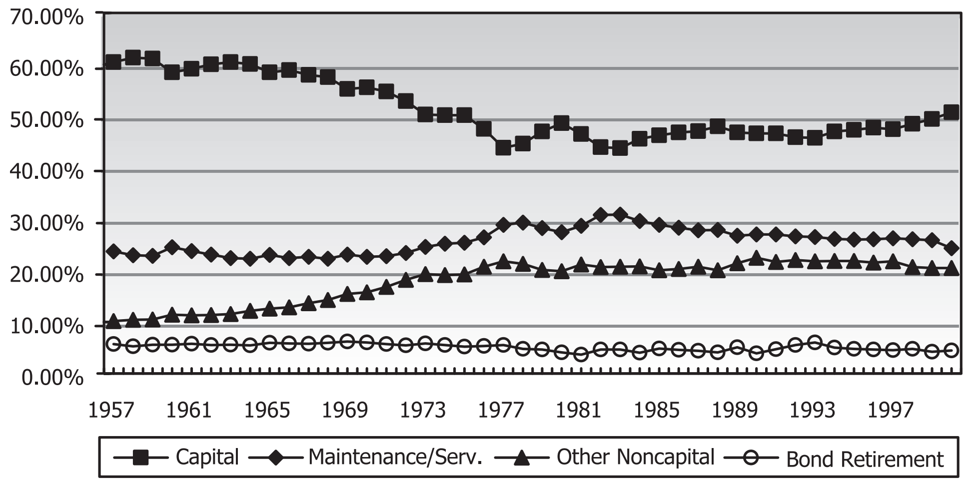
A. Maintenance in this report includes routine and regular expenditures required to keep the highway surface, shoulders, roadsides, structures, and traffic control devices in usable condition. This includes spot patching and crack sealing of roadways and bridge decks, and the maintenance and repair of 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.

Exhibit 6-7

Expenditures for Highways by Type, All Units of Government 1957-2000

Percent by Type of Expenditure



Billions of Dollars

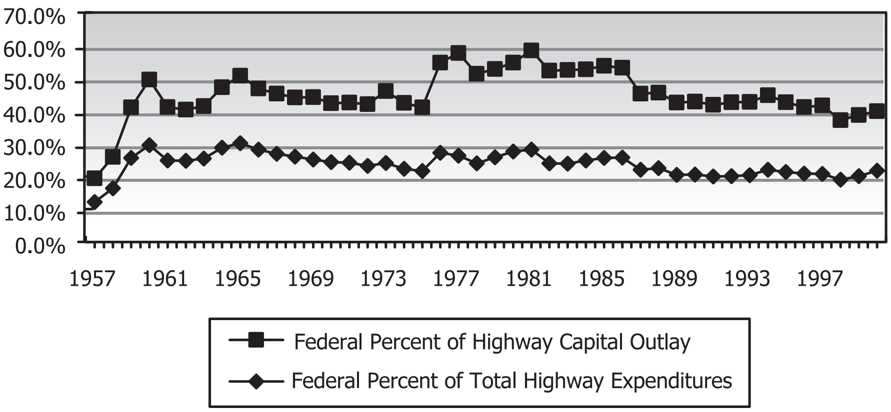
Year	Capital Outlay	Maintenance and Services	OTHER NON-CAPITAL: Administration	OTHER NON-CAPITAL: Highway Patrol & Safety	OTHER NON-CAPITAL: Interest On Debt	OTHER NON-CAPITAL: Total Other Non-Capital	Debt Retirement	Total
1957	$5.6	$2.2	$0.4	$0.3	$0.3	$0.9	$0.5	$9.3
1961	$6.8	$2.7	$0.5	$0.3	$0.4	$1.3	$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
1994	$42.4	$23.6	$8.4	$7.7	$3.7	$19.7	$4.5	$90.2
1995	$44.2	$24.3	$8.4	$8.2	$3.8	$20.4	$4.5	$93.5
1996	$46.8	$25.6	$8.4	$8.9	$3.8	$21.1	$4.6	$98.1
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	$64.6	$31.0	$10.3	$10.7	$5.1	$26.1	$5.7	$127.5

Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics Tables HF-10A and HF-10, various years.

Exhibit 6-8

Funding for Highways by Level of Government, 1957-2000

Percent of Total Highway Expenditures and Highway Capital Outlay Funded by the Federal Government



Year	Funding for Total Highway Expenditures: Billions of Dollars FEDERAL	STATE	LOCAL	TOTAL	Percent Federal	Funding for Capital Outlay: Billions of Dollars FEDERAL	TOTAL	Percent Federal
1957	$1.1	$6.1	$2.0	$9.3	12.2%	$1.1	$5.6	19.4%
1961	$2.9	$6.2	$2.4	$11.5	24.8%	$2.8	$6.8	41.1%
1965	$4.3	$7.3	$2.7	$14.3	30.1%	$4.2	$8.4	50.7%
1969	$4.7	$10.4	$3.7	$18.8	25.1%	$4.6	$10.4	44.2%
1973	$5.8	$13.8	$4.6	$24.2	24.1%	$5.6	$12.2	46.0%
1977	$7.8	$15.1	$6.9	$29.8	26.3%	$7.5	$13.1	57.6%
1981	$11.9	$20.1	$10.4	$42.4	28.1%	$11.5	$19.7	58.4%
1985	$14.7	$27.9	$14.9	$57.5	25.7%	$14.3	$26.6	53.8%
1989	$14.5	$36.4	$19.9	$70.9	20.5%	$14.1	$33.1	42.5%
1993	$17.6	$46.5	$22.3	$86.4	20.4%	$16.9	$39.5	42.7%
1994	$19.9	$45.1	$25.3	$90.2	22.0%	$19.0	$42.4	44.8%
1995	$19.9	$48.8	$24.7	$93.5	21.3%	$18.9	$44.2	42.6%
1996	$20.5	$51.5	$26.1	$98.1	20.9%	$19.3	$46.8	41.2%
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	$27.7	$67.0	$32.7	$127.5	21.7%	$25.8	$64.6	39.9%

Sources: Highway Statistics Summary to 1995 Table HF-210; Highway Statistics, various years, Tables HF-10A and HF-10.

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 Fiscal Year 1998, the increased funding under the legislation did not translate immediately 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 in 1999 and 2000, as the increased obligation authority provided under TEA-21 began to translate into higher cash outlays.

> **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.

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. However, the Federal percentage of capital funding dropped to 37.1 percent in 1998, and has not risen back to the 40 percent level since then. The 1999 C&P report incorrectly predicted that the Federal share for 1999-2003 would return to a range of 41 to 46 percent, after declining in 1998. This did not occur due to the unexpectedly large increases in State and local capital investment since 1997 that were noted above.

Spending by all levels of government on maintenance and traffic services increased by 15.7 percent from 1997 to 2000, 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 24.3 percent, its lowest level since 1972. Spending on other non-capital expenditures include highway law enforcement and safety, administration and research, and interest payments also grew more slowly than overall highway spending from 1997 to 2000, falling from 21.8 percent of total spending to 20.5 percent.

The 1999 edition of this report noted that expenditures for highway law enforcement and safety grew more quickly than other spending categories from 1995 to 1997. This trend has not been maintained in subsequent years, as spending growth in this category was slower than overall highway spending growth from 1997 to 2000. The 1999 edition also noted that expenditures for administration and research remained relatively flat between 1994 and 1997. Since 1997, this trend has changed, and growth in this category kept pace with the overall growth in highway spending over this later period. The share of total spending devoted to debt service also remained relatively equal between 1997 and 2000.

Constant Dollar Expenditures

Highway expenditures grew more quickly than inflation between 1997 and 2000. As noted earlier, total highway expenditures increased 25.0 percent from $102.0 billion to $127.5 billion between 1997 and 2000, which equates to an average annual growth rate of 7.7 percent. Over the same period, it is estimated that highway construction costs increased at an annual rate of 3.7 percent, and other costs rose at an annual rate of 2.4 percent. In constant dollar terms, total highway expenditures grew by 14.4 percent between 1997 and 2000.

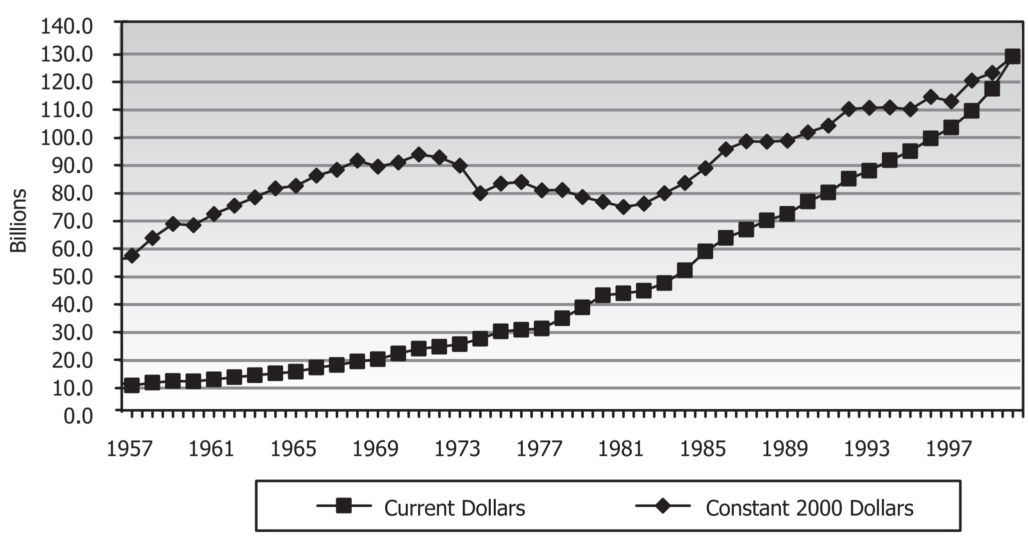
> **Q. What indices are used to convert current dollars to constant dollars in this report?**
>
> **A.** For captial outlay expenditures, the FHWA Construction Bid Price Index is used. For all other types of highway expenditures, the Consumer Price Index (CPI) is used.

Exhibit 6-9 shows that highway expenditures have grown in current dollar terms in each of the years from 1957 through 2000. 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 2000.

Much of the increase in constant dollar spending since 1981 has been driven by highway capital outlay expenditures, which have grown more quickly than maintenance and other non-capital expenditures in both current and constant dollar terms. Over this 19-year period, highway capital outlay grew at an average annual rate of 6.5 percent from $19.0 billion to $64.6 billion. In constant dollar terms, this equates to a 112.3 percent increase. Over this same period, maintenance and traffic services grew by 34.5 percent in constant dollar terms, and other non-capital expenditures grew by 53.4 percent in constant dollars. Highway

Exhibit 6-9

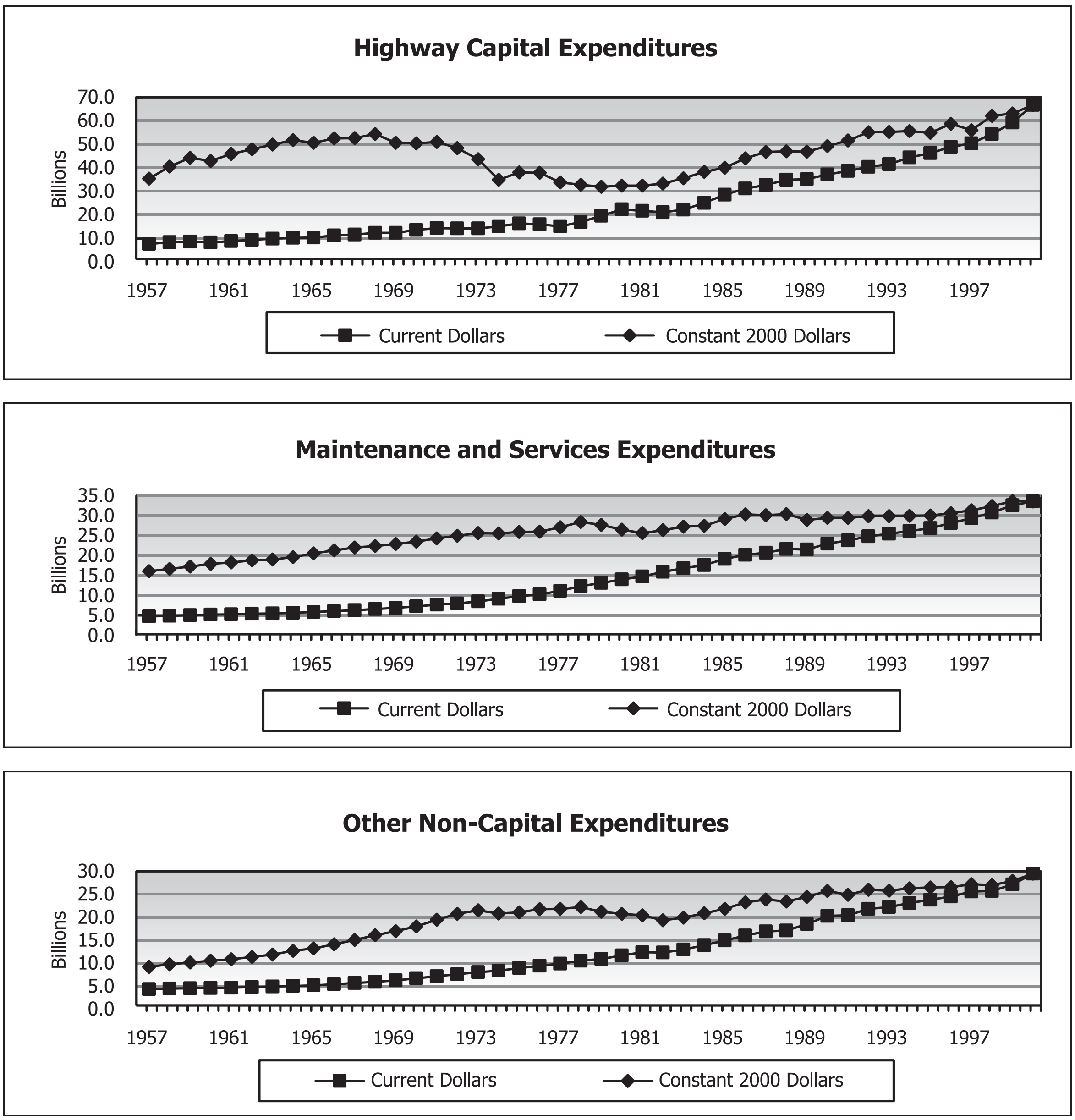
Total Highway Expenditures in Current and Constant 2000 Dollars, All Units of Government 1957-2000



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 2.3 percent since 1981, compared to an average annual increase in the CPI of 3.4 percent. Exhibit 6-10 compares current dollar and constant dollar spending for capital outlay, maintenance and traffic services, and other non-capital expenditures (including highway law enforcement and safety, administration and research, and interest payments).

Exhibit 6-10

Highway Capital, Maintenance, and Other Non-Capital Expenditures in Current and Constant 2000 Dollars, All Units of Government 1957-2000



Constant Dollar Expenditures per VMT

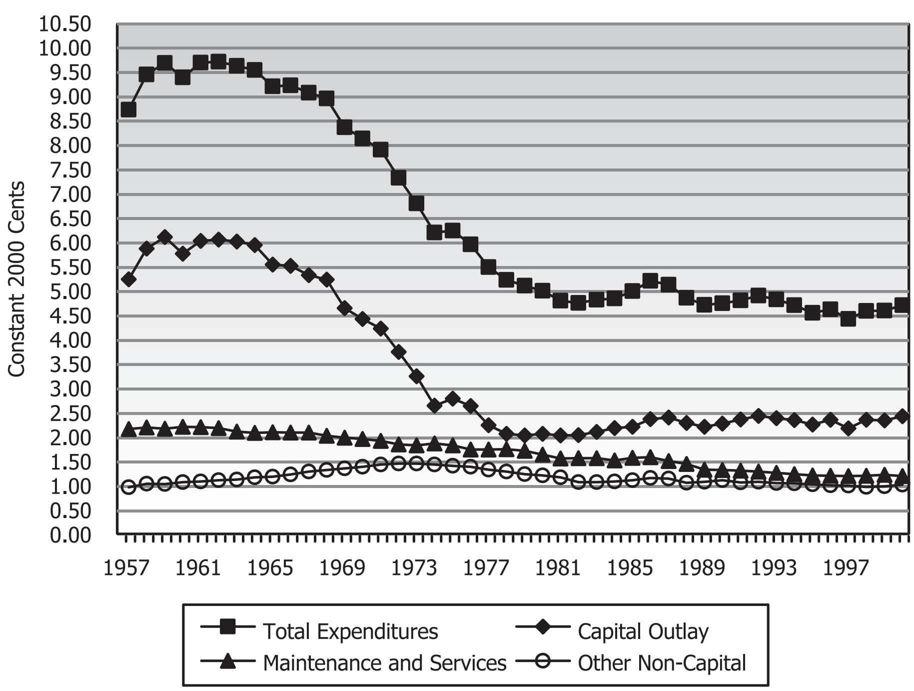
While not all types of highway expenditures would necessarily be expected to grow in proportion to vehicle miles traveled (VMT), increases in VMT do increase the wear and tear on existing roads, leading to higher capital and maintenance costs. The addition of new lanes and roads to accommodate additional 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 4.6 cents. Expenditures per VMT in constant dollars also rose in this period, increasing 6.6 percent. This increase reversed the downward trend noted in the 1999 C&P report. 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 2000 in constant dollar terms. The 2000 level of 2.35 cents per VMT was the second highest since 1976. As shown in Exhibit 6-11, over time, spending on maintenance and traffic services and other non-capital items has not kept pace with capital spending on a constant dollar per VMT basis.

Exhibit 6-11

Highway Expenditures per Vehicle Mile of Travel, All Units of Government 1957-2000 (Constant 2000 Cents)



Highway Capital Outlay Expenditures

State governments directly spent $47.6 billion on highway capital outlay in 2000. As discussed earlier in the chapter, and as shown in Exhibit 6-6, this figure includes the $24.4 billion received in grants from the Federal government for highways. Exhibit 6-12 shows how States applied this $47.6 billion to different functional systems and also includes an estimate of how the total $64.6 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 $7,825 per lane-mile in 2000, or 2.3 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 3.3 cents on rural other principal arterials to 1.5 cents on urban minor arterials. On a cents-per-VMT basis, capital outlay for rural roads is about 9 percent higher than for urban roads.

Exhibit 6-12

Highway Capital Outlay by Functional System, 2000

FUNCTIONAL CLASS	Direct State Capital Outlay ($Billions)	Capital Outlay, all Jurisdictions TOTAL ($Billions)	PER LANE-MILE (Dollars)	PER VMT (Cents)
Rural Arterials and Collectors				
Interstate	$4.5	$4.5	$32,977	1.6
Other Principal Arterial	$8.1	$8.2	$32,210	3.3
Minor Arterial	$3.4	$3.8	$13,239	2.2
Major Collector	$2.9	$4.2	$4,813	2.0
Minor Collector	$0.5	$1.3	$2,396	2.2
Subtotal	**$19.3**	**$21.9**	**$10,471**	**2.3**
Urban Arterials and Collectors				
Interstate	$9.6	$9.6	$128,838	2.4
Other Freeway & Expressway	$3.7	$3.9	$92,774	2.2
Other Principal Arterial	$7.0	$8.7	$46,479	2.2
Minor Arterial	$2.4	$4.9	$21,253	1.5
Collector	$0.7	$2.6	$13,671	1.9
Subtotal	**$23.4**	**$29.7**	**$41,056**	**2.1**
Subtotal, Rural and Urban	**$42.7**	**$51.6**	**$18,320**	**2.1**
Rural and Urban Local	**$4.9**	**$13.0**	**$2,391**	**3.6**
Total, All Systems	**$47.6**	**$64.6**	**$7,825**	**2.3**
Funded by Federal Government	**$24.4**	**$25.8**	**$3,121**	**0.9**

Source: Highway Statistics 2000 and unpublished FHWA data.

Capital Outlay by Improvement Type

States provide the Federal Highway Administration 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 $42.7 billion in State expenditures among these three categories. Detailed data on Federal Government and local expenditures is unavailable, so the combined $51.6 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 $64.6 billion invested on all systems in 2000, it was assumed that expenditure patterns were roughly equivalent to those observed for arterials and collectors.

In 2000, about $33.6 billion was spent on system preservation (51.9 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.

About $12.2 billion (18.9 percent of total capital outlay) was spent on the construction of new roads and bridges in 2000. An additional $13.7 billion (21.2 percent) is estimated to have been used to add lanes to existing roads. Another $5.1 billion (7.9 percent) was spent on system enhancement, including safety enhancements, traffic operations improvements, and environmental enhancements.

Exhibit 6-14 examines how the share of capital outlay devoted to these major categories has changed over time. 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. This represents a larger share than in 1995, and is significantly higher than the 44.7 percent reported for 1993. The share devoted to system enhancements was steady between 1997 and 2000, and remains higher than the 1993 level. Expenditures for new roads and bridges increased relative to other improvement expenditures between 1997 and 2000, from 15.6 percent of total expenditures to 18.9 percent. Other system

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 $24.2 billion was spent by all levels of government in 2000 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.

Exhibit 6-13

Highway Capital Outlay by Improvement Type, 2000 (Billions of Dollars)

	SYSTEM PRESERVATION	SYSTEM EXPANSION: New Roads & Bridges	SYSTEM EXPANSION: Existing Roads	SYSTEM ENHANCEMENT	TOTAL
Direct State Expenditures on Arterials and Collectors					
Right-of Way		1.5	1.5		2.9
Engineering	3.3	1.1	1.1	0.5	5.9
New Construction		5.4			5.4
Relocation			0.6		0.6
Reconstruction-Added Capacity	1.6		3.7		5.3
Reconstruction-No Added Capacity	1.9				1.9
Major Widening			2.0		2.0
Minor Widening	0.7				0.7
Restoration & Rehabilitation	6.5				6.5
Resurfacing	3.1				3.1
New Bridge		0.9			0.9
Bridge Replacement	2.2				2.2
Major Bridge Rehabilitation	1.3				1.3
Minor Bridge Work	1.3				1.3
Safety				1.1	1.1
Traffic Management/Engineering				0.5	0.5
Environmental and Other				1.0	1.0
Total, State Arterials & Collectors	**22.0**	**8.8**	**8.8**	**3.1**	**42.7**
Total, Arterials and Collectors, All Jurisdictions (estimated)*					
Highways and Other	20.7	8.8	10.9	4.1	44.6
Bridge	6.1	0.9			7.0
Total, Arterials and Collectors	**26.8**	**9.8**	**10.9**	**4.1**	**51.6**
Total Capital Outlay on all Systems (estimated)*					
Highways and Other	25.9	11.1	13.7	5.1	55.8
Bridges	7.6	1.2			8.8
Total, All Systems	**33.6**	**12.2**	**13.7**	**5.1**	**64.6**
Percent of Total	**52.0%**	**18.9%**	**21.2%**	**7.9%**	**100.0%**

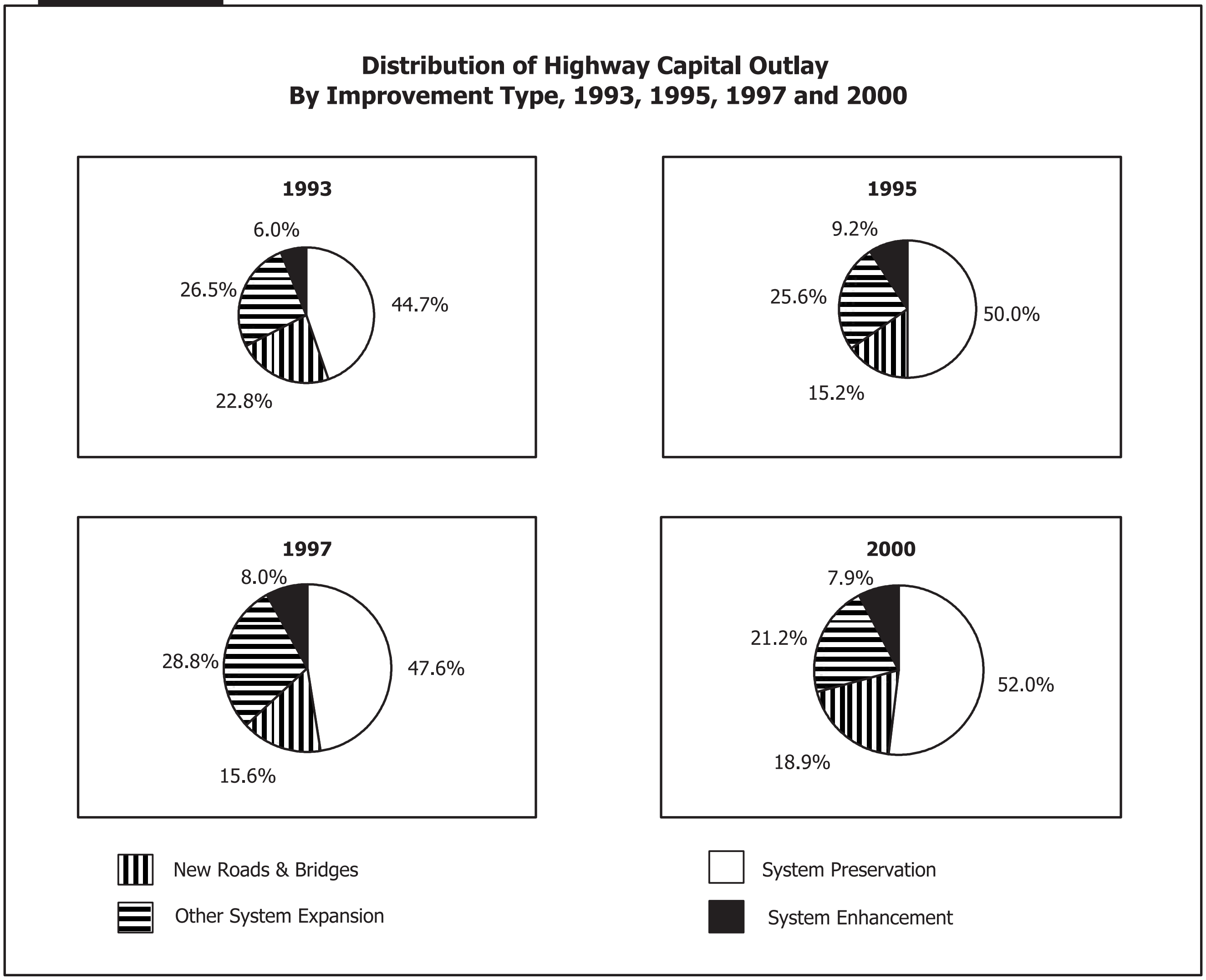
*Improvement type distribution was estimated based on State arterial and collector data.

Sources: Highway Statistics 2000, Table SF-12A and unpublished FHWA data.

expansion decreased significantly, however (28.8 percent in 1997 versus 21.2 percent in 2000), resulting in a proportional decrease overall for system expansion outlays, compared to preservation and enhancements.

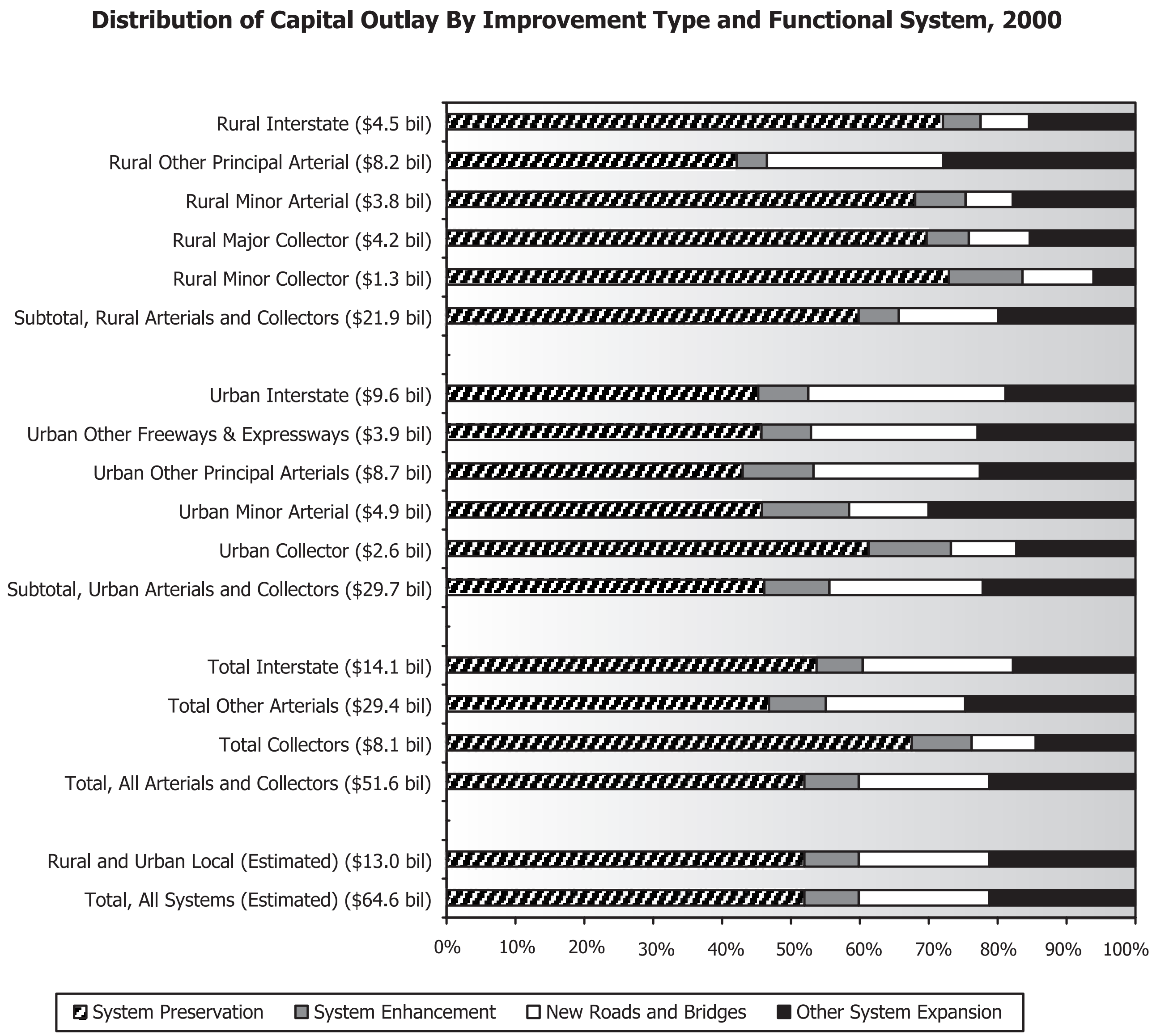
Exhibit 6-15 shows significant variations in the types of capital expenditures made by States on different functional systems. The portion of capital outlay devoted to system preservation ranges from 43.0 percent on urban other principal arterials to 72.9 percent on rural minor collectors. Overall, system preservation's share on arterials and collectors in rural areas (59.8 percent) was greater than in urban areas (46.1 percent).

Exhibit 6-14



System expansion expenditures also vary significantly by functional class. The portion of capital used for construction of new roads and bridges is highest on urban interstates, at 28.6 percent, while urban minor arterials have the largest share going to other system expansion improvements (30.0 percent). Rural other principal arterials have over 53 percent of capital investment devoted to system expansion. Total system expansion shares are lower on collectors (23.8 percent) than on interstates (39.6 percent) and other arterials (44.9 percent).

Exhibit 6-15


Distribution of Capital Outlay By Improvement Type and Functional System, 2000
Rural Interstate ($4.5 bil)
Rural Other Principal Arterial ($8.2 bil)
Rural Minor Arterial ($3.8 bil)
Rural Major Collector ($4.2 bil)
Rural Minor Collector ($1.3 bil)
Subtotal, Rural Arterials and Collectors ($21.9 bil)
Urban Interstate ($9.6 bil)
Urban Other Freeways & Expressways ($3.9 bil)
Urban Other Principal Arterials ($8.7 bil)
Urban Minor Arterial ($4.9 bil)
Urban Collector ($2.6 bil)
Subtotal, Urban Arterials and Collectors ($29.7 bil)
Total Interstate ($14.1 bil)
Total Other Arterials ($29.4 bil)
Total Collectors ($8.1 bil)
Total, All Arterials and Collectors ($51.6 bil)
Rural and Urban Local (Estimated) ($13.0 bil)
Total, All Systems (Estimated) ($64.6 bil)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
System Preservation
System Enhancement
New Roads and Bridges
Other System Expansion

Transit Finance

Transit Funding

In 2000, $30.8 billion was available from all sources to finance public transit investment and operations. Public 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 of the Highway Trust Fund and undedicated taxes allocated from Federal general fund appropriations such as personal and business income taxes. State and local governments also provide transit funding from their general fund appropriations as well as from fuel, income, sales, property, and other unspecified taxes, specific percentages of which are dedicated to transit *[See Exhibit 6-16]*. These percentages may vary considerably by type of tax and among taxing jurisdictions. Other public funds may also be provided from sources such as toll revenues and general transportation funds. System generated revenues are comprised principally of passenger fares, although additional revenues are also earned by transit systems for the provision of other services such as advertising and concessions, and from joint development fees. (See Exhibit 6-17 for a sources of total transit funding.)

Exhibit 6-16

Revenue Sources for Transit Financing 2000 (Millions of Dollars)

	FEDERAL	STATE	LOCAL	TOTAL	PERCENT
Public Funds	**$5,259**	**$5,419**	**$10,322**	**$20,999**	**68.1%**
General Fund	$999	$2,192	$2,322	$5,513	**17.9%**
Fuel Tax	$4,260	$395	$107	$4,762	**15.4%**
Income Tax		$152	$47	$198	**0.6%**
Sales Tax		$576	$4,209	$4,786	**15.5%**
Property Tax		$46	$522	$568	**1.8%**
Other Dedicated Taxes		$640	$392	$1,033	**3.3%**
Other Public Funds		$1,417	$2,722	$4,139	**13.4%**
System Generated Revenue				**$9,832**	**31.9%**
Passenger Fares				$7,811	25.3%
Other Revenue				$2,021	6.6%
Total All Sources				**$30,831**	**100.0%**

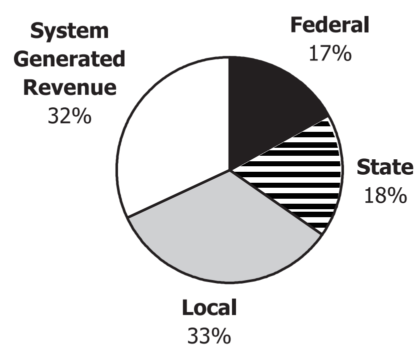
Source: National Transit Database.

Level and Composition of Public Funding

In 2000, public funds of $21.0 billion were available for transit and accounted for 68.1 percent of total transit funding. Of this amount, Federal funding was $5.3 billion and accounted for 25.0 percent of total public funds and 17 percent of all transit funding. State funding for transit was $5.4 billion and accounted for 25.8 percent of total public funds and 18 percent of all transit funding. Local jurisdictions provided the bulk of public transit funds, $10.3 billion in 2000, or 49.2 percent of total public funds and 33 percent of all transit funding.

Exhibit 6-17

Transit System Revenue Sources, 2000

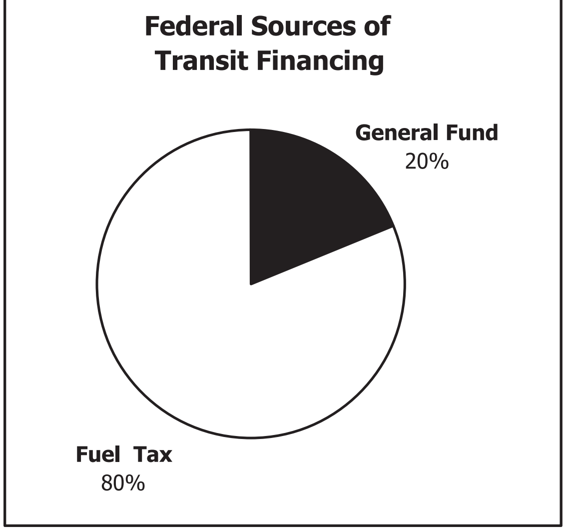


Source: National Transit Database.

Federal Funding

The fuel tax is the largest source of Federal funding for transit and accounts for 80.0 percent of total Federal funds. Allocations from the Federal general fund contribute the remaining 20.0 percent. *[See Exhibit 6-18]*.

Exhibit 6-18



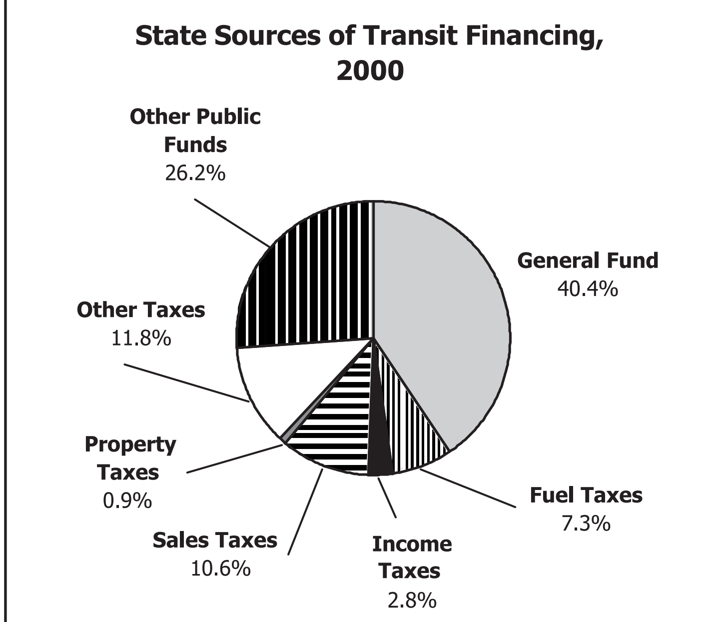
Transit funding from Federal Motor Fuel Tax was introduced in 1983 through the dedication of one cent of the Federal motor fuel tax to a public transportation trust fund for capital projects. In 1990, the dedicated portion of the Federal fuel tax was increased to 1.5 cents, in 1995 to 2.0 cents, in 1997 to 2.85 cents, and in 1998 to 2.86 cents (retroactive to October 1, 1997) with the passage of the Transportation Equity Act for the 21st Century (TEA-21). Federal gasoline taxes have increased in current dollars from 4.0 cents per gallon in 1965 to 18.4 cents per gallon in 1995.

The first Federal tax on gasoline was implemented in 1932. States had been collecting taxes on gasoline since 1919, but Congress did not implement a Federal gasoline tax until it identified a general revenue shortfall in 1932. Between 1932 and 1956, receipts from the Federal gasoline tax continued to go to the general fund. Taxes on other motor fuels were added during this period. In 1956, motor fuel taxes were earmarked for the Federal Highway Trust Fund.

State and Local Funding

General funds and other dedicated public funds are important sources of transit funding at both the State and local levels. *[See Exhibits 6-19 and 6-20]*. In 2000, 40.4 percent of State funds and 22.5 percent of local funds came from general funds. Allocations from other public funds accounted for just over 26.0 percent of total State and local transit funding. Dedicated sales taxes are a major source of revenue at the local level and in 2000 accounted for 40.8 percent of total local transit public funding. They contributed a smaller share, 10.6 percent, to State transit funding. 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.

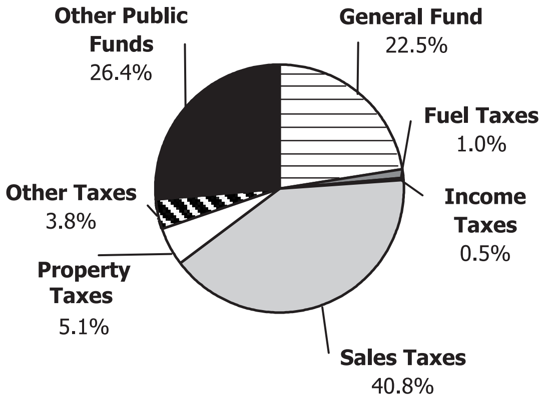
Exhibit 6-19



Source: National Transit Database.

Exhibit 6-20

Local Sources of Transit Finance, 2000



Source: National Transit Database.

Formula Grants Program

The Federal Transit Administration **(FTA) Formula Grants Program** is comprised of the **Urbanized Area Formula Program (Section 5307)**, the **Non-urbanized 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 $3.3 billion in FY2001. 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 Non-urbanized 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. Non-urbanized areas are defined as rural areas and urban areas with populations under 50,000.

Level and Composition of System-Generated Funds

System generated funds were $9.8 billion in 2000 and provided 31.9 percent of total transit funding. Passenger fares contributed $7.8 billion, accounting for 79.4 percent of system-generated funds and 25.3 percent of total transit funds. These passenger 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.

Trends in Public Funding

Prior to 1962, there was no Federal funding for public transit. State and local funding was limited, equal to about 16 percent of total current public funding in real terms. Public funding grew rapidly during the 1970s; at an average annual rate, Federal funding increased by 38.9 percent and State and local funding by 11.9 percent throughout the decade. Federal funding grew minimally 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. Since 1990, Federal funding has increased at an average annual rate of 4.3 percent, more slowly than the 4.8 percent average annual increase in State and local funding. *[See Exhibit 6-21].*

Exhibit 6-21

Growth in Public Funding for Transit by Government Jurisdiction, 1960-2000

	Average Annual Growth Rate		
YEAR	FEDERAL	STATE AND LOCAL	TOTAL
1960-70	na	8.18%	9.04%
1970-80	38.87%	11.91%	17.18%
1980-90	0.45%	7.84%	5.30%
1990-2000	4.28%	4.83%	4.69%

Source: Congressional Budget Office/National Transit Database.

Flexible Funding

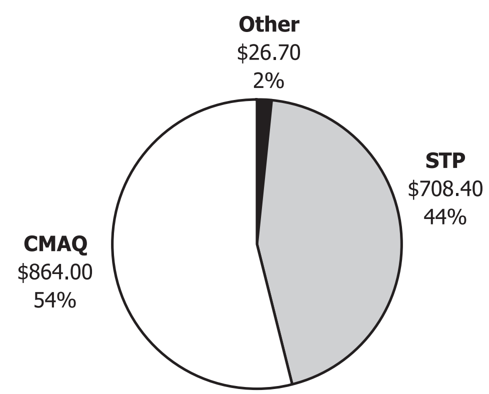
Since 1973, Federal surface transportation authorization statutes have contained flexible funding provisions that enable transfers from certain highway funds to transit programs and vice versa. In 1973, Congress began allowing local areas to exchange interstate transfer highway trust funds for transit 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 the Transportation Equity Act for the 21st Century (TEA-21). Transfers are subject to State, regional/local discretion, and priorities established through Statewide transportation planning processes. All States and territories within the U.S. participate in the flexible funding program, with the exceptions of Kansas, North Dakota, South Dakota, and Wyoming. *(See Exhibit 6-22).*

Flexible funds may be transferred from FHWA to FTA under the following programs:

- **Surface Transportation Program (STP):** STP is the largest flexible fund program. Flexible funds allocated from STP 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. *(See Exhibit 6-22).*
- **Congestion Mitigation and Air Quality Improvement Program (CMAQ):** Flexible funds from CMAQ funds are used to support transit projects to reduce vehicle emissions in areas that are not meeting air quality standards.
- **FHWA Other:** Flexible funds are allocated to FTA projects, earmarked under ISTEA and TEA-21 as innovative demonstration, congestion relief, and intermodel projects.

Exhibit 6-22

Sources of FHWA Flexible Fund Transfers to FTA, 2000 (Millions of Dollars)



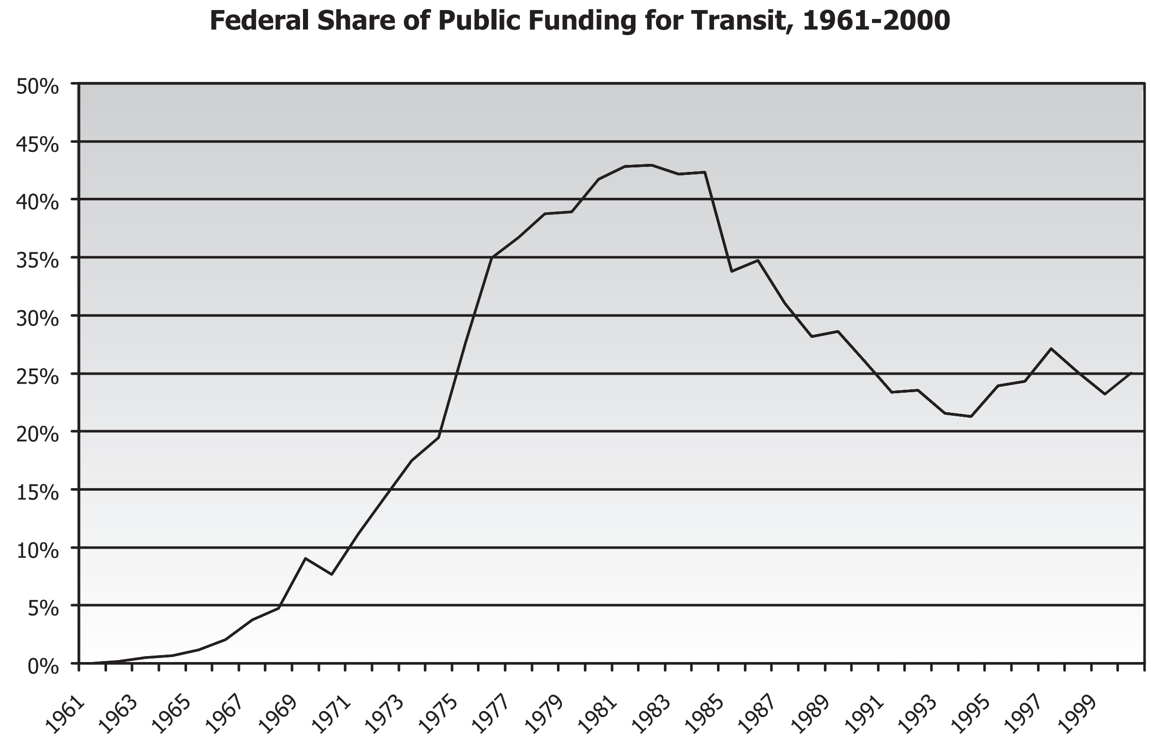
Source: Federal Transit Administrtion, Office of Resource Management and State Programs.

These flexible funds may be transferred to one or more of the following FTA programs.

- **Urbanized Area Formula Program (Section 5307)**. Funds are allocated to urban areas for transit capital and planning costs as well as for operating assistance to urbanized areas with populations of less than 200,000.
- **Non-urbanized Area Formula Program (Section 5311)**. Funds are allocated to support service to residents outside urban areas based on the size of States' non-urban populations.
- **Elderly and Persons with Disabilities Program (Section 5310)**. Funds are allocated for the provision of specialized transit services for the elderly and disabled.
- **Metropolitan Planning Program (Section 5303)**
- **Interstate Substitute Program**

Federal funding as a percentage of total public funding for transit reached a peak of 43.0 percent in the early 1980s. *[See Exhibit 6-23]*. However, as growth in State and local funding for transit vastly exceeded the growth of Federal funding during the 1980s, by 1990, the share of total public transit funds provided by Federal funds had fallen to 26.0 percent. The share of Federal funding fell to a low of 21.3 percent in 1994, climbed to 27.1 percent in 1997, fall back to 23.2 percent in 1999, and increased again slightly to 25.0 percent in 2000.

Exhibit 6-23



Source: National Transit Database.

Funding in Current and Constant Dollars

Total public funding for transit in current dollars reached its highest level in current dollars of $21.0 million in 2000 *(See Exhibit 6-24)*.

Total Federal funding in constant dollars has grown more unevenly than in current dollars, although it has increased in most years *(See Exhibit 6-25)*. The largest decline in constant dollar funding occurred between 1980 and 1984, a period of rapid inflation when funding in current dollars increased.

The growth of State and local funding, which as previously mentioned has been considerably more rapid than the growth in Federal funding, has also been more erratic on a constant, as compared with a current, dollar basis *(See Exhibit 6-26)*.

Exhibit 6-24

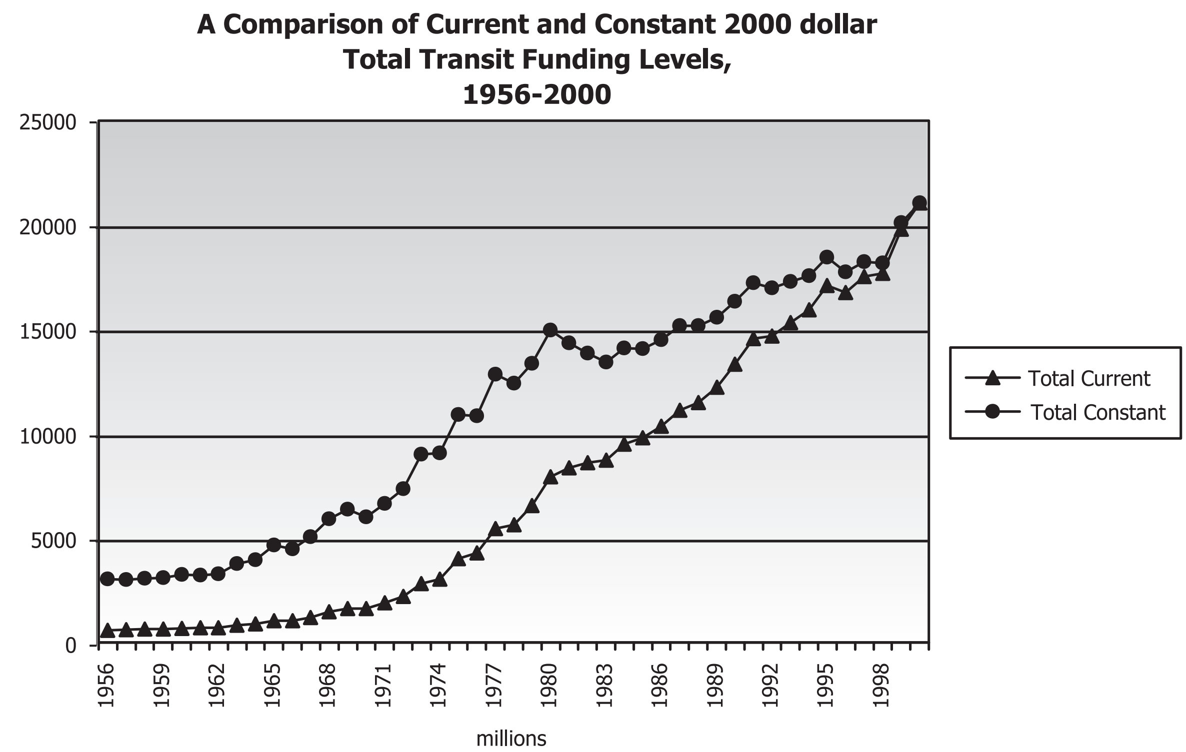
Public Funding for Transit by Government Jurisdiction
Selected Years, 1960-2000

YEAR	FEDERAL	STATE AND LOCAL	TOTAL	FEDERAL	STATE AND LOCAL	TOTAL	FEDERAL SHARE
	CURRENT DOLLARS			CONSTANT 2000 DOLLARS*			CURRENT DOLLARS
1960	$0	$683	**$683**	$0	$3,301	**$3,301**	0.0%
1970	$124	$1,499	**$1,623**	$465	$5,625	**$6,090**	7.6%
1980	$3,307	$4,617	**$7,924**	$6,314	$8,815	**$15,129**	41.7%
1990	$3,458	$9,823	**$13,281**	$4,296	$12,203	**$16,499**	26.0%
1991	$3,395	$11,116	**$14,511**	$4,060	$13,292	**$17,352**	23.4%
1992	$3,448	$11,195	**$14,643**	$4,018	$13,045	**$17,063**	23.5%
1993	$3,297	$11,991	**$15,287**	$3,752	$13,646	**$17,398**	21.6%
1994	$3,380	$12,522	**$15,902**	$3,765	$13,950	**$17,715**	21.3%
1995	$4,082	$12,971	**$17,053**	$4,450	$14,143	**$18,594**	23.9%
1996	$4,060	$12,643	**$16,703**	$4,340	$13,515	**$17,855**	24.3%
1997	$4,742	$12,728	**$17,470**	$4,972	$13,346	**$18,318**	27.1%
1998	$4,421	$13,200	**$17,620**	$4,571	$13,648	**$18,218**	25.1%
1999	$4,586	$15,166	**$19,752**	$4,681	$15,479	**$20,160**	23.2%
2000	$5,259	$15,739	**$20,999**	$5,259	$15,739	**$20,999**	25.0%

* Deflated with GDP Chained Price Index reported in The Budget of the US Government 2003.

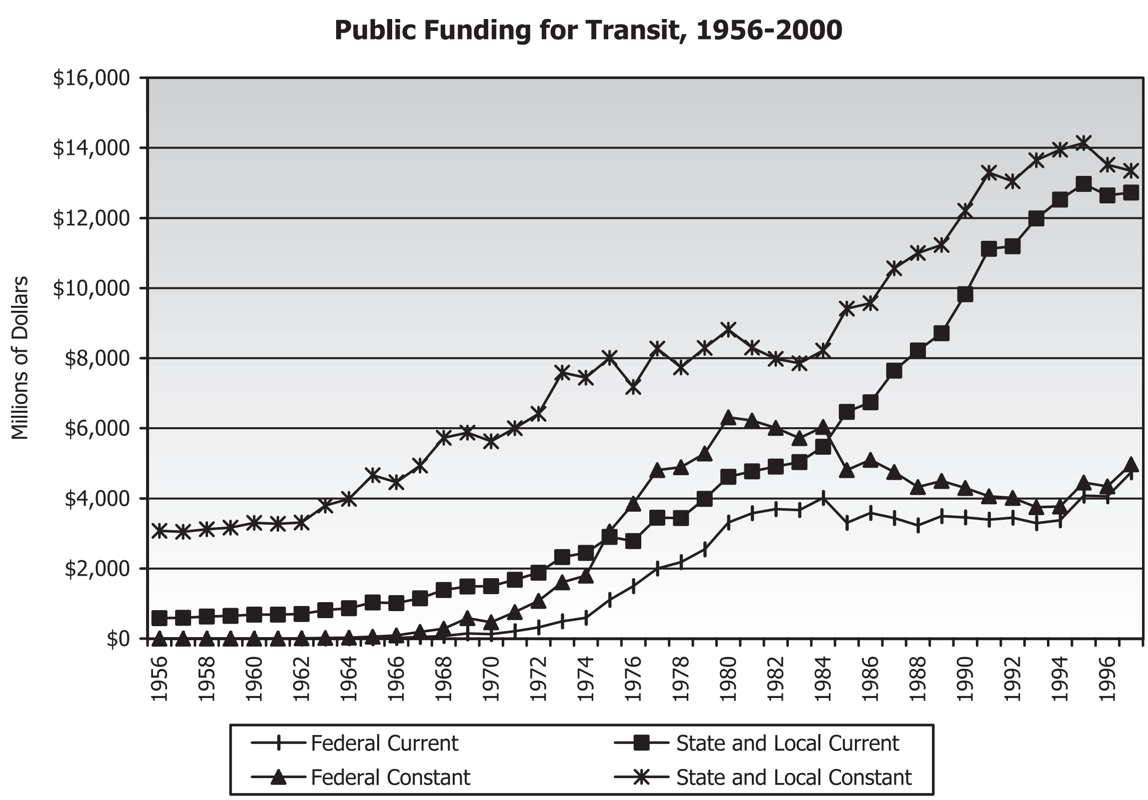
Source: National Transit Database/Office of Management and Budget.

Exhibit 6-25



Source: National Transit Database.

Exhibit 6-26



Sources: National Transit Database and Budget of the US Government, FY 2003.

Capital Funding and Expenditures

Transit operators generally use system generated revenue to fund operations. Therefore, funding for capital investments by transit operators in the U.S. comes principally from public sources. In 2000, 31.2 percent of total transit expenditures were for capital investment. Capital investments include the design and construction of 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, rail cars, 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 has 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), the State Infrastructure Bank (SIB) Pilot Program, and Grant Anticipation Revenue Vehicles (GARVEE bonds), which are discussed at the end of this chapter, contribute to the financing of transit capital investment.

In 2000, total capital expenditures on transit were $9.1 billion current dollars. *[See Exhibit 6-27].* Federal funding for transit capital expenditures grew at an average annual rate of 5.0 percent between 1990-2000, while State funding grew by 4.2 percent and local funding by 11.7 percent. There is considerable variation among these three sources in the year-to-year changes of funding levels.

Over the decade, the share of Federal funds allocated to capital expenditures has declined substantially, from 58.1 percent in 1990 to 47.2 percent in 2000, while the share of local funds has increased from 27.7 percent to 45.7 percent in 1999, decreasing slightly to 42.0 percent in 2000. This shift reflects an increase in local support for transit projects. The share of capital funding from State sources has remained relatively constant, fluctuating between 10.2 percent in 1999 and 14.2 percent in 1990—with the exception of 1993, when the State share soared to 23.0 percent.

Exhibit 6-27

Sources of Funds for Transit Capital Expenditures, 1990-2000 (Millions of Dollars)

	1990	1991	1993	1995	1997	1999	2000	Average Annual Growth
Federal	$2,636	$2,545	$2,383	$3,314	$4,138	$3,726	$4,275	5.0%
Share	58.1%	49.9%	41.6%	47.3%	54.2%	44.1%	47.2%	
State	$645	$638	$1,317	$989	$1,007	$858	$973	4.2%
Share	14.2%	12.5%	23.0%	14.1%	13.2%	10.2%	10.7%	
Local	$1,255	$1,914	$2,033	$2,706	$2,492	$3,860	$3,808	11.7%
Share	27.7%	37.6%	35.5%	38.6%	32.6%	45.7%	42.0%	
Total	**$4,536**	**$5,097**	**$5,733**	**$7,008**	**$7,636**	**$8,443**	**$9,056**	**7.2%**

Source: National Transit Database.

A higher percentage of total transit capital expenditures is allocated to rail rather than to bus modes of transportation, and to investment in transit facilities rather than in rolling stock. *[See Exhibit 6-29].* In 2000, $5.7 billion, or 63.1 percent of total transit capital expenditures, was for capital investment in rail modes of transportation such as commuter rail, heavy rail, light rail, etc., $2.9 billion, or 32.1 percent, for capital investment in bus modes, and $0.4 billion, or 4.8 percent, for capital investment in other transit modes. With regard to investments in fixed assets, $5.3 billion, or 58.0 percent of total capital expenditures, was spent on investment in transit facilities, $2.8 billion, 31.4 percent of the total, on investment in rolling stock, and $1.0 billion, or 10.6 percent of the total on other capital.

New Starts

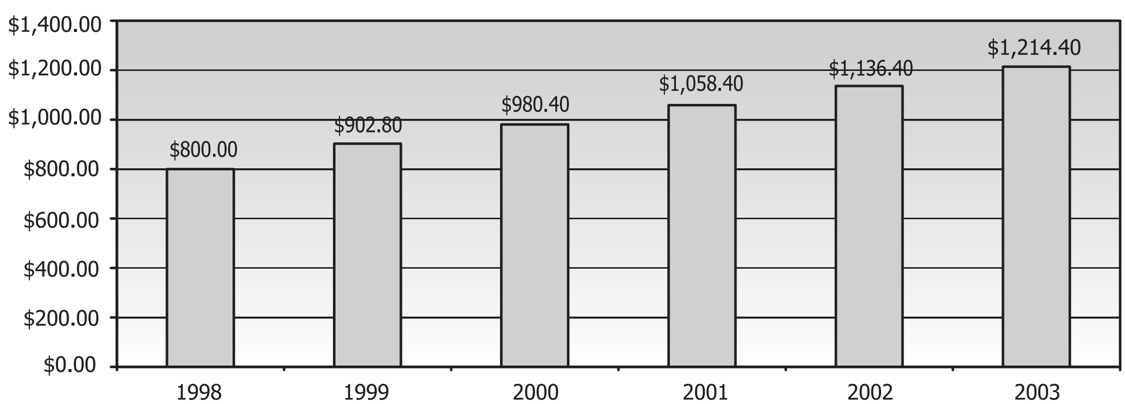
Section 49 USC 5309 provides for the allocation of funds for the construction of new fixed guideway systems, fixed guideway modernization and expansion, and bus capital requirements. Projects involving the construction of new fixed guideway systems are known as "New Starts."

In order 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. Proposed projects are evaluated on the basis of expected mobility improvements, environmental benefits, operating efficiencies and cost-effectiveness. 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 comprise up to 80.0 percent of a New Start funding requirement. The Administration is seeking a legislative change that would lower this share to no more than 50.0 percent, beginning in FY2004. 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 and will reach $1.2 billion in 2003. *[See Exhibit 6-28].*

Exhibit 6-28

New Starts Funding, 1998-2001
(Millions of Dollars)



Source: FTA.

A higher percentage of capital expenditures for rail modes is for facilities, and a higher percentage of capital expenditures for bus modes is for rolling stock. In 2000, 68.0 percent of all expenditures for capital investment in rail was for facilities, while 54.0 percent of all expenditures for capital investment in bus was for rolling stock. *[See Exhibit 6-29]*. These differences, which have remained relatively constant in recent years, reflect the reliance of rail modes on separately constructed fixed guideway systems, whereas buses, vanpools, and demand response vehicles travel on roads.

Exhibit 6-29

Transit Capital Expenditures by Type of Expenditure, 2000 (Millions of Dollars)

	ROLLING STOCK	FACILITIES	OTHER CAPITAL	TOTAL EXPENDITURE	PERCENT
Rail	$1,098	$4,135	$487	**$5,717**	63%
Bus	$1,576	$885	$444	**$2,905**	32%
Other	$165	$234	$30	**$434**	5%
Total	**$2,840**	**$5,254**	**$961**	**$9,055**	**100%**
Percent	31%	58%	11%	**100%**	

Source: National Transit Database.

Operating Expenditures

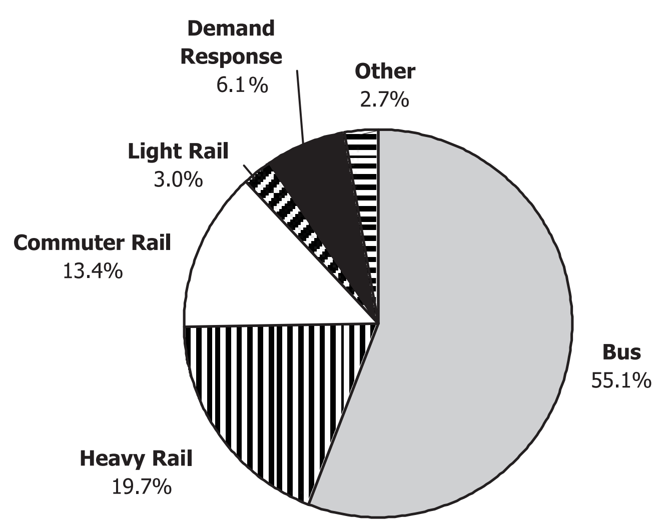
In 2000, operating expenditures, including purchased (contracted) transportation, were $20.0 billion and accounted for 68.8 percent of total transit expenditures. Transit operating expenditures include wages, salaries, fuel, spare parts, preventive maintenance, support services, and leases used in providing public transit service.

Operating Expenditures by Transit Mode

Buses account for the largest percentage of transit operating expenditures, $11.0 billion in 2000, or 55.1 percent of the operating expenditure total *(See Exhibits 6-30 and 6-31)*. Heavy rail accounted for $3.9 billion, 19.7 percent of the total, and commuter rail, $2.7 billion, 13.4 percent of the total. Operating expenditures for demand response vehicles have more than tripled over the past decade from $386.0 million in 1990 to $1.2 billion in 2000, reflecting increased services to the elderly and persons with disabilities pursuant to the Americans with Disabilities Act and new programs targeted toward the provision of services to these groups. These expenditures appear to be stabilizing, with a marginal decline from 1999 to 2000. In 2000, demand response systems accounted for 6.1 percent of total transit

Exhibit 6-30

Composition of Transit Operational Expenditures by Mode, 2000



Source: National Transit Database.

operating expenses. Light rail and other transit vehicles accounted for just under 3 percent each.

Exhibit 6-31

Mass Transit Operating Expenses by Mode
1988-2000
(Millions of Dollars)

YEAR	BUS	HEAVY RAIL	COMMUTER RAIL	LIGHT RAIL	DEMAND RESPONSE	OTHER	TOTAL
1988	$6,995	$3,524	$1,889	$197	$252	$261	**$13,118**
1989	$7,295	$3,704	$2,068	$209	$323	$284	**$13,883**
1990	$7,779	$3,825	$2,157	$236	$386	$323	**$14,706**
1991	$8,330	$3,841	$2,175	$290	$443	$325	**$15,404**
1992	$8,625	$3,555	$2,170	$307	$500	$342	**$15,499**
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**
Average Annual Growth Rate	3.9%	0.9%	3.0%	9.6%	14.1%	6.4%	3.6%

Source: National Transit Database.

Operating Expenditures by Transit Operations

In 2000, $10.3 billion, or 51.6 percent, of transit operating expenses were for vehicle operations. *[See Exhibit 6-32]*. Expenditures on vehicle maintenance were $4.2 million or 20.9 percent of the total. Bus and rail operations have inherently different cost structures. While 68.4 percent of total operations expenditures for demand response transit and 56.6 percent of total operations expenditures for buses were spent for actual operation of the vehicles, only 40.0 percent of rail operations expenditures were spent on the operation of rail vehicles. A significantly higher percentage of expenditures for rail modes of transportation

Exhibit 6-32

Disbursements for Transit Operations - All Modes by Function, 2000
(Millions of Dollars)

MODE	VEHICLE OPERATIONS		VEHICLE MAINTENANCE		NON-VEHICLE MAINTENANCE		GENERAL ADMINISTRATION	
Bus	$6,243	56.6%	$2,420	22.0%	$482	4.4%	$1,882	17.1%
Heavy Rail	$1,620	41.2%	$733	18.7%	$999	25.4%	$579	14.7%
Commuter Rail	$1,031	38.5%	$646	24.1%	$493	18.4%	$510	19.0%
Light Rail	$247	41.7%	$142	24.0%	$99	16.8%	$104	17.5%
Demand Response	$838	68.4%	$144	11.8%	$26	2.1%	$217	17.7%
Other	$341	62.1%	$89	16.1%	$41	7.5%	$78	14.3%
Total	**$10,319**	**51.6%**	**$4,174**	**20.9%**	**$2,141**	**10.7%**	**$3,369**	**16.8%**

Source: National Transit Database.

are classified as non-vehicle maintenance for the repair and maintenance of fixed guideway systems.

Rural Transit

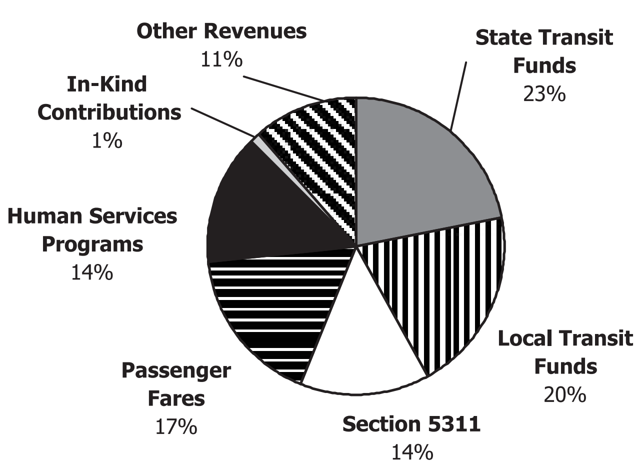
Since 1978, the Federal Government has contributed to the financing of transit in rural areas, i.e., areas with populations of less than 50,000. These rural areas are estimated to account for 36 percent of the U.S. population and 38 percent of the transit-dependent population.

Funding for rural transit is currently provided through Title 49 Section 5311, which, in 1994, replaced Section 18 of the Urban Mass Transit Act. Rural transit funding was increased substantially with passage of the Transportation Equity Act for the 21st Century (TEA-21). In FY 2000, Federal funding for transit under TEA-21 was $194 million. Federal funding for rural transit, will reach $240 million in 2003, the end of the TEA-21 authorization period. This is an 80 percent increase from the 1998 and a 266 percent increase from the 1991 levels. 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 comes from Section 5311 funds. *[See Exhibit 6-33].* State and local governments cover 23.0 and 21 percent, respectively, of their rural 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, 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 15 percent of rural operating budgets, and in-kind contributions and other revenues cover the remainder.

Exhibit 6-33

Sources of Rural Transit Operators Budget for Operating Expenditures, 2000



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

Innovative Finance

TIFIA: The Transportation Infrastructure and Finance Innovation Act of 1998 (TIFIA) authorized the U.S. Department of Transportation to establish a new credit program 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 or regional significance, provided that the borrower has a revenue stream, such as tolls or local sales taxes, which can be used to repay the debt issued by the project. To be eligible, a project must have eligible costs that total at least $100.0 million or alternatively equal 50.0 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 (ITS) projects are subject to a lower threshold, a minimum of $30.0 million. As of September 2002, 11 projects totaling $15.7 billion had been selected to receive TIFIA credit assistance, with commitments totaling more than $3.7 billion. These funding requests are for three transit projects, five highway and bridge projects, two intermodal projects, and one passenger rail project.

State Infrastructure Banks: Section 350 of the National Highway System Designation Act of 1995 (P.L. 104-59) authorized the U.S. Department of Transportation to establish the State Infrastructure Bank (SIB) 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 four States: Rhode Island, Missouri, California, and Florida. Texas was added later. The remaining states that participate in the SIB program operate under the provisions of the National Highway System Act rules and may not capitalize SIBs with TEA-21 funds. However, existing SIB programs continue to offer loan products. As of June 2002, 32 SIBs had entered into 294 loan agreements for a total of $4.0 billion. Six of these states (Arizona, Florida, Missouri, Ohio, South Carolina and Texas) account for over 92 percent of SIB loans nationwide.

GARVEE: Grant Anticipation Revenue Vehicles (GARVEE bonds) are a variation of a Grant Anticipation Note (GAN). A GAN is a form of debt that pledges anticipated grant money as a repayment source. GARVEE bonds permit 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 eligible for reimbursement. Debt instruments issued by special purpose non-profit 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 July 2002, six states (Alabama, Arkansas, Arizona, Colorado, New Mexico and Ohio) had sold 14 GARVEE bond issues totaling $2.5 billion.

Part II

Investment/Performance Analyses

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 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 Cost to Maintain scenarios for highways, bridges and transit are designed to show the investment required to keep future indicators of conditions and performance at current levels. 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 U.S. The chapter identifies any "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 involved 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 requirements projections presented in these chapters (and the models used to create the projections) were developed exclusively for the Conditions and Performance 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 methodology used to estimate investment requirements for highways, bridges, and transit is 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.

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 the **Maintain User Costs** scenario from the Highway Economic Requirements System (HERS), and the **Maintain Backlog** scenario from the National Bridge Investment Analysis System (NBIAS). The **Cost to Improve** Highways and Bridges combines the **Maximum Economic Investment** scenario from HERS, and the **Eliminate Deficiencies** scenario from NBIAS.

As in the 1999 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 1999, 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 Improve and Cost to Maintain scenarios are developed fully in this report: the **Maximum Economic Investment** scenario and the **Maintain User Costs** scenario. The investment required to **Maintain Physical Conditions** and **Maintain Average Speed** are also identified, as separate benchmarks.

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. At this level of investment, key indicators such as pavement condition, total highway user costs, and travel time would all improve.

The **Maintain User Cost** scenario shown in Chapter 7 and the **Maintain Physical Conditions** and **Maintain Average Speed** benchmarks shown in Chapter 9 were developed by progressively increasing the minimum BCR cutoff point above 1.0 so that fewer highway improvements would be implemented, until the point where these key indicators would be maintained at current levels, rather than improving. For the **Maintain User Costs** scenario, the minimum BCR cutoff point was raised until the point where highway user costs (travel time costs, vehicle operating costs, and crash costs) in 2020 would match the baseline highway user costs calculated from the 2000 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 2020 would match that observed in 2000. The **Maintain Physical Conditions** benchmark shows the level of investment required so that the projected average pavement condition at the end of the 20-year analysis period matched the current 2000 values. The **Maintain Average Speed** benchmark indicates the investment necessary to hold average highway operating speeds at their 2000 levels.

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 is used for the first time in this 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 **Eliminate Deficiencies** scenario, all existing bridge deficiencies, and all new deficiencies expected to develop by 2020, would be eliminated through bridge replacement, improvement, repair, or rehabilitation, if it is cost-beneficial to do so. Under the **Maintain Backlog** scenario, existing deficiencies and newly accruing deficiencies would be selectively corrected. At the end of the 20-year analysis period, the total backlog of cost-beneficial investments required to correct bridge deficiencies would remain the same as the current amount.

The NBIAS model and other changes in bridge investment requirements modeling in this report are presented in Appendix B.

Investment Requirements for System Enhancements

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 to 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 on non-modeled 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. 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. 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 requirements 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:

  - Cost to Improve. 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.
  - Cost to Maintain. 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.
- Expansion of the Asset Base. As the Nation's highway and transit systems expand over time, the cost of maintaining this larger asset base will also tend to increase. For assets with useful lifetimes of less than 20 years, future expansions will also affect the 20-year investment requirements 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 requirements 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 techniques, new empirical evidence, and changes in transportation planning objectives have combined to encourage the development 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 "wish list" of State highway "needs." Early in the 1970s the focus changed from system expansion to management of the existing system. National engineering standards were defined and applied in the identification of system deficiencies. By the end of the decade, a comprehensive database, the HPMS, had been developed to monitor system conditions and performance.

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. This procedure was founded on engineering principles: engineering standards defined which system attributes were considered deficient and the improvement option "packages" assigned to potentially correct given deficiencies were based on standard engineering practice.

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. The culmination of this effort was the development of the Highway Economic Requirements System (HERS). HERS was first utilized in the 1995 C&P report to develop one of the two highway investment requirement scenarios. In subsequent reports, HERS has been used to develop all of the highway scenarios.

Executive Order 12893, "Principals for Federal Infrastructure Investments," issued January 26, 1994, directs that Federal infrastructure investment be based on a systematic analysis of expected benefits and costs. This order provided additional momentum for the shift toward developing investment requirement analytical tools that would perform economic analysis.

In the 1997 C&P report, FTA introduced the Transit Economic Requirements Model (TERM), which was used to develop both of the transit investment requirement scenarios. TERM is based on extensive engineering surveys of transit asset conditions and data from the National Transit Database. TERM incorporates benefit cost analysis into its investment requirements analysis.

The FHWA has recently developed the National Bridge Investment Analysis System (NBIAS), which incorporates economic analysis into bridge investment requirements modeling for the first time. The 1999 C&P report introduced NBIAS, though it was not then used to generate estimates of bridge investment requirements. In this report, NBIAS is used for all bridge investment scenarios.

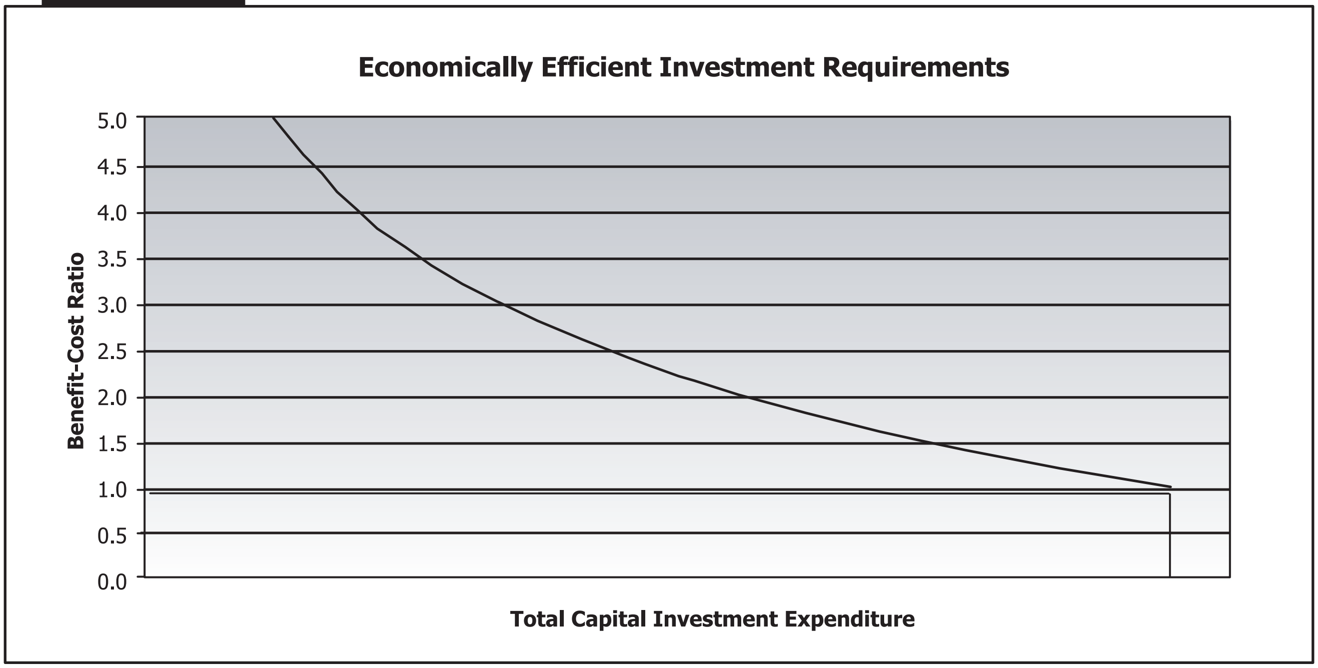
Economic Focus versus Engineering Focus

The economic approach to transportation investment is fundamentally an analysis of the economic benefits and costs of that investment. Projects with "net benefits" (benefits greater than costs) increase societal welfare, and are thus "good" investments from a public perspective. The cost of an investment 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 travel time and vehicle operating costs), and others who are affected by the operation of the transportation system (such as environmental costs).

Traditional engineering-based analytical tools focus mainly on transportation agency costs and the 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 investment from the agency perspective, predicting the optimal pattern of investment to minimize life-cycle costs. However, this approach does not fully consider the needs of the consumers of transportation services.

The HERS, TERM, and NBIAS models have a broader focus than traditional engineering-based models, looking at the service that the transportation system provides to its users. They also attempt to take into account some of the impacts that transportation investment has on non-users. By expanding the scope of benefits considered in the analysis, the models are able to yield an improved understanding of existing and future investment needs.

Exhibit II-1



One way to conceptualize the goal of the HERS, TERM, and NBIAS models is shown in Exhibit II-1. For some projects, the benefits of transportation investment greatly exceed the costs of that investment, resulting in a high benefit-cost ratio (BCR). As additional projects are considered and implemented, however, the gap between benefits and costs of subsequent projects diminishes, reducing the BCR and eventually reaching a point where further investments will no longer increase net benefits (at a BCR of 1.0). Projects that do not meet this threshold of economic viability will not be implemented by any of the three models.

Using an economics-based approach to transportation investment may result in different decisions about potential improvements than would occur using a purely engineering-based approach. For example, if a highway segment, bridge, or transit system is greatly underutilized, benefit-cost analysis might suggest that it would not be worthwhile to fully preserve its condition, or address its deficiencies. Conversely, an economics-based model might recommend additional investments to improve system conditions above and beyond the levels dictated by an engineering life-cycle cost analysis, 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. This helps provide guidance in directing limited transportation capital investment resources to the areas that will provide the most benefits to transportation system users.

Multimodal Analysis

HERS, TERM, and NBIAS all use a consistent approach for determining the value of travel time and the value of life, which are key variables in any economic analysis of transportation investment. However, while HERS, TERM, and NBIAS all utilize benefit-cost analysis, their methods for implementing this analysis are very different. The highway, transit, and bridge models 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). Further development of HERS, TERM, and NBIAS will include efforts to allow feedback between the models.

Uncertainty in Transportation Investment Requirements Modeling

The three investment requirements models used in this report are deterministic, rather than probabilistic, meaning that they provide a single projected value rather than a range of likely values. As a result, it is only possible to make general statements about the limitations of the 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. Potential highway improvements are evaluated based on a benefit/cost analysis. However, this analysis does not include all external costs (such as noise pollution) or external benefits (such as the favorable impacts of highway improvements on the economy) that may be considered in the actual selection process of individual projects. Some of these limitations are discussed further in Chapter 15. To some extent, such external effects cancel each other out, but to the extent that they don't reveal the "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 in reality, while other projects that the models would reject might actually be justifiable, if all factors were considered.

While it is not possible to present precise confidence intervals for the estimates found in this report, it is possible to examine the sensitivity of the estimates to changes in some of the key parameters underlying the models. Such an analysis is presented in Chapter 10.

Chapter 7

Capital Investment Requirements

Summary

Exhibit 7-1 compares the 20-year average annual investment requirements in this report with those presented in the 1999 C&P report. The first column shows the projection for 1998-2017 based on 1997 data shown in the 1999 C&P report, stated in 1997 dollars. The second column restates these highway and transit values in 2000 dollars, to offset the effect of inflation. The third column shows new average annual investment requirement projections for 2001-2020 based on 2000 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, with the exception of those for rural and special service transit, are estimated by the Transit Economic Requirements Model (TERM). Requirements for rural and special services are estimated separately based on the number of vehicles, percentage of overage vehicles and vehicle replacement costs.

Exhibit 7-1

Highway, Bridge and Transit Investment Requirement Projections Compared With Data from the 1999 C&P Report

STATISTIC	1998-2017 PROJECTION (BASED ON 1997 DATA): 1999 REPORT	1998-2017 PROJECTION (BASED ON 1997 DATA): ADJUSTED FOR INFLATION	2001-2020 PROJECTION (BASED ON 2000 DATA)
Average Annual Investment Requirements	**1997 $**	**2000 $**	**2000 $**
Cost to Improve			
Highways and Bridges	$94.0 bil	$104.8 bil	$106.9 bil
Transit	$16.0 bil	$16.8 bil	$20.6 bil
Cost to Maintain			
Highways and Bridges	$56.6 bil	$63.1 bil	$75.9 bil
Transit	$10.8 bil	$11.3 bil	$14.8 bil

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. 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.

Both the highway and transit analyses depend heavily on forecasts of future demand. Chapter 10 explores the effects that varying demand forecasts and some of the other key underlying assumptions 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 **Cost to Improve** highways and bridges is projected to be $106.9 billion for 2001-2020. This figure represents an "investment ceiling" above which it would not be cost-beneficial to invest. Accounting for inflation (using the FHWA Construction Bid Price Index), this estimate is 2.0 percent greater than the Cost to Improve for 1998-2017 reported in the 1999 C&P report. The average annual **Cost to Maintain** highways and bridges is projected to be $75.9 billion for 2001-2020, which is 20.3 percent larger than the estimate in the 1999 C&P report for 1998-2017, 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 2000 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 oh historic trends in public funding for highways and transit by different levels of government.

The changes in projected investment requirements from the 1999 report are due 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. The Cost to Maintain scenario in this report incorporates a more ambitious goal of maintaining overall conditions and performance as measured by their impact on average highway user costs, while the values in the 1999 C&P report focused on maintaining the physical condition of the highway and bridge infrastructure. This change represents a return to the general approach used in earlier C&P reports.

While a Maintain User Costs figure derived from HERS was presented in the 1999 C&P report as a supplementary benchmark, it is not directly comparable to the value shown in this report. As described in Chapter 4, since the transmittal of the 1999 C&P report, new measures of congestion have been adopted in the annual FHWA performance plans that better quantify declines in the overall operational performance of the highway system. The HERS model has been modified in a comparable fashion, and is now equipped to consider delay due to incidents and the premium that travelers place on travel time reliability as part of its analysis of highway user costs. Factoring in these additional components of congestion into the analysis increases the level of investment required to stop user costs from rising. Further information on these methodological changes are presented later in this chapter, as well as in Appendix A.

The increase in the Cost to Improve highways and bridges relative to the last report is not unexpected. Capital investment by all levels of government between 1997 and 2000 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.

The NBIAS was introduced in the 1999 C&P report, but this edition of the report is the first to use it as the primary model for estimating future investment requirements for bridge preservation. NBIAS includes a benefit cost screen in its evaluation of potential bridge improvements, which has the effect of reducing the bridge component of the Cost to Improve Highways and Bridges. However, NBIAS is also better at evaluating the condition of the subcomponents of the Nation's bridges, and in assessing the value of routine repair and rehabilitation of bridge elements as part of a comprehensive asset management approach to avoid costly replacements in the future. Consequently, it projects higher investment requirements to maintain the backlog of bridge deficiencies than the model it replaced. Further information on NBIAS is presented later in this chapter, as well as in Appendix B.

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. Appendices A and B include more discussion of the methodological changes in this report.

Transit

The average annual **Cost to Improve** both the physical condition of transit assets and transit operational performance to targeted levels by 2020 is estimated to be $20.6 billion in 2000 dollars, a 22.8 percent increase over the inflation adjusted amount reported for 1997 in the 1999 C&P report. The estimated average annual **Cost to Maintain** transit asset conditions and operating performance is estimated to be $14.8 billion, 30.7 percent higher than the 1997 amount. More than 90 percent of transit investment requirements will be in urban areas with populations of over 1 million, reflecting the fact that 90 percent of the Nation's passenger miles are currently in these areas.

These increased investment requirements reflect an enlarged transit infrastructure base and an increase in the absolute amount of overage transit infrastructure. They also reflect an updating of capital cost estimates for vehicles based on information that FTA maintains on the actual costs paid by transit operators for new vehicles. These costs are somewhat higher than those used to estimate investment requirements in the 1999 Report.

In the case of rail, a high proportion of fixed guideway elements, which account for slightly more 40 percent of the total value of the existing U.S. transit asset base, are currently not in acceptable condition. Rail systems (substations, overhead wire, and third rail), estimated to comprise about 10 percent of the value of the transit asset base, will also require significant investments. Although a large percentage of these rail systems is in adequate or better condition, they have an average useful life of around half that for other non-vehicle assets and require an accelerated replacement schedule. Rail facilities and stations will require the smallest levels of investment. The largest incremental investments needed to Maintain Performance through the expansion of the asset base will be for guideway elements and vehicles. To Improve Performance, significant investment will be required in system design and rights-of-way acquisition.

The purchase of vehicles accounts for the largest component of non-rail investment requirements. Guideway elements and facilities will also account for considerable proportions (20 percent each) of future non-rail asset expansion.

Highway and Bridge Investment Requirements

This section presents the projected investment requirements for highways and bridges for two primary performance targets. The **Cost to Maintain Highways and Bridges** represents the annual investment necessary to maintain the current level of highway system performance. The **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 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 to 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, due to the different natures of the models used to develop them. However, it is useful to combine them in order to show combined investment. This 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 investment required to **Improve Highways and Bridges** over the 20-year period 2001-2020 is projected to be **$106.9 billion** in 2000 dollars. The average annual **Cost to Maintain Highways and Bridges** is projected to be **$75.9 billion** (also in 2000 dollars).

Cost to Improve Highways and Bridges

The average annual Cost to Improve 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 $61.3 billion, or 57.3 percent of the total average annual Cost to Improve Highways and Bridges. Investment requirements on rural arterials and collectors are $23.8 billion or 22.3 percent of the total, while the investment requirements for rural and urban local roads and streets total $21.8 billion (20.4 percent).

The **Cost to Improve Highways and Bridges** scenario combines the **Maximum Economic Investment** scenario from the Highway Economic Requirements System (HERS) and the **Eliminate Deficiencies** scenario from 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 $43.2 billion, or 56.9 percent of the average annual Cost to Maintain Highways and Bridges. Investment requirements for rural arterials and collectors total $17.3 billion (22.7 percent), while the investment requirements for rural and urban local roads and streets total $15.5 billion (20.4 percent).

The **Cost to Maintain Highways and Bridges** scenario combines the **Maintain User Costs** scenario from HERS and the **Maintain Backlog** scenario from NBIAS with external adjustments to the two models.

Exhibit 7-2

Average Annual Investment Required to Improve Highways and Bridges, (Billions of 2000 Dollars)

FUNCTIONAL CLASS	SYSTEM PRESERVATION HIGHWAY	SYSTEM PRESERVATION BRIDGE	SYSTEM PRESERVATION TOTAL	SYSTEM EXPANSION	SYSTEM ENHANCEMENTS	TOTAL
Rural Arterials & Collectors						
Interstate	$3.0	$0.6	$3.6	$1.9	$0.4	$5.8
Other Principal Arterial	$3.2	$0.6	$3.8	$1.5	$0.6	$5.9
Minor Arterial	$2.8	$0.6	$3.4	$0.9	$0.5	$4.7
Major Collector	$3.3	$1.2	$4.6	$0.3	$0.4	$5.3
Minor Collector	$1.0	$0.6	$1.5	$0.4	$0.2	$2.1
Subtotal	**$13.3**	**$3.5**	**$16.8**	**$4.9**	**$2.1**	**$23.8**
Urban Arterials & Collectors						
Interstate	$5.5	$1.3	$6.8	$13.2	$1.2	$21.1
Other Freeway & Expressway	$2.2	$0.5	$2.7	$5.7	$0.5	$8.9
Other Principal Arterial	$4.0	$0.6	$4.6	$8.8	$1.5	$14.9
Minor Arterial	$3.2	$0.4	$3.6	$6.3	$1.0	$11.0
Collector	$2.2	$0.2	$2.4	$2.4	$0.5	$5.3
Subtotal	**$17.2**	**$3.0**	**$20.2**	**$36.4**	**$4.6**	**$61.3**
Subtotal Rural and Urban						
Rural and Urban Local	$8.6	$2.8	$11.5	$8.6	$1.7	$21.8
Total	**$39.1**	**$9.4**	**$48.5**	**$49.9**	**$8.4**	**$106.9**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System.

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: system preservation, system expansion, and system enhancement, which are defined in Chapter 6. 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 adding new roads and bridges. System enhancements include safety enhancements, traffic operations 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 $48.5 billion under the Cost to Improve scenario and $37.1 billion under the Cost to Maintain scenario. These totals comprise constitute 45.4 and 48.8 percent, respectively, of the totals for the two scenarios. Figures 7-2 and 7-3 also indicate that bridge preservation investments represent about one-fifth of total preservation investment requirements

Exhibit 7-3

Average Annual Investment Required to Maintain Highways and Bridges, (Billions of 2000 Dollars)

FUNCTIONAL CLASS	SYSTEM PRESERVATION HIGHWAY	SYSTEM PRESERVATION BRIDGE	SYSTEM PRESERVATION TOTAL	SYSTEM EXPANSION	SYSTEM ENHANCEMENTS	TOTAL
Rural Arterials & Collectors						
Interstate	$2.1	$0.5	$2.6	$1.6	$0.3	$4.5
Other Principal Arterial	$2.5	$0.5	$3.0	$0.9	$0.4	$4.3
Minor Arterial	$2.2	$0.5	$2.7	$0.3	$0.3	$3.3
Major Collector	$2.1	$1.0	$3.1	$0.2	$0.3	$3.6
Minor Collector	$0.7	$0.4	$1.1	$0.3	$0.2	$1.5
Subtotal	**$9.6**	**$2.9**	**$12.5**	**$3.3**	**$1.5**	**$17.3**
Urban Arterials & Collectors						
Interstate	$5.2	$1.0	$6.2	$11.3	$0.8	$18.4
Other Freeway & Expressway	$1.9	$0.4	$2.3	$4.2	$0.3	$6.8
Other Principal Arterial	$3.1	$0.5	$3.6	$4.0	$1.0	$8.7
Minor Arterial	$2.3	$0.4	$2.6	$2.8	$0.7	$6.1
Collector	$1.6	$0.2	$1.7	$1.1	$0.4	$3.2
Subtotal	**$14.0**	**$2.4**	**$16.4**	**$23.5**	**$3.3**	**$43.2**
Subtotal Rural and Urban						
Rural and Urban Local	$6.1	$2.0	$8.1	$6.1	$1.2	$15.5
Total	**$29.7**	**$7.3**	**$37.1**	**$32.9**	**$6.0**	**$75.9**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System.

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

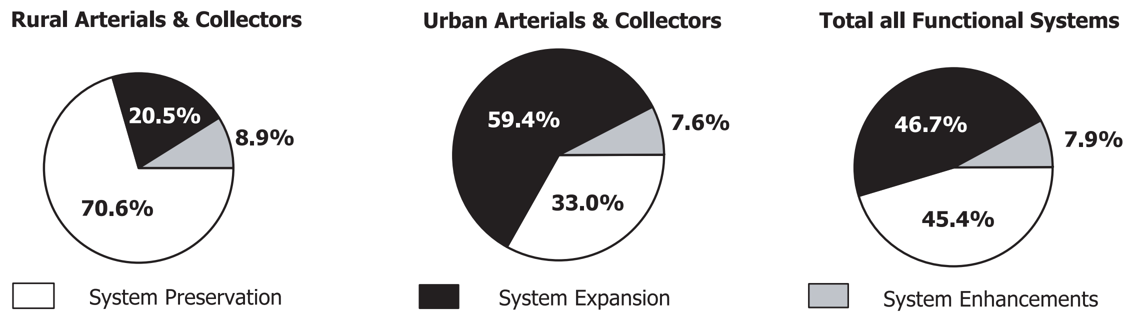
The $49.9 billion in average annual investment requirements for system expansion represent 46.7 percent of the total Cost to Improve Highways and Bridges. Comparable figures for the Cost to Maintain scenario are $32.9 billion and 43.3 percent. Exhibits 7-2 through 7-4 indicate that system expansion requirements 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.

System Enhancements

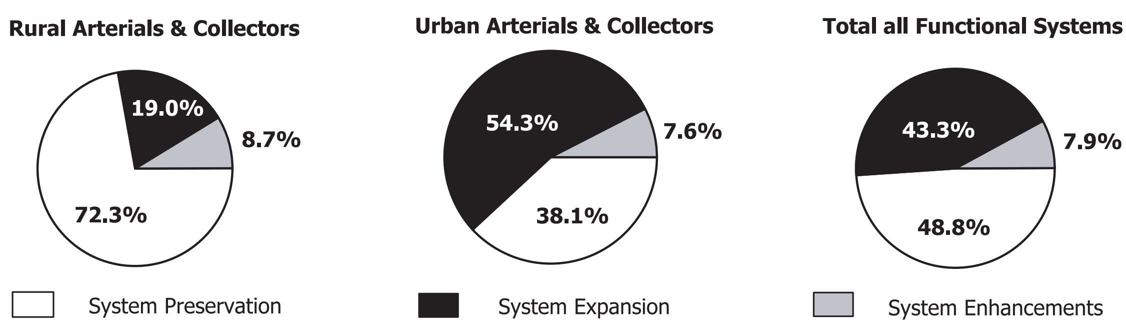
Investment requirements for system enhancements represent 7.9 percent of both the Cost to Improve Highways and Bridges ($8.4 billion) and the Cost to Maintain Highways and Bridges ($6.0 billion). Investment requirements for safety enhancements, traffic operation facilities, and environmental enhancements are not directly modeled, so this amount was derived solely from the external adjustment procedures described on the next page.

Exhibit 7-4

Cost to Improve Highways and Bridges, 2001-2020
Distribution by Improvement Type



Cost to Improve Highways and Bridges, 2001-2020
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, highway capacity can be increased more cost effectively by improving the utilization of the existing infrastructure. Consequently, a portion of the investment requirements identified for "System Expansion" could also be met through increased investment in types of "System Enhancements" that also increase capacity. Some of the potential strategies for increasing effective highway capacity, including intelligent transportation systems, are discussed in Chapter 21. A limited number of these strategies have been incorporated into the calculations made by HERS (See Appendix A). Procedures for evaluating additional strategies have been developed, but could not be incorporated in HERS in time for this edition of the C&P report.

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 that 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 rail line, busway, or mixed-use high occupancy vehicle/transitway. See Appendix A for more on this feature.

Sources of the Highway and Bridge Investment Requirements Estimates

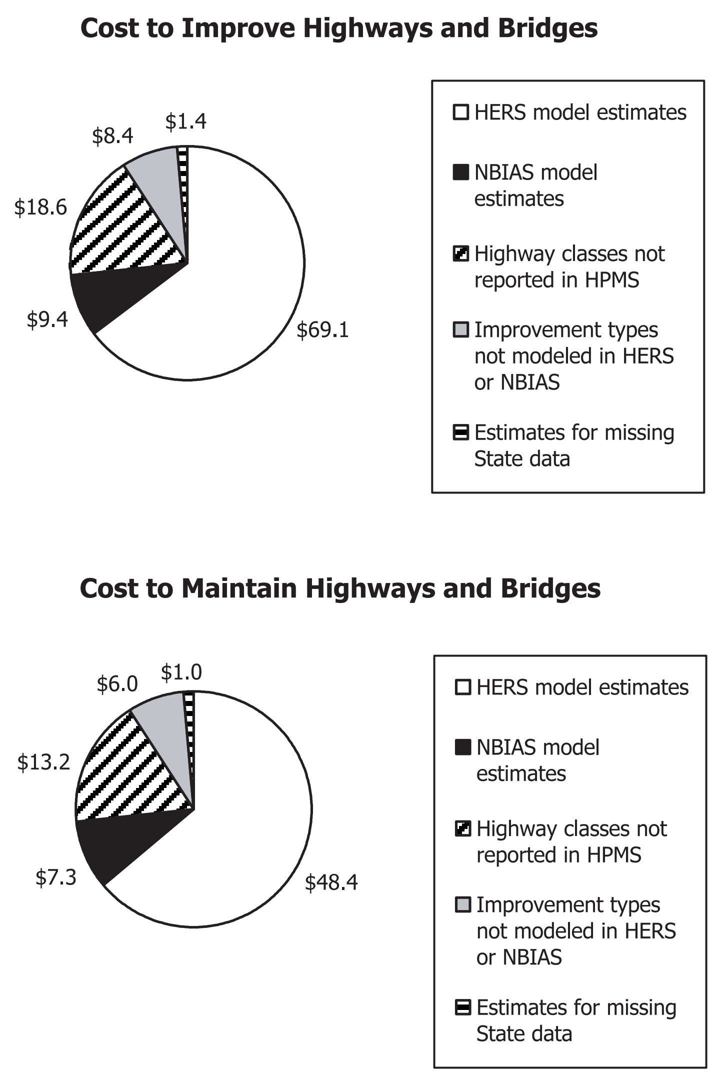
The estimates of investment requirements for highways and bridges under the Improve and Maintain scenarios were derived from three sources:

- Highway and bridge capacity expansion and highway preservation investments were modeled using HERS.
- Bridge preservation investments were modeled using the 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, types of capital investment that are not currently modeled, and missing State data.

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.

Exhibit 7-5

Sources of the Highway and Bridge Investment Requirements Estimates (Billions of 2000 Dollars)



The percentage of total investment requirements that are modeled in HERS is somewhat larger than was the case in the 1999 C&P report. The reason for this change is that investment requirements for new highway and bridge construction are now being directly modeled along with expansion of existing roadways, through the use of the high cost capacity improvements feature in HERS. This change is discussed in greater detail in Appendix A.

External Adjustments

External adjustments were made to the directly modeled improvements generated by HERS and NBIAS in two areas:

- <u>Highway functional classes</u>. 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.

- 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.

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 rises 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.

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, since they would be expected to be less reliable than those derived from HERS and NBIAS.

Adjustments for Missing State Data

A third adjustment was made to compensate for missing State data. The reliability of the investment requirement projections derived from the HERS model depends heavily on the accuracy of the HPMS sample data collected by States and reported annually to the FHWA. In some previous editions of this report, the HPMS data for certain States was not complete enough to be analyzed by HERS or its predecessor models, so some States were excluded from the analysis, and the national results were factored upward to compensate. Such procedures were not utilized in the production of the 1999 C&P report, as the data for all States was deemed sufficiently complete to be included in the analysis. This was possible in part because of major improvements to the HPMS software provided by the FHWA to the States. The software now includes a variety of new features to assist the States in improving the quality of their data submissions.

For this edition of the report, however, the data reported by one State in the 2000 HPMS did not include pavement condition data for those roads not under State jurisdiction. As a result, the HPMS data for that State did not represent a statistically valid sample of all roads within the State. Consequently, all 2000 HPMS sample data for that State were removed from the data used to run HERS for this report, and a separate analysis was conducted processing older HPMS data through HERS to derive an adjustment factor to supplement the results of the national analysis.

Highway Economic Requirements System (HERS)

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 113,000 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.

HERS 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 HPMS sample dataset. It then considers potential improvements on sections with one or more deficiencies, including resurfacing, reconstruction, alignment improvements, and widening or adding travel lanes. HERS then selects the improvement with the greatest net benefits, where benefits are defined as reductions in direct highway user costs, agency costs, and societal costs. In cases where none of the potential improvements produces benefits exceeding construction costs, the segment is not improved. Appendix A contains a fuller description of the project selection and implementation process used by HERS.

One of the key features of HERS as an economics-based model (introduced in the 1997 C&P report) 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. HERS 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

Q. Does HERS identify a single "correct" level of highway investment?

A. No. HERS 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 public sector priorities. The investment requirement 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."

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 due to 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, so that the "true" level of investment that would achieve the outcome desired under the scenarios could be higher than that shown in this report.

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 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, as well as recent changes in the elasticity procedures to account for traffic diversion and segment length.

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.

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. HERS estimates that a total of $271.7 billion of investment could be justified based solely on the current conditions and operational performance of the highway system. Approximately 82 percent of the backlog is in urban areas, with the remainder in rural areas. About 58 percent of the backlog relates to capacity deficiencies on existing highways; the remainder results from pavement deficiencies.

Note that this figure does not include rural minor collectors, or rural and urban local roads and streets, because HPMS does not contain sample section data for these functional systems. The backlog figure also does not contain any estimate for system enhancements. Appendix A explains how the backlog was calculated.

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.

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. HERS 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 minimum BCR for all improvements implemented in a given model run. By varying the minimum BCR 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.

Exhibit 7-6

HERS Investment Requirements Scenarios 2001-2020 (Billions of 2000 Dollars)

SCENARIO/BENCHMARK	AVERAGE ANNUAL INVESTMENT REQUIRED	
	TOTAL	HERS-MODELED
Maximum Economic Investment	$106.9	$69.1
Maintain User Costs	$75.9	$48.4

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 **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 due to pavement deterioration and travel growth. As shown in Exhibit 7-6, the average annual investment modeled by the HERS Maximum Economic scenario is $69.1 billion.

Q. Why was the Highway Maintain User Costs scenario used to estimate the Cost to Maintain Highways and Bridges, rather than the Highway Maintain Conditions scenario, which was used in the 1999 C&P report?

A. The change was made for several reasons. The first relates to the use of the NBIAS model for bridge investment requirements estimates in this report. The investment estimates produced by this model, which is more economics-based than previous bridge investment models, are more comparable to the highway scenarios and benchmarks based on economic indicators. Second, the Maintain User Costs scenario is more in line with the concept of maintaining both conditions and performance, as in the baseline Maintain scenario for transit investment outlined in this chapter. The Maintain User Costs scenario is also more consistent with the Cost to Maintain scenarios used in C&P reports up to 1997. Third, the definition of user costs has been improved to include delay due to incidents and the premium that travelers place on travel time reliability. Finally, the user cost concept has found increasing acceptance within the transportation community in recent years as a measure of conditions and performance from the vantage of system users, as was reflected in the feedback received at outreach sessions conducted after the release of the 1999 C&P report.

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 vehicle miles traveled (VMT) at the end of the 20-year analysis period to match the baseline 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 $48.4 billion.

The **Maintain User Costs** concept was 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, due to the operation of the travel demand elasticity feature.

The impact on individual highway user cost components at this and other levels of investment are discussed in Chapter 9.

National Bridge Investment Analysis System (NBIAS)

The bridge investment requirements shown in this report are derived primarily from the NBIAS, which is summarized in this section. Appendix B provides a more comprehensive look at this approach. Although NBIAS was introduced in the 1999 C&P report, this edition is the first to use it as the primary model for estimating future investment requirements for bridge preservation.

NBIAS is the latest in a series of bridge models used by the FHWA and its partners. It replaces the Bridge Needs and Investment Process (BNIP) model, which estimated bridge investment requirements for the 1999 C&P report. Like BNIP, NBIAS is based on data from the NBI, which provides information on the characteristics and conditions of more than 525,000 bridges in the United States.

The internal logic of NBIAS is derived from the PONTIS Bridge Management System. PONTIS is licensed by the American Association of State Highway and Transportation Officials to 45 State departments of transportation. Because this approach relies on having element-level condition data, which is not currently contained in the NBI, NBIAS begins its analysis by synthesizing element condition data from the general bridge condition ratings that are available. NBIAS considers individual bridges for improvement and replacement needs, but the current version of the model analyzes maintenance, repair, and rehabilitation (MR&R) needs on an aggregate level, rather than looking at individual bridges.

NBIAS improves upon BNIP in several ways. NBIAS includes a benefit/cost screen, which filters out improvements that are not cost-beneficial within the 20-year funding horizon. NBIAS is also more accurate in evaluating bridge subcomponents and determining the value of routine repair and rehabilitation of bridge elements. Finally, NBIAS provides estimates that are more reflective of the way State and local transportation agencies undertake bridge management strategies.

Q. How does NBIAS aggregate bridge data?

A. Aggregation of bridge data is a prerequisite for NBIAS analysis. Instead of managing individual bridges, NBIAS groups them into a number of cells. Each cell represents a group of bridges with common modeling characteristics. The common characteristics are called strata, and the process of grouping the bridges is known as stratification. NBIAS considers four main stratification dimensions for a bridge: its functional system; whether it is part of the National Highway System; average daily traffic (ADT); and climate zone. There are 13 functional systems, two NHS categories, five ADT classes, and four climate zones, producing 520 cells of bridges with common modeling characteristics.

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. NBIAS, like BNIP, defines deficiencies broadly, and covers more than the structurally deficient and functionally obsolete categories defined in Chapter 3. NBIAS estimates that $54.7 billion of investment could be invested immediately in a cost-beneficial fashion to replace or otherwise address currently existing bridge deficiencies.

The $54.7 billion bridge investment backlog is substantially lower than the $87.3 billion backlog reported in the 1999 C&P. This is due to the use of benefit/cost analysis in the NBIAS model. NBIAS determines that the optimal time to address some bridge deficiencies may not be in the first year of a 20-year planning horizon; instead, improvements or replacements may be made at other points of the planning period. This is more consistent with the real world experiences of State and local transportation agencies, which deal with bridge deficiencies over a multi-year planning period.

Bridge Investment Requirements Scenarios

While modeling techniques have changed from the BNIP to NBIAS models, the investment requirements scenarios are defined similarly. Two scenarios are examined: the **Eliminate Deficiencies** and **Maintain Backlog** scenarios. The results are described in Exhibit 7-7.

The Eliminate Deficiencies scenario is the bridge component of the Cost to Improve Highways and Bridges described earlier in this chapter. Where it is cost-beneficial to do so, the Eliminate Deficiencies scenario would eliminate the existing bridge investment backlog and correct other deficiencies that are expected to develop over the next 20 years. **The average annual investment required under this scenario is estimated to be $9.4 billion**, which is 8.8 percent of the $106.9 billion average annual investment required to improve highways and bridges over a 20-year period.

The Maintain Backlog scenario is the bridge component of the Cost to Maintain Highways and Bridges. The Maintain Backlog scenario identifies the level of annual investment that would be required so that the bridge investment backlog would not increase above its current level. Existing deficiencies and newly accruing deficiencies would be selectively corrected to minimize the investment required to maintain the same backlog of deficient bridges in 2020 that exists in 2000. **The average annual investment required under this scenario is estimated at $7.3 billion**, or 9.7 percent of the $75.3 billion average annual investment required to maintain highways and bridges over a 20-year period.

Exhibit 7-7

NBIAS Investment Requirements Scenarios 2001-2020 (Billions of 2000 Dollars)

SCENARIO/BENCHMARK	AVERAGE ANNUAL INVESTMENT REQUIRED: TOTAL	AVERAGE ANNUAL INVESTMENT REQUIRED: NBIAS-MODELED
Eliminate Deficiencies	$106.9	$9.4
Maintain Backlog	$75.9	$7.3

Q. **How do the 1999 NBIAS estimates compare with the BNIP estimates in the 1999 Conditions and Performance Report?**

A. NBIAS estimates higher investment requirements to maintain the backlog than does BNIP, but projects lower investment requirements to eliminate all deficiencies. To avoid costly replacements in the future, NBIAS recommends more investment in repair and rehabilitation. This is consistent with a sound bridge management and asset management strategy.

BNIP estimated that the average annual investment required under the Eliminate Deficiencies scenario between 1998 and 2017 would be $10.6 billion. For the same scenario, NBIAS estimates a $9.4 billion average annual investment between 2001 and 2020. Approximately $0.5 billion is the result of a reduction in the number of deficient bridges that has occurred since 1997. The rest is due to the application of a cost/benefit analysis. Some bridge improvements are not cost-beneficial within the 20-year funding horizon. This is an improved, more realistic way to model the way governments make bridge investments.

For the Maintain Backlog scenario, BNIP estimated an average annual investment of $5.8 billion between 1998 and 2017. For the same scenario, NBIAS estimates a $7.3 billion average annual investment between 2001 and 2020. NBIAS does a better job of identifying repair and rehabilitation actions that will become increasingly necessary as the average age of the Nation's bridges increases.

Transit Investment Requirements

The Federal Transit Administration (FTA) uses the Transit Economic Requirements Model (TERM), based on engineering and economic concepts, to estimate future transit capital investment. TERM was developed to improve the quality of estimates of future transit capital funding needs. The 1997 Conditions and Performance Report was the first in this series to report investment requirements based on TERM. For this report, TERM was used to project the dollar amount of capital investment that will be required by the transit sector in order to meet various asset condition and operational performance goals by 2020. These capital investment requirements estimates are based on the 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). Estimated requirements are presented on an average annual basis, though as calculated by TERM, they fluctuate from year to year. All investments identified by TERM are subject to a benefit-cost test, requiring that all investments incorporated in the model have a benefit-cost ratio that is greater than 1. (A technical description of TERM is provided in Appendix C.)

TERM projects transit capital investment requirements for the four 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 Metropolitan Planning Organizations (MPOs).

- **Improve Conditions**
  Transit asset rehabilitation and replacement is accelerated to improve the average condition of each asset type to a least a "good" level at the end of the 20-year period (2020).

- **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 slowest systems to reduce vehicle utilization rates (and crowding) and increase average transit operating speeds.

Investment Requirements

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 transit investment requirements, at a minimum, are estimated to be $14.8 billion to Maintain the Conditions and Performance of the Nation's transit systems at their 2000 level, assuming an average annual increase in transit ridership of 1.6 percent. To improve the average condition level of transit assets to "good" by 2020, as well to Improve Performance by increasing transit speeds and reducing occupancy rates to threshold levels, would require an additional $5.8 billion per year for a total average annual capital investment of $20.6 billion.

As shown in Exhibit 7-9, replacement and rehabilitation costs are estimated to be $9.2 billion to Maintain Conditions and Performance, and $10.3 billion to Improve Conditions and Performance. Asset expansion costs needed to meet the projected 1.6 percent average annual increase in ridership growth are estimated to be $5.6 billion if conditions are maintained and $5.7 billion if conditions are improved to a "good" level. The incremental $1.1 billion needed for asset rehabilitation and replacement under the Improve Conditions scenario results from the extra investment that will be required to rehabilitate and replace additional asset purchases. The expenditures needed to Improve Performance are estimated to be $4.6 billion annually.

Exhibit 7-8

Summary of Average Annual Transit Investment Requirements, 2001-2020 (Billions of 2000 Dollars)

CONDITIONS	PERFORMANCE	AVERAGE ANNUAL COST
Maintain	Maintain	$14.8
Improve	Maintain	$16.0
Maintain	Improve	$19.5
Improve	Improve	$20.6

Source: Transit Economic Requirements Model and FTA staff estimates.

Exhibit 7-9

Average Annual Transit Investment Requirements by Type of Improvement (Billions of 2000 Dollars)

TYPE OF IMPROVEMENT	MAINTAIN CONDITIONS & PERFORMANCE	IMPROVE CONDITIONS & MAINTAIN PERFORMANCE	MAINTAIN CONDITIONS & IMPROVE PERFORMANCE	IMPROVE CONDITIONS & PERFORMANCE
Replacement and Rehabilitation	$9.2	$10.3	$9.2	$10.3
Asset Expansion	$5.6	$5.7	$5.7	$5.7
Performance Improvements			$4.6	$4.6
Total	**$14.8**	**$16.0**	**$19.5**	**$20.6**

Source: Transit Economic Requirements Model and FTA staff estimates.

Average Annual Costs to Maintain and Improve Conditions and Performance

Exhibit 7-10 provides a detailed breakdown of transit investment requirements by TERM scenario and area population size. More than 90 percent of transit investment will be required in urban areas with populations of over 1 million, reflecting the fact that 90 percent of the Nation's passenger miles are currently in these areas. It is estimated that an average of $13.4 billion would be needed annually to Maintain Conditions and Performance of transit assets in these large urban areas and $18.1 billion annually to Improve Conditions and Performance. The needs of less populated areas, i.e., those with populations under 1 million, are estimated to be considerably lower because they currently have fewer transit assets. It is estimated that $1.4 billion would be needed annually to Maintain Conditions and Performance of the transit infrastructure in these areas and $2.5 billion to improve them.

Exhibit 7-10

Transit Infrastructure
Annual Average Cost To Maintain and Conditions and Performance, 2001-2020
(Millions of 2000 Dollars)

MODE, PURPOSE & ASSET TYPE		COST TO MAINTAIN CONDITIONS & PERFORMANCE	INCREMENTAL COSTS TO IMPROVE CONDITIONS	INCREMENTAL COST TO IMPROVE PERFORMANCE	COSTS TO IMPROVE CONDITIONS & PERFORMANCE
Areas Over 1 Million in Population					
Non-rail (*)					
Replacement & Rehabilitation	(Vehicles)	$1,421	$471		$1,892
	(Non-Vehicles) (**)	781	0		781
Asset Expansion	(Vehicles)	585	12		598
	(Non-Vehicles)	990	0		990
Improve Performance	(Vehicles)			286	286
	(Non-Vehicles) (**)			345	345
Special Service(***)	(Vehicles)	27	14		41
Subtotal Non-rail		**3,804**	**497**	**631**	**4,933**
Rail					
Replacement & Rehabilitation	(Vehicles)	2,044	-122		1,923
	(Non-Vehicles) (**)	3,810	293		4,103
Asset Expansion	(Vehicles)	1,007	0		1,007
	(Non-Vehicles) (**)	2,785	0		2,785
Improve Performance	(Vehicles)			317	317
	(Non-Vehicles) (**)			3,038	3,038
Subtotal Rail		**9,646**	**171**	**3,355**	**13,171**
Total Areas Over 1 Million		**13,450**	**668**	**3,986**	**18,104**
Areas Under 1 Million in Population					
Non-rail (*)					
Replacement & Rehabilitation	(Vehicles)	517	188		705
	(Non-Vehicles) (**)	194	0		194
Fleet Expansion	(Vehicles)	174	3		177
	(Non-Vehicles) (**)	82	0		82
Improve Performance	(Vehicles)			120	120
	(Non-Vehicles) (**)			71	71
Special Service (***)	(Vehicles)	151	82		233
Rural	(Vehicles)	237	207	315	758
	(Non-Vehicles) (**)	4	9	11	24
Subtotal Non-rail		**1,359**	**489**	**517**	**2,364**
Rail					
Replacement & Rehabilitation	(Vehicles)	5	3		8
	(Non-Vehicles) (**)	6	0		6
Fleet Expansion	(Vehicles)	4		0	4
	(Non-Vehicles) (**)	17		0	17
Improve Performance	(Vehicles)			10	10
	(Non-Vehicles) (**)			102	102
Subtotal Rail		**32**	**3**	**112**	148
Total Areas Under 1 Million		**1,391**	**492**	**629**	**2,512**
Total		**14,841**	**1,160**	**4,615**	**20,616**

(*) Buses, vans and other (including ferry boats.)
(**) Non-vehicles comprise guideway elements, facilities, systems and stations.
(***) Vehicles to serve the elderly and disabled.

Source: Transit Economic Requirements Model and FTA staff estimates.

Non-rail Needs in Urban Areas with Populations over 1 Million—The cost of maintaining the conditions of the non-rail infrastructure (buses, vans, and ferryboats) in urban areas with populations over 1 million is much lower than the cost of maintaining the rail infrastructure. About 30 percent of the total transit investment requirement in these areas, or about $3.8 billion annually, would be needed to maintain this infrastructure's conditions and performance. Fifty-eight percent, or $2.2 billion annually, would be needed to rehabilitate and replace assets to Maintain Conditions and 42 percent, or $1.6 billion, to purchase new assets in order to Maintain Performance. It is estimated that sixty-five percent of rehabilitation and replacement expenditures would be for vehicles, while asset expansion would be geared more heavily toward non-vehicles. The incremental costs to improve non-rail conditions are estimated to be $497 million annually, of which $471 million, would be needed for vehicle rehabilitation and replacement. The incremental costs to Improve Performance are estimated to be $631 million annually, of which 45 percent, or $286 million, would be spent on new vehicles (principally buses) and 55 percent, or $345 million, on new non-vehicle assets. Expenditures on non-vehicle assets include investments for the purchase or construction of dedicated highway lanes for Bus Rapid Transit. A total of $4.9 billion would be needed on an average annual basis to Improve both Conditions and Performance.

Rail Needs in Urban Areas with Populations over 1 Million—About 70 percent of the total transit investment requirements of large urban areas, or about $9.6 billion annually, would be needed to Maintain Conditions and Performance of the rail infrastructure. Sixty-one percent, or $5.9 billion annually, would be required to rehabilitate and replace assets to Maintain Conditions, and 39 percent, or $3.8 billion, for asset expansion, i.e., to purchase new assets to Maintain Performance as ridership increases. Sixty-six percent of the investments to rehabilitate and replace existing assets and 75 percent of the investment to acquire new assets would be for non-vehicles. The incremental cost to improve rail asset conditions so that they achieve an average condition rating of "good" by 2020 is estimated to be $171 million annually. This $171 million results from an incremental increase of $293 million for non-vehicle asset rehabilitation and replacement coupled with an incremental decrease of $122 million in vehicle rehabilitation and replacement. Vehicle rehabilitation and replacement expenditures are reduced under this scenario since vehicles are replaced earlier in their useful life leading to a reduction in rehabilitation expenses. The incremental costs to Improve Performance of these rail systems are estimated to be $3.4 million annually, including the cost of purchasing rights-of-way. Ninety percent, or $3.0 billion, of this would be needed to expand the non-vehicle rail infrastructure. This split between vehicle and non-vehicle investment for performance improvement is typical for new heavy and light rail infrastructure development projects. A total of $13.2 billion would be needed on an average annual basis to Improve both Conditions and Performance of rail in these areas.

Non-rail Needs in Areas with Populations of Under 1 Million—Over 95 percent of the transit investment requirements in areas with populations under 1 million is projected to be for non-rail transit. The annual cost to Maintain Conditions and Performance of the non-rail transit infrastructure in these areas is estimated to be $1.4 billion. The incremental investment required to Improve non-rail conditions, is estimated to be $489 million annually, with the bulk to be spent for vehicle acquisitions. Of the $517 million incremental annual investment to Improve Performance 84 percent, or $435 million, would need to be invested in acquiring new vehicles and 16 percent or $82 million would need to be invested in the new non-vehicle infrastructure. Sixty-three percent of investment required to Improve Performance stems from the lack of coverage by rural transit systems and unmet rural transit needs. The total amount needed to Improve both Conditions and Performance of non-rail transit in these areas is estimated to be $2.4 billion annually.

Rail Needs in Areas with Populations of Under 1 Million—Rail needs in these less populated areas are minimal because only three light-rail systems currently operate in them. An estimated $32 million annually would be needed to Maintain Conditions and Performance. An additional $3 million would be required to Improve Conditions by increasing the rate at which old vehicles are replaced with new vehicles. The additional $112 million to Improve Performance will be principally for expansions of light rail. Of this amount, $10 million is estimated to be needed to purchase vehicles and $102 million to purchase non-vehicle assets—reasonably in line with the industry rule-of-thumb that light rail projects typically have a ratio of vehicle-to-total-system costs of about 11 percent. A total of $148 million would be required to Improve both Conditions and Performance of rail in rural areas.

Q. Why have estimated requirements for rural areas increased so significantly since the last C&P Report?

A. Investment requirements in rural areas have been reevaluated to take into account their lack of transit coverage. This lack of coverage was most recently documented in a 1994 survey of rural systems undertaken by the Community Transportation Association of America (CTAA), but estimates of the unmet requirements were not included in the 1999 C&P Report. (The most recent CTAA survey in 2000 did not resurvey rural system coverage.) Although the number of rural transit vehicles increased at an average annual rate of 7.8 percent between 1994-2000 and the population in areas of less than 50,000 inhabitants decreased by 3.4 percent between 1990-2000, there are still believed to be significant unmet rural transit needs. Recent surveys of rural transit needs in five states—Minnesota, Montana, North Carolina, Vermont and West Virginia—identified considerable unmet requirements within these states. The investment requirements estimates presented here assume an annual rural vehicle growth rate of 3.5 percent.

Average Annual Investment Requirements by Detailed Asset Type

Exhibit 7-11 provides disaggregated annual investment requirements for rail and non-rail transportation modes by asset type for:

- asset replacement and rehabilitation,
- asset expansion, and
- performance improvement.

Assets are disaggregated into 5 categories—facilities, guideway elements, stations, systems, and vehicles. The annual funding requirements for supporting services are provided under "other project costs." These include expenditures for administrative services and vehicles used for administrative or security purposes. The annual investment needed to design rail new systems and acquire rights-of-way to support new rail investments are reported under the Improve Performance scenario.

Rail—More than 40 percent of rail rehabilitation and replacement investment, both in the Maintain Conditions and Improve Conditions scenarios, is estimated to be required for investment in guideway elements, including elevated structures, systems structures, and track. Investment required to Maintain guideway conditions is estimated to be $2.3 billion annually, and to Improve guideway conditions, $2.6 billion annually. Guideway elements are estimated to account for slightly more than 40 percent of the total value of the existing U.S. transit asset base. Twenty-four percent of elevated structures, 23 percent of underground tunnels, and 17 percent of rail track are in less than-adequate condition (below condition level 3).

Exhibit 7-11

Transit Infrastructure
Average Annual Investment Requirements by Asset Type, 2001-2020
(Millions of 2000 Dollars)

MAINTAIN CONDITIONS AND PERFORMANCE

ASSET TYPE	REHABILITATION AND REPLACEMENT	ASSET EXPANSION	IMPROVE PERFORMANCE	TOTAL
Rail				
Guideway Elements	$2,318	$1,427		$3,746
Facilities	111	123		235
Systems	1,007	231		1,239
Stations	379	313		692
Vehicles	2,049	1,011		3,060
Other Project Costs		707		707
Subtotal Rail	**5,865**	**3,813**		**9,678**
Non-Rail				
Guideway Elements	11	342		353
Facilities	802	325		1,127
Systems	145	62		207
Stations	21	141		162
Vehicles	2,352	759		3,111
Other Project Costs	0	203		203
Subtotal Non-Rail	**3,331**	**1,832**		**5,163**
Total Maintain Conditions	**9,196**	**5,645**		**14,841**

IMPROVE CONDITIONS AND PERFORMANCE

ASSET TYPE	REHABILITATION AND REPLACEMENT	ASSET EXPANSION	IMPROVE PERFORMANCE	TOTAL
Rail				
Guideway Elements	2,607	1,427	768	4,802
Facilities	111	123	59	294
Systems	1,012	231	120	1,363
Stations	379	313	289	981
Vehicles	1,930	1,011	327	3,269
Other Project Costs		707	614	1,321
System Design and Right-of-Way Acquisition			1,290	1,290
Subtotal Rail	**6,039**	**3,813**	**3,467**	**13,319**
Non-Rail				
Guideway Elements	11	342	107	460
Facilities	802	333	258	1,393
Systems	145	62	2	209
Stations	21	141	37	199
Vehicles	3,314	774	721	4,809
Other Project Costs	0	203	24	227
Subtotal Non-Rail	**4,293**	**1,855**	**1,149**	**7,297**
Total Improve Conditions	**10,332**	**5,668**	**4,616**	**20,616**

Source: Transit Economic Requirements Model and FTA staff estimates.

More than 32 percent of total rail rehabilitation and replacement investment will be needed for vehicles—$2.0 billion annually to Maintain vehicle conditions and $2.9 billion annually to Improve vehicle conditions.

Rail systems (substations, overhead wire, and third rail), estimated to comprise about 10 percent of the value of the transit asset base, would also require investments—$1.0 billion annually, or 17 percent of total rail infrastructure investment needs. Although many of these systems are in adequate or better condition (level 3 or above), they have an average useful life of around half that for other non-vehicle assets and have a more accelerated replacement schedule.

Facilities and stations would require the smallest levels of investment. Although 36 percent of facilities and 16 percent of stations are in less than adequate conditions, they have longer average replacement ages and comprise a relatively smaller proportion of the total rail infrastructure base (about 10 percent each).

The largest incremental investments needed to Maintain Performance through the expansion of the asset base would be for guideway elements ($1.4 billion annually) and vehicles ($1.0 billion annually). To Improve Performance $1.3 billion annually is estimated to be required for system design and rights-of-way acquisition.

Non-rail—Vehicles account for the largest component of non-rail investment requirements. The bulk (70 to 75 percent) of non-rail rehabilitation and replacement expenditures would be for vehicles—$2.4 billion annually to Maintain Conditions and $3.3 billion annually to Improve Conditions. Vehicles are also estimated to account for the largest proportion (about 40 percent) of non-rail asset expansion investments, at about $800 million under both the Maintain and Improve scenarios. Guideway elements and facilities would also account for considerable proportions (20 percent each) of future non-rail asset expansion—$342 million annually for guideways and $333 million annually for facilities. About 62 percent of the expenditures required for performance improvement would be for vehicles ($721 million annually), 22 percent for facilities ($258 million annually), and 9 percent for guideway elements ($107 million annually).

Existing Deficiencies in the Transit Infrastructure

TERM estimates the amount of investment that would be required in order to correct existing deficiencies in the Nation's transit infrastructure. This deficiency may also be referred to as the transit investment "backlog" similar to the backlog requirement calculated by HERS. TERM corrects infrastructure deficiencies by replacing all assets with conditions below the specified replacement level. These expenditures are averaged

Q. **Could U.S. Federal Lands benefit from additional investment in transit?**

A. A recent study of transportation alternatives on Federal Lands managed by the Interior Department identified transit investment requirements of $1.71 billion in 1999 constant dollars over the period 2001-2020, which converts to about $1.75 billion in 2000 dollars. The largest investments will be required by the National Park Service ($1,554 million) with considerably smaller amounts required by the U.S. Fish and Wildlife Service ($126 million) and the Bureau of Land Management ($30). (In 2000 dollars these estimated investment requirements are $1,586 million, $129 million and $31 million, respectively.) These investment requirements, which have been estimated outside the TERM framework and which have not explicitly been included in the estimates of transit investment requirements presented in this chapter, are discussed in more detail in Chapter 27.

over the 20-year investment period. *[See Appendix C]*. TERM estimates that the $16.4 billion would be needed to correct all existing deficiencies under the Maintain Conditions scenario and $30.7 billion under the Improve Conditions scenario**.** These numbers do not include the costs of correcting for deficiencies in rural or special service transit services.

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 1999 C&P report. The first column of figures contains values shown in the 1999 C&P report, which compared 1997 spending with the average annual investment requirements for 1998-2017.

Exhibit 8-1

Highway, Bridge and Transit Spending Versus Investment Requirements Compared With Data from the 1999 C&P Report

	BASED ON 1997 DATA	BASED ON 2000 DATA
Percent by which Investment Requirements Exceed Current Spending		
Cost to Improve		
Highways and Bridges	92.9%	65.3%
Transit	110.2%	127.5%
Cost to Maintain		
Highways and Bridges	16.3%	17.5%
Transit	41.0%	63.8%

Highways and Bridges

The average investment requirements estimated for the Cost to Improve Highways and Bridges scenario in the 1999 C&P report were 92.9 percent ($45.3 billion) higher than highway capital expenditures in 1997. The estimated gap has been reduced to 65.3 percent ($42.2 billion) in 2000, and is projected to further decline to an average of 56.6 percent ($38.7 billion) annually from 2001 through 2003. The primary reason for the decrease in the gap between current spending and the cost to improve is the increased Federal funding under the Transportation Equity Act for the 21st Century (TEA-21) and larger highway capital outlays by State and local governments.

Direct comparisons between reports for the Cost to Maintain Highways and Bridges are misleading, because the definition of the scenario has changed between the two reports. As described in Chapter 7, the Cost to Maintain scenario in this edition utilizes a more ambitious goal of maintaining overall conditions and performance as measured by their impact on average user costs, while the scenario in the 1999 edition focused on a more limited goal of maintaining only the physical conditions of the highway and bridge infrastructure. While the difference between the Maintain scenario and 2000 spending of 17.5 percent ($11.2 billion), appears to be fairly consistent with the 16.3 percent ($7.9 billion difference identified in the 1999 C&P report, the nature of the gap is distinctly different. The approach used in this edition of the C&P report is more consistent with the traditional definition of the Cost to Maintain scenario used in the 1997 edition and previous editions of the report.

Transit

From 1997 to 2000, the estimated gap between current spending on transit and required investments to improve or maintain transit conditions and performance widened. These additional investment requirements are reported in 2000 dollars. An additional investment of $5.7 billion annually (63.4 percent above actual capital investment in transit infrastructure in 2000) is estimated to be required to Maintain Conditions and Performance. An additional annual investment of $11.5 billion annually (127.5 percent above actual transit capital investment in 2000) is estimated to be required to "Improve" conditions and performance. The comparable ratios for 1997 reported in the 1999 Report were 41 percent to Maintain Conditions and Performance and 110.2 percent to Improve Conditions and Performance.

Required capital investment in vehicles, on an average annual basis, is estimated to be $6.2 billion (117 percent more than actual expenditures in 2000) to maintain transit vehicle conditions and performance, and $8.1 billion (184 percent more than actual expenditures) to improve conditions and performance. Required capital investment in non-vehicle transit infrastructure (on an average annual basis) is estimated to be $8.7 billion (65 percent higher than it was in 2000) to maintain conditions and performance and $12.5 (101 percent higher) to improve conditions and performance.

These comparisons, however, overestimate the gap between capital investment requirements and future funding for transit capital investment. This overestimation results because of the lags that occur between the authorization of capital funds, the obligation of these funds and actual capital spending. Since the enactment of TEA-21, annual obligations by FTA for capital investment have grown rapidly to $7.2 billion in FY 2000 from $4.1 billion in FY 1998. As these higher levels of authorized funds are obligated and spent, capital investment will rise and the gap between actual capital spending and estimated annual capital investment requirements will decrease.

Highway and Bridge Spending Versus Investment Requirements

This section starts by comparing the average annual investment requirements estimated in Chapter 7 with the 2000 highway and bridge capital spending outlined in Chapter 6. A second analysis compares average annual investment requirements with projected spending for 2001-2003, since highway capital investment is expected to rise during this period as a result of the higher funding levels under the Transportation Equity Act for the 21st Century (TEA-21).

> **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.

As was 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 highway travel were to increase at a faster rate than is projected in the Highway Performance Monitoring System (HPMS) sample data set (as affected by the elasticity procedures in HERS), then the funding gap would be larger; should the growth in vehicle miles be less than currently forecast, 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.

Average Annual Investment Requirements Versus 2000 Spending

Exhibit 8-2 compares the average annual investment requirements under the **Cost to Maintain** and **Cost to Improve** scenarios (See Chapter 7) with 2000 highway and bridge capital expenditures. The average annual Cost to Maintain Highways and Bridges projected for the 2001-2020 period is $11.3 billion (17.5 percent) higher than 2000 capital expenditures, while the estimated Cost to Improve Highways and Bridges exceeds current spending by $42.2 billion (65.3 percent). Expenditures for bridge preservation in 2000 slightly exceeded the corresponding component of the Cost to Maintain scenario, which is drawn from the Maintain Backlog scenario in NBIAS (See Chapter 7).

Types of Improvements

Exhibit 8-3 compares the distribution of highway and bridge capital outlay by improvement type for the Cost to Improve Highways and Bridges and the Cost to Maintain Highways and Bridges with the actual pattern of capital expenditures in 2000. In 2000, 40.1 percent of highway and bridge capital outlays went for system expansion. The investment requirement scenarios developed using the HERS and NBIAS models suggest that it would be cost-beneficial to increase the share of capital investment devoted to system expansion in the future. For the Cost to Maintain Highways and Bridges, 43.3 percent of the projected 20-year investment requirements is for system expansion. If funding were to increase above this level, the analysis suggests that even more cost-beneficial system expansion expenditures would be found, so that for the Cost to Improve Highways and Bridges, 46.7 percent of the total investment requirements is for system expansion.

Exhibit 8-2

Average Annual Investment Requirements versus 2000 Capital Outlay

	2000 CAPITAL OUTLAY ($BILLIONS)	INVESTMENT REQUIREMENTS (BILLIONS OF 2000 DOLLARS) COST TO MAINTAIN	PERCENT DIFFERENCE	COST TO IMPROVE	PERCENT DIFFERENCE
Highway Preservation	$25.9	$29.7	14.6%	$39.1	50.8%
Bridge Preservation	$7.6	$7.3	-4.0%	$9.4	22.4%
System Expansion	$26.0	$32.9	26.7%	$49.9	92.4%
System Enhancements	$5.1	$6.0	17.5%	$8.4	65.3%
Total	**$64.6**	**$75.9**	**17.5%**	**$106.9**	**65.3%**

As discussed in Chapter 7, investment requirements for non-modeled items were determined by assuming that any future increase in this type of investment would be proportional to increases in total capital spending. For system enhancements, the percentage for the Cost to Improve Highways and Bridges and for the Cost to Maintain Highways and Bridges were set at 7.9 percent, to match the percentage of expenditures in 2000.

Investment Requirements Versus Projected 2001-2003 Spending

The passage of TEA-21 has resulted in significant increases in Federal highway funding (See Chapter 6), which are projected to continue through 2003. This will help reduce the gap somewhat between the investment requirement scenarios and current spending levels identified earlier in this chapter. As

Q. **How does the improvement mix for the investment scenarios in this report compare to those in the 1999 C&P?**

A. The investment scenarios in this report suggest a shift from preservation to capacity improvements relative to the previous report. One reason for this is the inclusion of incident delay in HERS (See Appendix A). As a result, the model now finds an additional benefit to capacity improvements that was not previously considered. The change also reflects recent trends in physical conditions (which have improved) and operating performance (which has declined), resulting in a relatively larger backlog of cost-beneficial capacity improvements.

Exhibit 8-3

Highways and Bridges Investment Requirements and 2000 Capital Outlay, Percentage by Improvement Type

	SYSTEM PRESERVATION			SYSTEM EXPANSION	SYSTEM ENHANCEMENTS	TOTAL
	HIGHWAY	BRIDGE	TOTAL			
Cost to Improve Highways and Bridges	36.6%	8.8%	45.4%	46.7%	7.9%	100.0%
Cost to Maintain Highways and Bridges	39.1%	9.7%	48.8%	43.3%	7.9%	100.0%
2000 Capital Outlay	40.1%	11.8%	52.0%	40.1%	7.9%	100.0%

indicated in Chapter 6, due 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. Federal cash outlays are projected to be fairly stable from 2001 to 2003.

State and Local Funding

State and local funding for highway capital outlay has increased in every year since 1981, and has grown in constant dollar terms over time. The model predicts that annual increases in State highway funding (in nominal dollars) will range from 4.4 percent to 6.0 percent during the period from 2000 to 2003. This would actually represent a slowdown in funding increases, since State funding for highways increased at an average annual rate of 11.1 percent from 1997 to 2000.

> **Q. How were future State and local highway funding levels projected?**
>
> **A.** In 1996, the FHWA commissioned the development of two State Highway Funding Models to forecast future State highway funding levels. These models are used in the development of supporting materials for the annual FHWA budget submission. State Highway Funding Model I forecasts total State receipts for highways based on estimates of future fuel consumption, State general fund revenues, and nominal Gross Domestic Product (GDP).

This report assumes that State and local government funding for highway capital expenditures will increase by approximately the same rates.

Projected Federal, State, and Local Expenditures

Exhibit 8-4 shows projected expenditures by all levels of government for highway capital projects in current dollars and constant 2000 dollars. As indicated in Chapter 6, historical capital expenditures are converted to constant dollars using the Federal Highway Administration (FHWA) Construction Bid Price Index. However, there are no projections available for future values for this index, so the expenditure projections were converted to constant dollars using forecasts of the Consumer Price Index (CPI) instead.

> **Q. How do the projected highway capital expenditures for 2000-2003 presented in this report compare to the projections made for the 1999 C&P report?**
>
> **A.** Total highway capital expenditures in 2000 and the projections for 2001-2003 are substantially higher than the projections made for those years in the previous report. The 1999 report projected nominal expenditures of $57.3 billion in 2000, increasing to $64.6 billion by 2003.

Stated in constant 2000 dollars, highway capital expenditures are expected to rise from $64.6 billion in 2000 to $69.3 billion in 2003, a 5.5 percent increase, with over half of the growth occurring in 2001.

Comparison of Investment Requirements and Projected 2001-2003 Spending

When making multi-year comparisons of spending and investment requirements, it is important to note that the investment requirements shown in this report are cumulative. To achieve a given performance target at the

Exhibit 8-4

Projected Highway Capital Expenditures 2000-2003, All Levels of Government

YEAR	PROJECTED CAPITAL EXPENDITURES STATED IN BILLIONS OF NOMINAL DOLLARS		PROJECTED ANNUAL RATE OF INFLATION*	PROJECTED CAPITAL EXPENDITURES STATED IN BILLIONS OF CONSTANT 2000 DOLLARS	
	AMOUNT	INCREASE OVER PRIOR YEAR		AMOUNT	INCREASE OVER PRIOR YEAR
2000	64.6			64.6	
2001	68.9	6.6%	2.8%	67.0	3.7%
2002	71.6	3.9%	1.9%	68.4	2.0%
2003	74.2	3.6%	2.2%	69.3	1.3%

* Based on CPI projections from the Fiscal Year 2003 Budget.

end of 20 years, cumulative spending over the 20-year period would have to match the cumulative investment requirements specified for that target. For example, if spending in 2020 matched the average annual investment requirements identified as the Cost to Maintain Highways and Bridges, but spending in 2001 through 2019 fell below this threshold, highway and bridge conditions would be expected to decline. Highway and bridge conditions and performance would only be maintained under this scenario if the cumulative average annual spending for the 2001-2020 period reached $75.9 billion (in constant 2000 dollars), the average annual Cost to Maintain Highways and Bridges.

Exhibit 8-5 compares the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges with projected spending for the years 2001 through 2003. The row for 2000 is included to relate the table to Exhibit 8-2, but the 2000 values are not included in the cumulative capital expenditure figures shown. The "Average Annual" column shows the average annual capital expenditures corresponding to the years included in the "Cumulative" column, i.e., the $68.2 billion average annual expenditures shown for the year 2003 represent the average expenditures for the 3-year period 2001 to 2003.

Exhibit 8-5

Average Annual Investment Required to Maintain and Improve Highways and Bridges Versus Projected 2001-2003 Capital Outlay

YEAR	PROJECTED CAPITAL EXPENDITURES STATED IN BILLIONS OF CONSTANT 2000 DOLLARS			COST TO MAINTAIN HIGHWAYS AND BRIDGES		COST TO IMPROVE HIGHWAYS AND BRIDGES	
	ANNUAL	CUMULATIVE	AVERAGE ANNUAL	AVERAGE ANNUAL	PERCENT ABOVE PROJECTED SPENDING	AVERAGE ANNUAL	PERCENT ABOVE PROJECTED SPENDING
2000	64.6			75.9	17.5%	106.9	65.3%
2001	67.0	67.0	67.0	75.9	13.3%	106.9	59.5%
2002	68.4	135.4	67.7	75.9	12.2%	106.9	57.9%
2003	69.3	204.6	68.2	75.9	11.3%	106.9	56.6%

Exhibit 8-5 shows the gap between projected cumulative average annual spending and the estimated average annual investment requirements closing slightly between 2000 and 2003, to 11.3 percent for the Cost to Maintain and 56.6 percent for the Cost to Improve.

Comparison with Previous Reports

The comparison between spending and investment requirements in this chapter matches the presentation in the 1999 report, but differs from earlier C&P reports. Exhibit 8-6 compares the estimated differences between current spending and average annual investment requirements for this and the 1995, 1997, and 1999 reports.

Exhibit 8-6

Average Annual Investment Requirements Versus Current Spending 1995, 1997, 1999, and 2002 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*)
1995	Average Annual investment requirements for 1994-2013 compared to 1993 spending	57.5%	112.6%
1997	Average Annual investment requirements for 1996-2015 compared to 1995 spending	21.0%	108.9%
1999	Average Annual investment requirements for 1998-2017 compared to 1997 spending	16.3%	92.9%
2002	Average Annual investment requirements for 2001-2020 compared to 2000 spending	17.5%	65.3%

* The investment requirement scenarios are not fully consistent between reports. See Chapter 7 and Appendix A.

The percentage difference between current spending and the Cost to Maintain Highways and Bridges is up only slightly from the 1999 report. Note, however, that the definition of the Maintain scenario has changed slightly in each report (See Chapter 7). As shown in Exhibit 8-6, the 1999 C&P report estimated that average annual investment requirements were 16.3 percent above current spending.

The difference between current spending and the Cost to Maintain Highways and Bridges is also smaller than comparable figures from recent C&P reports. While the 1995 C&P report did not directly compare average annual investment requirements for the Cost to Maintain Highways and Bridges with 1993 report-related capital outlay, the difference would have been 57.5 percent. An analysis of the data in the 1997

Q. How do changes in the "funding gap" since the 1995 report relate to changes in highway capital expenditures over that time?

A. The Cost to Maintain gap has decreased from 57.5 percent (based on 1993 data) to 17.5 percent (based on 2000 data), while the Cost to Improve gap has decreased from 112.6 percent to 65.3 percent. From 1993 to 2000, constant dollar highway capital outlays increased by 21.6 percent.

C&P report (not presented then, but created for the 1999 C&P) would have shown a 21.0 percent difference between the average investment requirements to Maintain User Costs, and 1995 spending.

Based on the information in the 1995 C&P report, the difference between the Cost to Improve Highways and Bridges would have been 112.6 percent, similar to the 108.9 percent gap based on the 1997 report. This difference fell to 92.9 percent in the 1999 C&P report and has shrunk considerably to 65.3 percent in this report.

Transit Capital Spending Compared with Investment Requirements

2000 Capital Spending and Estimated Average Annual Investment Requirements

Total Capital Spending

In 2000, combined capital investment in public transportation by Federal, State, and local governments was $9.1 billion, below the requirements estimated by the Federal Transit Administration (FTA). FTA estimates that an additional investment of $5.7 billion annually (63.8 percent above actual capital investment in 2000) would be required to Maintain Conditions and Performance and an additional annual investment of $11.5 billion annually (127.5 percent above actual capital investment in 2000) would be required to Improve Conditions and Performance. *[See Exhibit 8-7]*.

This comparison, however, overestimates the gap between capital investment requirements and future funding for transit capital investment. This overestimation results because of lag that occurs between the authorization of capital funds, the obligation of these funds and actual capital spending. Since TEA-21, annual obligations by FTA for capital investment have grown rapidly to $7.2 billion in FY 2000 from $4.1 billion in FY 1998. Higher levels of authorizations have not yet worked their way through the process into capital spending. As these higher levels of authorized funds are obligated and spent, capital investment will rise and the gap between actual capital spending and estimated annual capital investment requirements will decrease.

Exhibit 8-7

2000 Transit Capital Expenditures Versus Estimated Average Annual Investment Requirements
(Billions of 2000 Dollars)

		ESTIMATED ANNUAL AVERAGE REQUIREMENTS MINUS EXPENDITURES IN 2000	PERCENT AVERAGE ANNUAL REQUIREMENTS ABOVE ACTUAL 2000 EXPENDITURES
Actual 2000 Capital Expenditures	$9.1		
2001-2020 Estimated Annual Average Requirements			
Cost to:			
Maintain Conditions & Performance	$14.8	$5.8	63.8%
Improve Conditions & Maintain Performance	$16.0	$6.9	76.6%
Maintain Conditions & Improve Performance	$19.5	$10.4	115.2%
Improve Conditions & Performance	$20.6	$11.6	127.5%

Sources: National Transit Database (NTD), Transit Economic Requirements Model (TERM) and FTA staff estimates.

Capital Spending by Asset Type

In 2000, $2.8 billion was invested in transit vehicles and $6.2 billion in non-vehicle transit infrastructure, i.e., facilities, guideway elements, stations, and systems. Between 2001 and 2020, investment in transit vehicles would need to grow more rapidly than investment in the non-vehicle transit infrastructure to both Maintain and Improve the transit infrastructure conditions and performance *[See Exhibits 8-8 and 8-9]*.

Capital Spending on Vehicles

FTA estimates that capital investment in transit vehicles would need to be $6.2 billion annually to Maintain Conditions and Performance (117 percent more than actual expenditures in 2000) and $8.1 billion annually to Improve Conditions and Performance (184 percent more than actual expenditures in 2000). In 2000, there were estimated to be 6,770 overage rail vehicles and 16,000 overage buses, compared with 5, 381 overage rail vehicles and 17,681 overage bus vehicles in 1997. (The decline in the number of overage buses has largely resulted from an estimated decline in the number of overage vans.) The entire bus fleet will need to be replaced at least once during the period of 2001 to 2020 since large and medium-sized buses have an expected life of 12 years and small buses and vans have an expected life of 7 years. Commuter rail self-propelled passenger coaches and heavy rail vehicles account for the largest percentage of overage rail vehicles—22 percent and 61 percent, respectively. Each of these modes will need to purchase a considerable number of new vehicles. These purchases will only need to be made once between 2001 and 2020, given an expected rail vehicle life of 25 years. Rail vehicle requirements to Improve Conditions are higher than in the 1999 C&P Report because, as discussed in Chapter 3, conditions for all rail vehicles except commuter rail have been revised downward from a "good" to an "adequate" level.

Exhibit 8-8

Average Annual Transit Investment Requirements Versus 2000 Capital Spending by Asset Type

	VEHICLES			NON-VEHICLE ASSETS		
	BILLIONS OF 2000 DOLLARS	PERCENT ABOVE ACTUAL SPENDING	PERCENT OF TOTAL CAPITAL SPENDING/ REQUIRE-MENTS 1/	BILLIONS OF 2000 DOLLARS	PERCENT ABOVE ACTUAL SPENDING	PERCENT OF TOTAL CAPITAL SPENDING/ REQUIRE-MENTS 1/
2000 Capital Spending 2/	$2.8		31%	$6.2		69%
Costs to:						
Maintain Conditions & Performance 2/	$6.2	117%	42%	$8.7	40%	58%
Improve Conditions & Performance	$8.1	184%	39%	$12.5	101%	61%

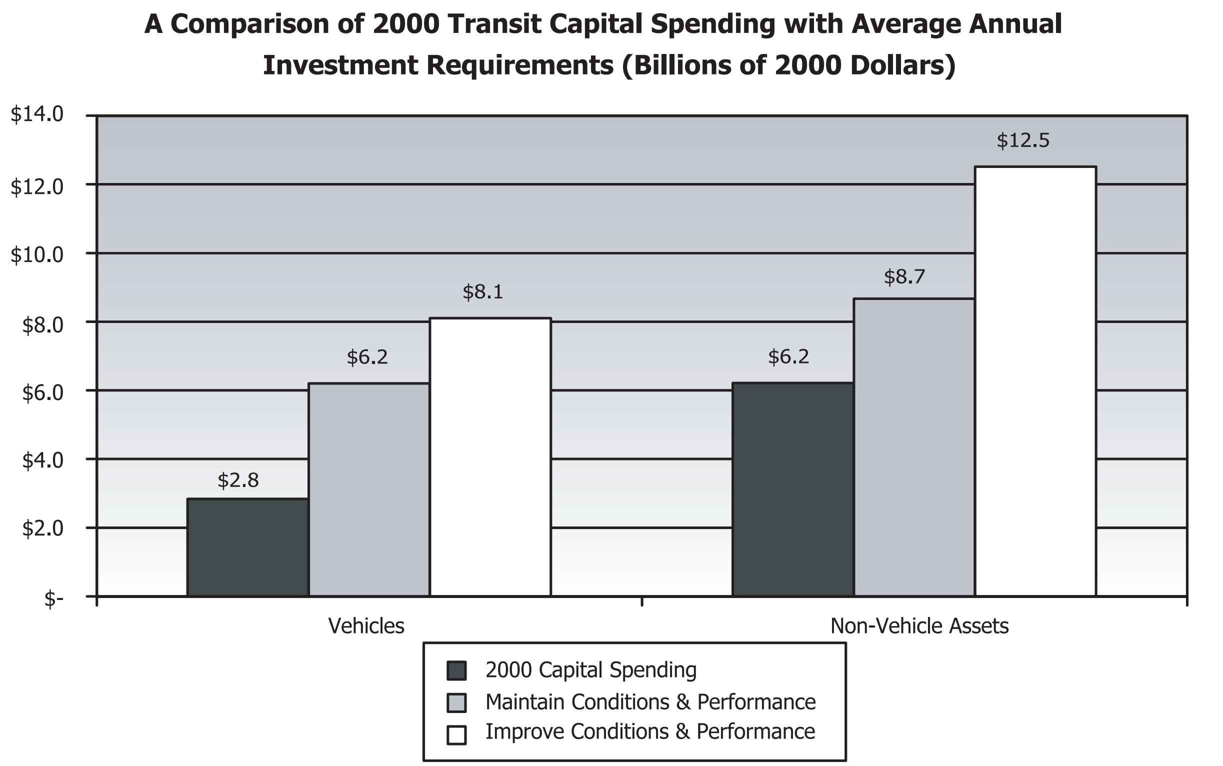
1/Percent of total 2000 capital spending/ percent of total investment requirements to Maintain and Improve Conditions and Performance.
2/Note: numbers do not add due to rounding.

Source: Transit Economic Requirements Model and FTA staff estimates.

Capital Spending on Non-vehicle Infrastructure

TERM estimates that an annual capital investment in non-vehicle transit infrastructure of $8.7 billion (40 percent above 2000 capital spending) would be needed to Maintain Conditions and Performance of these assets and $12.5 billion (101 percent above 2000 capital spending) would be needed to Improve them. As discussed in Chapter 7, the bulk of this investment would be needed for guideway elements—elevated structures (bridges), tunnels, and track—and rail systems.

Exhibit 8-9



Source: Transit Economic Requirements Model and FTA staff estimates. Note: Numbers may not add due to rounding.

Investment Requirements versus Projected 2001-2003 Spending

Exhibit 8-10 provides estimated total (Federal, State, and local) capital funding available from 2000 to 2003 in current and constant 2000 dollars. Note that estimated capital funding available in 2000 is $12.4 billion, $3.4 billion higher than actual capital spending. In the case of formula funding this difference reflects a lag between authorizations and spending and in the case of flexible funding a lag between the obligations and spending. Exhibit 8-10 compares Federal capital funding levels from 2000-2003 in current and constant 2000 dollars.

Exhibit 8-10

Transit Capital Funding Levels, 2000-2003 (Millions of Dollars)

YEAR	AVAILABLE CAPITAL FUNDING LEVELS IN CURRENT DOLLARS	AVAILABLE CAPITAL FUNDING LEVELS IN CONSTANT 2000 DOLLARS	GDP DEFLATOR*
2000	$12,484	$12,484	100.0%
2001	$13,319	$13,018	102.3%
2002	$14,150	$13,533	104.6%
2003	$14,985	$14,079	106.4%

*Chained price index. Converted from a 1996 to 2000 base.

Sources: Transit Economic Requirements Model and Budget of the United States FY2003.

Q. **How were capital funding levels from 2000-2003 derived?**

A. Total capital funding is calculated as the sum of capital funding allocated through the five FTA formula programs and through flexible funding, Title 23 (FHWA), plus a State and local matching amount. Funds authorized under Section 5308, 5309, and 5310 programs are used exclusively for capital needs. Based on recent grant obligations trends, it has been assumed that 93 percent of the Section 5307 authorizations and 46 percent of the Section 5311 authorization levels will be allocated to capital investment. The percentage of Section 5307 authorizations assumed to be for capital investment was increased to 93 percent from 84 percent, which was used in the last edition of this report. This revision reflects the fact that since TEA-21, Section 5307 funds have been precluded from being used for most operating expenditures and hence a larger percentage of these funds has been spent on capital investment. The amount of flexible funding used for transit is assumed to equal $1.0 billion per year, the average annual amount of these funds obligated by FTA since TEA-21. Earlier editions of this report did not include flexible funds in estimates of total funding levels. The amount of flexible funds used for transit was considerably lower in those years. State and local governments are assumed to match federal funding levels, in line with the split between “Federal” and “State and local funding” in recent years. In 2000, State and local governments provided 47 percent of all capital funding and, in 1997, 54 percent. Authorized funding levels for 2001 to 2003 are deflated to a 2000 constant dollar using the chained GDP price index reported in the 2003 Budget of the United States for comparison with estimated transit investment requirements, which are in 2000 dollars.

A Comparison of Authorized Capital Expenditures with Estimated Investment Requirements (2000-2003)

Projected available funding levels for the duration of TEA-21 are lower than estimated investment requirements, with the gap declining over the period. *[See Exhibit 8-11].* In 2003, investment requirements to Maintain Conditions and Performance are estimated to exceed available authorized funding levels by 9.6 percent, and those to Improve Conditions and Performance by 52.2 percent.

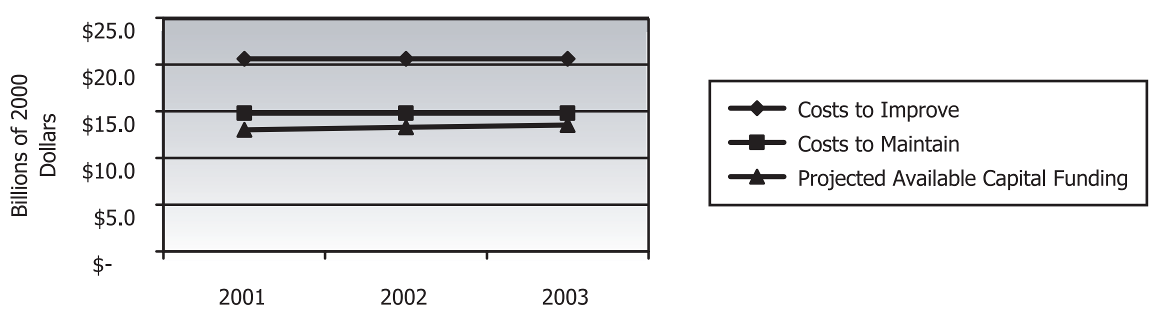
Comparison with Previous Reports

Exhibit 8-12 compares the percentage difference between current spending levels and investment requirements in 2000 to the same percentage differences provided in the 1995, 1997, and 1999 Conditions and Performance Reports. As a result of methodological changes, estimated investment requirements are not directly comparable from year to year. The ratio of investment requirements to actual spending to Maintain Conditions and Performance increased to approximately 60 percent in the present report from approximately 40 percent in earlier reports. The increase in this ratio between 1997 and 2000 reflects increases in vehicle acquisition costs and increased purchases in general as a result of expansion in infrastructure size. The increase in the ratio of investment requirements to actual expenditures under the Improve Conditions and Performance scenario resulted in part from the downward revision in the average condition of rail vehicle conditions based on re-estimated decay curves. Again these differences will narrow in the future as obligated funds are invested.

Exhibit 8-11

Projected Transit Available Capital Funding Versus Investment Requirements, 2000-2003 (Billions of 2000 Dollars)

YEAR	PROJECTED AVERAGE ANNUAL AVAILABLE CAPITAL FUNDING		COST TO MAINTAIN CONDITIONS AND PERFORMANCE		COST TO IMPROVE CONDITIONS AND PERFORMANCE	
	ANNUAL	AVERAGE ANNUAL	AVERAGE ANNUAL	PERCENT ABOVE PROJECTED AVERAGE ANNUAL AVAILABLE CAPITAL FUNDING	AVERAGE ANNUAL	PERCENT ABOVE PROJECTED AVERAGE ANNUAL AVAILABLE CAPITAL FUNDING
Actual Capital Expenditures						
2000	$9.06		$14.84	63.9%	$20.62	127.7%
Projected Available Capital Funding						
2001	$13.02	$13.02	$14.84	14.0%	$20.62	58.3%
2002	$13.53	$13.28	$14.84	11.8%	$20.62	55.3%
2003	$14.08	$13.54	$14.84	9.6%	$20.62	52.2%



Sources: Transit Economic Requirements Model, TEA-21, and FTA staff estimates.

Exhibit 8-12

Average Annual Transit Investment Requirements versus Current Spending 1995, 1997, 1999 and 2000 Conditions and Performance 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%

Source: Transit Economic Requirements Model and FTA staff estimates.

Chapter 9

Impacts of Investment

Summary

This chapter, which was first introduced in the 1999 Report, 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 with the financial trends reported in Chapter 6. The second is to discuss 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 points out that transit investment requirements are driven by projected transit demand, but do not, at this time, take into account any additional demand that may be generated by this transit capital investment. The transit section also examines historical trends in condition and performance measures, and the differences between recent transit capital funding levels and estimated rehabilitation and replacement needs.

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 non-modeled 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 2000 by 33.7 percent, from $48.4 billion to $64.6 billion. This equates to a 19.9 percent increase in constant dollar terms, as spending grew much faster than the rate of inflation. Over the same period, the percentage of total capital outlay used for system preservation rose from 47.6 percent in 1997 to 52.0 percent in 2000. The combined result of this increase in total capital investment and the shift in the types of investments being made was a 45.7 percent increase in spending on system preservation, from $23.0 billion to $33.6 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 40.2 percent in 2000. Spending for system expansion grew more slowly than that for system preservation over this period, rising 20.8 percent from $21.5 billion dollars in 1997 to $25.9 billion in 2000.

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 miles on the National Highway System with "acceptable" ride quality increased from 89.5 percent to 93.5 percent from 1997 to 2000. Acceptable miles on Interstate highways in urbanized areas rose from 90.0 percent to 93.0 percent, over this period. The percent of urbanized Interstates meeting the stricter criteria for "good" ride quality increased from 39.3 percent to 48.2 percent over this same period. While pavement conditions declined on some of the lower ordered functional systems, the percentage of road miles with good ride quality rose from 43.2 percent to 43.5 percent between 1997 and 2000. The percent of deficient bridges decreased from 1998 to 2000, falling from 29.6 percent to 28.6 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 new performance measures adopted by the Federal Highway Administration (FHWA) and described in Chapter 4, congestion has continued to increase between 1997 and 2000. The Percent of Travel Under Congested Conditions increased from 31.7 percent to 33.1 percent from 1997 to 2000, while the Percent Additional Travel Time increased from 45.0 percent to 51.0 percent. The annual change in Percent Additional Travel Time has remained constant since 1997, increasing at approximately two percentage points per year. The yearly increase for Percent of Travel Under Congested Conditions has remained fairly constant at one-half percentage point per year.

The Average Annual Hours of Traveler Delay in urbanized areas increased from 28.1 hours to 31.2 hours between 1997 and 2000. However, the rate of change for Annual Hours of Traveler Delay has decreased. Prior to 1997, the increase in the Average Annual Hours of Traveler Delay was over 1 hour per year. This has reduced to a rate of approximately 0.6 hours per year between 1997 and 2000. This decline may be the result of increased investment in system expansion and traffic operational improvements, over this period. However, this level of investment has not stopped the overall growth in congestion.

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 new 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 to 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.

Impact of Future Investment on Highway Conditions and Performance

The HERS model has recently been modified to provide output measures that are consistent with the condition and performance measures discussed in Chapters 3 and 4. As a result, the model can now forecast future values of these metrics under different funding scenarios.

Impact on 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 vehicle miles 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.

Exhibit 9-1

Projected Changes in Highway Physical Conditions Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS) Total	HERS Derived	PERCENT CHANGE IN AVERAGE IRI	PERCENT OF VMT ON ROADS WITH IRI<95	IRI<170	FUNDING LEVEL DESCRIPTION: Investment Required to...
			43.9%	85.1%	2000 Values
$106.9	$69.1	-13.9%	59.2%	94.0%	Improve Highways and Bridges
$90.5	$58.2	-6.1%	51.6%	89.8%	
$82.6	$52.9	**0.0%**	44.7%	86.5%	**Maintain Average IRI**
$77.1	$49.2	6.1%	39.4%	83.2%	
$75.9	$48.4	7.8%	38.2%	82.6%	Maintain Highways and Bridges
$73.8	$46.8	10.4%	35.9%	80.9%	
$70.6	$44.3	16.5%	31.6%	78.2%	
$68.0	$42.4	20.9%	28.6%	75.9%	
$64.6	$39.8	26.1%	25.6%	73.4%	Maintain Current Spending

Source: Highway Economic Requirements System.

At the funding level estimated in Chapter 7 as the Cost to Improve Highways and Bridges ($106.9 billion annually), the average pavement quality would improve by 14 percent, while the percentage of miles traveled on pavement rated as adequate or better would rise from 85 percent to 94 percent. At the Cost to Maintain level, average IRI would increase by 7.8 percent, and the travel percentage on good pavement would decrease from 44 percent to 38 percent.

Exhibit 9-1 also shows projections of pavement quality at other funding levels, of which two deserve special attention. The HERS model predicts that an average annual overall funding level of $82.6 billion (which includes $52.9 billion in directly modeled expenditures) would be necessary to maintain average IRI. This was the indicator used to define the **Maintain Physical Conditions** benchmark in the 1999 C&P, which in turn was used to define the Cost to Maintain Highways and Bridges in that report. It shows the level of investment such that the average pavement condition at the end of the 20-year analysis period would match that observed in 2000. Under this investment strategy, existing and accruing system deficiencies would be selectively corrected; some highway sections would improve, some would deteriorate. Note that this scenario assumes that investment in system enhancements will continue to occur and that system expansion will continue where economically justified, so it does not represent the absolute minimum amount required to preserve the existing system. At this level of investment, the percentages of travel on good and/or adequate roads would increase slightly.

The **Maintain Current Spending** benchmark noted in Exhibit 9-1 relates directly to highway funding levels, rather than to measures of conditions and performance. At this point, highway spending would be held at 2000 funding levels (in constant dollars), increasing only with inflation. At this level of funding, average IRI would increase by 26 percent, while the percentage of travel on roads with good and adequate pavement would fall to 26 percent and 73 percent, respectively. Note, however, that these values from HERS assume the shift from preservation improvement spending toward capacity improvements that was discussed in Chapter 8.

Q. **Would it be necessary to invest the full amount identified in Exhibit 9-1 as the Cost to Maintain Average IRI, in order to maintain average pavement condition?**

A. No. The $82.6 billion average annual amount specified includes a mix of improvements designed to attain the highest possible level of benefits, including some improvements that do not address the physical conditions of highways and bridges. If all investment requirements for system expansion and system enhancements were ignored, an average annual investment of $39.7 billion in system preservation would be sufficient to maintain physical conditions. However, if total highway and bridge capital investment were limited to $39.7 billion annually, the analytical procedures used in this report suggest that it would be more cost-beneficial to split this amount among system preservation, system expansion, and system enhancements, rather than use it all for system preservation.

It should also be noted that the level of investment identified by HERS as necessary to maintain IRI is higher than the level needed to maintain user costs (per the HERS scenario used for the Cost to Maintain Highways and Bridges elsewhere in this report). This is the reverse of what was presented in the 1999 C&P. The reason is that, in this case, HERS is identifying more cost-beneficial capacity improvements relative to pavement improvements than previously, resulting in a lower minimum benefit-cost ratio (and thus higher investment total) being necessary to maintain IRI at its current level. This is due both to the recent trends toward improved pavement quality and worsening congestion on highways, and to the addition of other types of delay (most notably incident delay) to the HERS analysis of highway user costs.

Impact on Performance

Exhibit 9-2 shows 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 TERM (See Chapter 7). The table indicates that an average annual investment of $73.8 billion would be sufficient to maintain average highway speeds at their 2000 level of 42.3 miles per hour. This dollar amount is slightly lower than

Exhibit 9-2

Projected Changes in Highway Performance Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS) Total	HERS Derived	AVERAGE SPEED (MPH)	PERCENT OF VMT ON ROADS WITH V/SF>.80	V/SF>.95	FUNDING LEVEL DESCRIPTION: Investment Required to...
		42.3	22.2%	12.3%	2000 Values
$106.9	$69.1	44.8	15.4%	6.2%	Improve Highways and Bridges
$90.5	$58.2	44.1	21.2%	10.0%	
$82.6	$52.9	43.4	24.1%	11.7%	
$77.1	$49.2	42.8	25.9%	12.8%	
$75.9	$48.4	42.7	26.2%	13.0%	Maintain Highways and Bridges
$73.8	$46.8	**42.3**	26.7%	13.4%	**Maintain Average Speed**
$70.6	$44.3	41.7	27.2%	14.1%	
$68.0	$42.4	41.1	27.5%	14.4%	
$64.6	$39.8	40.3	27.7%	14.8%	Maintain Current Spending

Source: Highway Economic Requirements System.

the amount identified as the Cost to Maintain Highways and Bridges. At the Cost to Improve level of spending, average speeds would increase to 44.8 miles per hour, whereas they would drop by 2.0 miles per hour if highway expenditures were maintained at their 2000 levels.

The next two indicators show the estimated percentage of vehicle miles traveled (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 2000 highway funding levels were maintained through 2020, the percentage of VMT on congested and severely congested roads to 15.4 percent and 6.2 percent, respectively.

Q. What are the projected values for the new FHWA performance measures in 2020 at different levels of investment?

A. Chapter 4 discussed three new highway performance measures (and their historic and 2000 values) that have been adopted by the FHWA for its strategic and performance planning process. The three measures (defined in Chapter 4) are Percent Additional Travel Time, Annual Delay per Capita, and Percent Congested Travel. The HERS model has recently been modified to calculate current and projected values of congestion measures similar to these. Some preliminary results from this output are shown in Exhibit 9-3.

Exhibit 9-3

Projected Changes in Highway Performance Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS)					
Total	HERS Derived	PERCENT ADDITIONAL TRAVEL TIME	ANNUAL DELAY PER CAPITA	PERCENT CONGESTED TRAVEL	FUNDING LEVEL DESCRIPTION: Investment Required to...
		51	31.2	33.1	2000 Values
$106.9	$69.1	33	26.1	34.3	Improve Highways and Bridges
$90.5	$58.2	37	29.8	35.7	
$82.6	$52.9	40	31.9	36.0	
$77.1	$49.2	42	33.8	36.2	
$75.9	$48.4	42	34.2	36.3	Maintain Highways and Bridges
$73.8	$46.8	43	34.7	36.3	
$70.6	$44.3	45	35.7	36.4	
$68.0	$42.4	44	35.5	36.4	
$64.6	$39.8	45	35.9	36.4	Maintain Current Spending

Source: Highway Economic Requirements System.

Exhibit 9-3 indicates that greater levels of highway capital expenditures will generally result in improvements in the values of the three FHWA performance measures. The projected 2020 value for Annual Delay per Capita is 26.1 hours at the Cost to Improve level and 35.9 hours at the current funding level, compared with a 2000 value of 31.2 hours. However, projections for the Percent Additional Travel Time measure indicate substantial improvements at all levels of investment, whereas the Percent Congested Travel would increase at all levels of investment. Further calibration of the HERS model will be necessary to ensure that the calculation of these measures is consistent with those done for the FHWA performance plan.

At the Cost to Maintain level of investment, the percentage of VMT on congested roads would also increase, to 26.2 percent. In order for capacity improvements to be "implemented" by HERS, the improvement must meet the minimum BCR test. 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.

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 a Maintain User Costs benchmark. The analysis presented there estimates that an average annual investment of $75.9 billion would be required to maintain highway user costs at their baseline 2000 levels.

Exhibit 9-4 describes how travel time costs, vehicle operating costs, and total user 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 $75.9 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would fall by 1.0 percent, whereas average vehicle operating costs would rise by 1.8 percent. A slightly lower investment of between $70.6 and $73.8 billion would be sufficient to maintain travel time costs. Vehicle operating costs would be maintained or decreased only if average annual investment exceeded $90.6 billion for highways and bridges.

Exhibit 9-4

Projected Changes in Highway User Costs Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS)		PERCENT CHANGE IN			
Total	HERS Derived	TOTAL USER COSTS	TRAVEL TIME COSTS	VEHICLE OPERATING COSTS	FUNDING LEVEL DESCRIPTION: Investment Required to...
$106.9	$69.1	-3.6%	-6.3%	-0.7%	Improve Highways and Bridges
$90.5	$57.6	-2.4%	-4.4%	0.4%	
$82.6	$52.2	-1.3%	-2.8%	0.7%	
$77.1	$48.6	-0.3%	-1.4%	1.4%	
$75.9	$48.0	**0.0%**	-1.0%	1.8%	**Maintain User Cost**
$73.8	$46.7	0.5%	-0.2%	2.2%	
$70.6	$44.0	1.6%	1.4%	2.9%	
$68.0	$42.2	2.6%	2.8%	3.2%	
$64.6	$40.6	3.9%	5.0%	3.9%	Maintain Current Spending

Source: Highway Economic Requirements System.

Estimates of total user costs vary at different levels of future investment, rising 3.9 percent at the current spending level and falling 3.6 percent at the maximum economic level of investment. Travel time costs show slightly greater variation, ranging from a 5.0 percent increase at current funding levels to a 6.3 percent decrease at the Cost to Improve 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.

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 only be measured 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.

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. 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 due to 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 only be valid for a single level of investment in HERS. Thus, the State-supplied 20-year growth forecasts in HPMS would only be valid under a specific set of conditions. HERS assumes 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 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 which is very similar to the baseline growth rate implicit in the HPMS data.

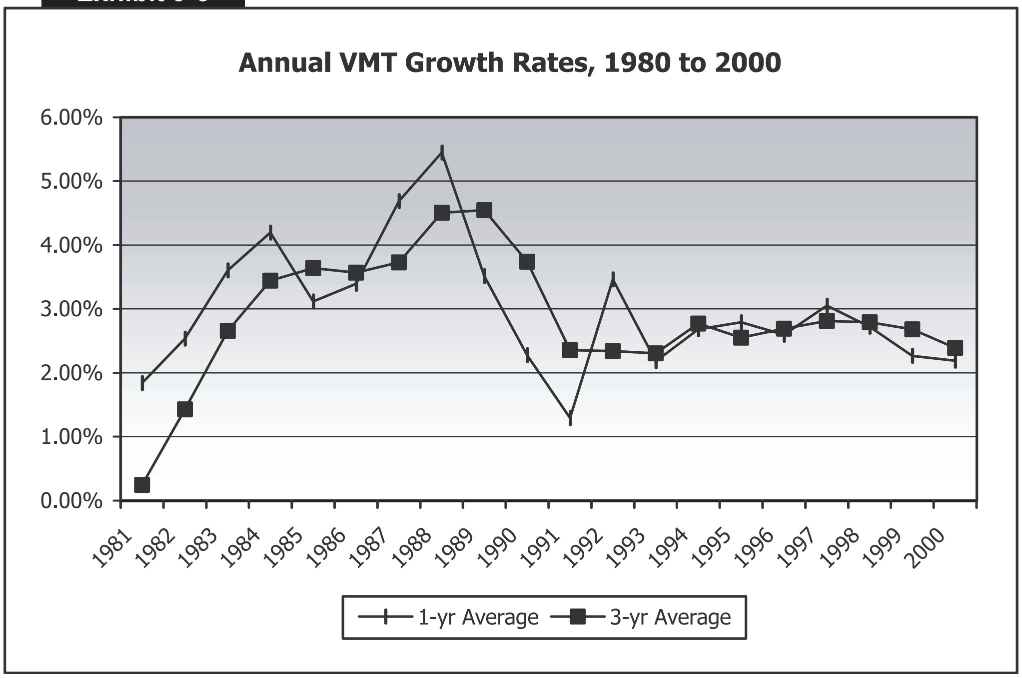
Historic Travel Growth

Exhibit 9-5 shows annual VMT growth rates for the 20-year period from 1980 to 2000. The average annual VMT growth rate over this period was 2.99 percent. Travel growth has varied somewhat in individual years, ranging from 1.29 percent in 1991 to an increase of 5.45 percent in 1988. 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 the 1981-1982 and 1990-1991 recessions, while annual VMT growth was higher than 3 percent every year from 1983 through 1989. Exhibit 9-2 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.

Q. Does annual highway VMT ever decrease from one year to the next?

A. Yes. In three different years during the energy crises of the 1970's (1974, 1978, and 1979), annual VMT in the U.S. declined by 2.5, 1.0, and 0.1 percent, respectively.

Exhibit 9-5



Projected Average Annual 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 2.08 percent. Projected growth in rural areas (2.26 percent average annual) is somewhat larger than in urban areas (1.96 percent).

If average annual highway and bridge capital outlay rose to $75.9 billion in constant 2000 dollars, HERS predicts that overall highway user costs would remain at 2000 levels. The Maintain User Costs scenario derived from HERS attempts to maintain the average user costs for the entire highway system, but user costs can vary on individual functional classes and on individual highway sections. In this particular analysis, however, the resulting average annual VMT growth rates in urban areas and in the Nation as a whole at this level of investment match those derived from the baseline HPMS data. Rural VMT growth rates would be just slightly higher than the baseline.

Implementing all of the cost-beneficial highway investments in the $106.9 billion Cost to Improve scenario would reduce user costs, resulting in higher travel growth rates than currently projected in HPMS, due to the travel demand elasticity features in HERS. Total VMT would grow at an average annual rate of 2.26 percent, while rural and urban VMT would grow at 2.37 and 2.19 percent, respectively. Note, however, that these elevated levels are well below the average annual growth rates experienced over the last 20 years.

In 2000, all levels of government spent $64.6 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 1.72 percent and average annual rural VMT growth to 2.21 percent, both of which are below the baseline forecasts in HPMS.

As indicated in Chapter 8, average annual capital investment on highways and bridges by all levels of government from 2000-2003 is expected to grow to $67.9 billion in constant 2000 dollars. This amount is approximately equal to the $68.0 billion shown in the next-to-last row in Exhibit 9-6. The table indicates that

Q. What about VMT growth in large urbanized areas?

A. The weighted average annual growth rate for all HPMS sample sections in urbanized areas with population over 1 million is 1.82 percent, which is lower than the rate for urban areas generally. The average annual VMT growth rates forecast by metropolitan planning organizations (MPOs) in large urbanized areas surveyed by the Federal Transit Administration (FTA) imply an average annual growth rate of 1.74 percent, indicating that the MPO forecasts may continue to imply slightly rising highway user costs in those areas.

Exhibit 9-6

Projected Average Annual VMT Growth Rates 2001-2020 for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS) Total	HERS Derived	AVERAGE ANNUAL VMT GROWTH Total	Rural	Urban	FUNDING LEVEL DESCRIPTION: Investment Required to...
		2.08%	2.26%	1.96%	HPMS Baseline
$106.9	$69.1	2.26%	2.37%	2.19%	Improve Highways and Bridges
$90.5	$58.2	2.20%	2.34%	2.10%	
$82.6	$52.9	2.14%	2.31%	2.04%	
$77.1	$49.2	2.10%	2.28%	1.98%	
$75.9	$48.4	2.08%	2.28%	1.96%	Maintain User Cost
$73.8	$46.8	2.06%	2.27%	1.92%	
$70.6	$44.3	2.01%	2.24%	1.85%	
$68.0	$42.4	1.96%	2.23%	1.79%	
$64.6	$39.8	1.91%	2.21%	1.72%	Maintain Current Spending

Source: Highway Economic Requirements System.

if this level of investment were sustained for 20 years, and used in the manner recommended by HERS, the model projects that urban VMT growth would rise at an average annual rate of approximately 1.79 percent, and overall VMT would grow at an average of 1.96 percent.

Overall Projected Travel, Year by Year

The future travel growth projections in HPMS indicate future levels of VMT, but don't provide any information as to how travel will grow year by year within the 20-year forecast period. The 2.08 percent overall average annual projected travel growth derived from HPMS is below the 2000 growth rate of 2.19 percent and well below the 2.99 percent average annual VMT growth rate from 1980 to 2000. Rather than assuming that VMT growth will suddenly drop to 2.08 percent in 1998 and remain constant for the next 20 years, the HERS model assumes that VMT growth rates will gradually decline over the 2000 to 2020 period. As discussed in Chapter 7, the model accomplishes this by assuming that VMT growth will be linear, growing by a constant amount annually rather than at a constant rate. For example, if travel grows at an average annual rate of 2.08 percent, this would result in an increase in travel between 2000 and 2020 of 1.41 trillion vehicle miles. The baseline forecasts used in the HERS model would assume that VMT will increase by 1/20 of this amount, 70.3 billion vehicle miles, during each of the 20 years. As VMT grows each year, the fixed annual increase will represent a smaller percentage of the existing VMT base. This assumption is also consistent with the FHWA's year-by-year national VMT forecasts referred to above.

Exhibit 9-7 shows projected year-by-year VMT derived from HERS for three different funding levels. If average annual investment were to reach the Cost to Improve Highways and Bridges level, VMT would be expected to grow to 4.32 trillion in 2020. If average annual investment remains at 2000 levels in constant dollar terms, VMT would grow to only 4.04 trillion, while VMT growth at the Cost to Maintain level of investment would reach 4.18 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

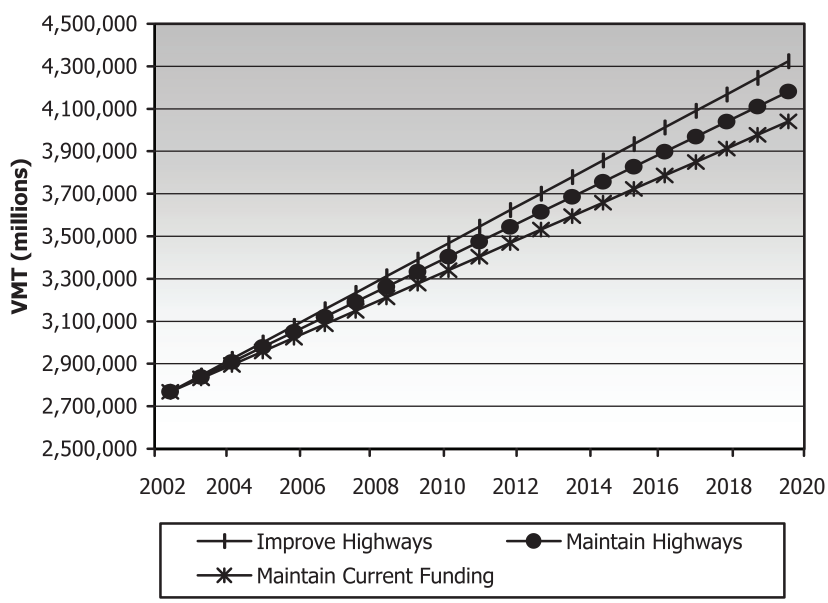
Chapter 7 notes that funding bridge investments at $9.4 billion annually over a 20-year period would eliminate the existing backlog and correct other deficiencies by 2020. This is the Eliminate Deficiencies Scenario. Chapter 7 notes that funding bridge investments at $7.3 billion annually would ensure that the existing bridge investment backlog does not increase above its current level. This is the Maintain Backlog scenario.

Exhibit 9-8 describes projected changes in the bridge backlog for different funding levels. The existing backlog is estimated at $54.7 billion. If investment over the 20-year period were limited to $4.0 billion per year, the backlog would rise to $130.2 billion. If bridge investment were maintained at the 2000 funding level in constant dollars ($7.6 billion), the bridge backlog would be projected to decrease by 13.7 percent, to $47.2 billion.

Exhibit 9-7

Annual Projected Highway VMT at Different Funding Levels
(VMT in Millions; Funding in Billions of 2000 Dollars)

FUNDING LEVEL DESCRIPTION	COST TO IMPROVE HIGHWAYS AND BRIDGES	COST TO MAINTAIN HIGHWAYS AND BRIDGES	ACTUAL 2000 CAPITAL OUTLAY
Funding Level ($ Billions)	**$106.9**	**$75.9**	**$64.6**
2000	**2,767,367**	**2,767,367**	**2,767,367**
2001	2,845,161	2,838,006	2,831,033
2002	2,922,956	2,908,646	2,894,700
2003	3,000,750	2,979,285	2,958,366
2004	3,078,544	3,049,925	3,022,033
2005	3,156,338	3,120,564	3,085,699
2006	3,234,133	3,191,203	3,149,365
2007	3,311,927	3,261,843	3,213,032
2008	3,389,721	3,332,482	3,276,698
2009	3,467,516	3,403,122	3,340,365
2010	3,545,310	3,473,761	3,404,031
2011	3,623,104	3,544,400	3,467,698
2012	3,700,899	3,615,040	3,531,364
2013	3,778,693	3,685,679	3,595,030
2014	3,856,487	3,756,319	3,658,697
2015	3,934,281	3,826,958	3,722,363
2016	4,012,076	3,897,597	3,786,030
2017	4,089,870	3,968,237	3,849,696
2018	4,167,664	4,038,876	3,913,362
2019	4,245,459	4,109,516	3,977,029
2020	**4,323,253**	**4,180,155**	**4,040,695**



Source: Highway Economic Requirements System.

Exhibit 9-8

Projected Changes in Bridge Preservation Backlog Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS)	BACKLOG	PERCENT CHANGE FROM 2000	FUNDING LEVEL DESCRIPTION: Investment Required to...
$9.4	$0.0	-100.0%	Eliminate Deficiencies
$9.0	$19.5	-64.4%	
$8.0	$41.9	-23.4%	
$7.6	$47.2	**-13.7%**	Maintain Current Spending
$7.3	$54.7	**0.0%**	Maintain Backlog
$7.0	$65.6	20.5%	
$6.0	$80.9	47.9%	
$5.0	$96.5	76.4%	
$4.0	$130.2	138.1%	

Source: National Bridge Investment Analysis System.

Transit Investment Impacts

Transit investment leads to improved transit access, an increase in transit ridership, a reduction in the number of cars on the road, improved air quality, and improved accessibility to jobs and other local resources. For example, transit investment of $10.5 billion in 21 New Starts projects as authorized by TEA-21 for Full Funding Grant Agreements are expected to:

- Add over 550,000 average weekday boardings and carry an additional 162 million riders, of which about 75.5 million would have formerly driven to work.
- Remove 62.5 million cars from the road annually.
- Improve air quality by reducing 60 billion tons of carbon dioxide emissions annually.
- Remove 62,500 million cars from the road and save over 76 million hours of travel-time annually.
- Provide transit access to an additional 920 thousand households, of which 87 thousand are low income.

Transit Investment, Historical Conditions, and Performance Trends

Historically and since 1993 (as shown in Chapter 8, Exhibit 8-12), actual investment in transit capital infrastructure has fallen below estimated investment requirements to Maintain Conditions and Performance and to Improve Conditions and Performance. As a result, asset conditions over the last years have not changed significantly while capacity has increased below the rate of increase in ridership.

Historical Condition Trends

FTA has historical information on average vehicle age, number of overage vehicles and average vehicle condition back to 1987. Historical trends, therefore, are analyzed over this period. As indicated in Chapter 3, Exhibit 3-38, the average condition of bus vehicles has been relatively constant over the last 13 years, with a very slight improvement since 1993, in spite of the spending and requirements gap. The average condition of rail vehicles, on the other hand, appears to be very gradually declining—from 3.91 in 1987 to 3.55 in 2000. [See Chapter 3, Exhibit 3-4]. While the average age of bus vehicles (including vans) has remained relatively constant, the average age of the rail fleet has increased from 15.6 years in 1987 to 20.4 years in 1997 and 21.8 years in 2000. The absolute number of overage vehicles, both bus and rail, has also increased. In 2000, there were about 16,000 overage buses—44 percent more than in 1987—and 6,770 overage rail vehicles—138 percent more than in 1987. Although the condition of the non-vehicle infrastructure appears to be similar to the condition in 1997, as discussed in Chapters 3 and 7, a significant percentage of this infrastructure is in less-than-adequate condition.

Historical Performance Trends

Historical performance trends between 1987 and 2000 are provided in Chapter 4, Exhibits 4-17 and 4-20. The performance of non-rail modes has been relatively constant. The average speed of non-rail vehicles in 2000 was the same as the 14-year average for the years between 1987 and 2000. The bus vehicle utilization rate was relatively low in 2000, compared to the rates that existed over this 14-year period, and in particular when compared with the rates between 1987 and 1991. The utilization rate of demand response vehicles in 2000 was slightly above the 14-year average, but lower than the utilization rates in 1997, 1998 and 1999. There is an indication that the performance of rail transit modes, as evidenced by speed and occupancy rates, may be very slightly declining. In 2000, the average rail speed was 24.9 miles per hour—its lowest rate since 1990 (average rail speeds were slightly lower between 1987 and 1989)—and rail vehicle utilization rates (an indicator of potential crowding) reached new highs in 2000, well above the utilization rates that existed in any of the previous years back to 1987. *[See Chapter 4, Exhibit 4-17 and Exhibit 4-20].*

Historical Transit Investment and Estimated Rehabilitation and Replacement Needs

As discussed in Chapter 8 previous C&P reports have estimated that then-current capital spending levels were well below the amount required to Maintain both Conditions and Performance. *[See Exhibit 8-12].* As shown in Exhibit 9-9, these amounts have been equal to or slightly higher than the pure replacement and rehabilitation levels necessary to Maintain Conditions. Based on theinformation reported to FTA on transit agencies' asset purchases, about half of current capital spending appears to have been allocated to rehabilitation and replacement expenditures. The remainder has gone to asset expansion, also contributing to higher average condition levels through the purchase of new assets.

Maintain Conditions—Past spending levels have resulted in maintained conditions for buses and almost maintained conditions for rail vehicles, even though the absolute number of overage bus and rail vehicles has increased considerably since the late eighties. The investment required to Maintain Conditions will continue to increase in line with increases in the size of the transit infrastructure base.

Maintain Performance—Over the past few years, funding levels have been sufficient to Maintain Performance for bus modes of public transport, but may not have been sufficient for rail modes, as evidenced by a slight decline in the average speed and slight increase in vehicle utilization rates of rail transit services.

Exhibit 9-9

Current Transit Capital Spending Levels vs Rehabilitation and Replacement Needs, 1993-2000

(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

Sources: National Transit Database and Transit Economic Requirements Model.

Impact of Investment Levels on Future Transit Use (PMT Growth)

Assumed growth in passenger miles traveled (PMT) based on Metropolitan Planning Organization (MPO) forecasts is the primary factor in the estimation of transit investment needs. (See Chapter 10 for an analysis of the effect of variations in PMT growth on transit investment needs.) Estimated capital spending levels are those that would be required to assure that increases in demand, i.e., ridership, are accommodated without degrading overall performance, i.e., service quality. The Transit Economic Requirements Model (TERM) does not yet permit an assessment of how the required investment levels estimated by TERM would affect transit ridership, user costs, and the potential for additional capital investment. The problem is that it is difficult to separate the effect of capital investment from the effect of other variables that impact ridership. This is an area for further FTA research.

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.

There is a great deal of uncertainty about the appropriate values for the 20-year travel growth rates on which HERS and TERM rely. The highway and transit sections both show the impact that changing these assumptions would have on the investment requirement projections. Alternative estimates of highway investment requirements are shown for scenarios in which future highway travel growth rates match those observed over the last 20 years and for scenarios in which travel growth is substantially lower than that projected in the Highway Performance Monitoring System (HPMS) sample data. 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 showing 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. The highway section also considers alternative values for additional parameters, including the value of a statistical life, truck shares, and travel demand elasticity.

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 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 Travel Growth Assumptions

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, the Highway Economic Requirements System (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 the 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 2000 levels. If HERS predicts that highway-user costs will deviate from baseline 2000 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 the 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 either the HPMS forecasts don't precisely represent the travel that will occur if a constant level of service is maintained, or if the travel demand elasticity procedures in HERS don't accurately predict the response that highway-users will have 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 2000 to 2020 average 2.08 percent per year, well below the 2.99 average annual VMT growth rate observed from 1980 to 2000.

The HERS model assumes that the 2.08 percent composite VMT growth projection in HPMS represents the growth that will occur at a constant level of service. If this forecast understates future growth, the investment requirements will be higher than predicted.

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 10-1 shows the impact on investment requirements of assuming that the VMT growth that would occur at a constant level of service is different from what is indicated in the HPMS forecasts. The first line assumes a growth rate of 2.99 percent annually (matching the actual average annual growth rate over the last 20 years), rather than the 2.08 percent rate derived from the HPMS forecasts. This is achieved by factoring up the growth rates entered into the HERS model for each section by 43.8 percent. Modifying the travel growth projections in this fashion would increase the Cost to Maintain Highway and Bridges by 52.5 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 2000 levels. The Cost to Improve Highways and Bridges would increase by 50.4 percent based on this change in assumptions. The increased travel would increase the number of pavement and capacity projects that HERS would find to be cost-beneficial.

The second line in Exhibit 10-1 shows what the projected investment requirements would be if the average VMT growth rate at a constant level of service were 1.17 percent rather than 2.08 percent. This value represents the effect of doubling the decline in the average annual VMT growth rate (relative to the historic values) that is implicit in the HPMS forecasts (i.e., the average annual growth rate over 20 years would drop from 1.82 percent (2.99 to 1.17) rather than by 0.91 percent (2.99 to 2.08)). The impact on the Cost to Maintain Highways and Bridges would be a decrease of 30.6 percent, and the impact on the Cost to Improve Highways and Bridges would be a decrease of 29.2 percent.

Exhibit 10-1

Impact of Alternate VMT Growth Assumptions on Investment Requirements

	Cost to Maintain Highways & Bridges		Cost to Improve Highways & Bridges	
	($BILLIONS)	PERCENT CHANGE	($BILLIONS)	PERCENT CHANGE
Chapter 7 Baseline	$75.9		$106.9	
Overall VMT Growth Rates				
Increased from 2.08% to 2.99%	$115.8	52.5%	$160.8	50.4%
Decreased from 2.08% to 1.17%	$52.7	-30.6%	$75.7	-29.2%

Source: Highway Economic Requirements System (HERS).

Alternative Model Parameters

The HERS model uses several key input parameters whose values may be subject to considerable uncertainty or debate. To assess the importance of such uncertainty, the estimates of future investment requirements were recomputed using different values for some of these parameters, including short run and long run elasticity; the value of ordinary travel time; the value of reductions in incident delay; the value of a statistical life; improvement costs; and truck share growth. Exhibit 10-2 shows the impacts of the alternative parameter values on the Cost to Improve Highways and Bridges.

Elasticity Values

The travel demand elasticity values used in this report were -0.6 for short term elasticity with an additional -0.4 (total -1.0) for the long term share. In the 1999 C&P report, values of -1.0 and -0.6 (total -1.6) were used. The changes in the elasticity procedures are explained in Appendix A.

Under the highway Maximum Economic Investment scenario, highway user costs are projected to decline. At this level of investment, the elasticity procedures in HERS tend to induce travel growth. Therefore, raising the elasticity values back to the levels used in the 1999 C&P report would increase the amount of induced travel and thus increase the investment requirements slightly.

Exhibit 10-2

Impact of Alternate Model Features and Parameters on Investment Requirements Cost to Improve Highways & Bridges

	($BILLIONS)	PERCENT CHANGE
Chapter 7 Baseline	$106.9	
Elasticity Values		
Use 1999 C&P Values	$107.6	0.7%
Value of Ordinary Travel Time		
Increase 100 percent	$119.3	11.7%
Reduce 50 percent	$98.2	-8.1%
Value of Incident Delay Reduction		
3 times value of ordinary travel time	$108.7	1.7%
Equal to value of ordinary travel time	$105.4	-1.4%
Value of a Statistical Life		
Increase 100 percent	$107.3	0.4%
Reduce 50 percent	$106.7	-0.2%
Improvement Costs		
Increase 25 percent	$124.1	16.1%
Truck Shares		
Increasing by 0.9 percent annually	$107.3	0.4%

Source: Highway Economic Requirements System (HERS).

Value of Ordinary Travel Time

The value of time in HERS was developed using a standard methodology adopted by the U. S. Department of Transportation (USDOT). This methodology provides consistency among different analyses performed within the Department. However, there is a great deal of debate about the appropriate way to value time, and no single methodology has been uniformly accepted by the academic community, or within the Federal Government.

Doubling the value of ordinary travel time in HERS would increase the Cost to Improve Highways and Bridges by 11.7 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 over 49 percent of total improvement costs. Reducing the value of time by 50 percent would have the opposite effect, resulting in an 8.1 percent reduction in the Cost to Improve Highways and Bridges.

Value of Incident Delay Reduction

As noted in Appendix A and elsewhere in this report, the HERS model has recently been modified to calculate the delay associated with traffic incidents (such as crashes), in addition to recurring congestion delay and signal delay. Research has indicated that such unpredictable delay is even more "costly" to highway users (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 10-2 shows the impacts of setting this premium at a) 3.0 times the ordinary travel time value and b) equal to that value.

Changing the reliability premium associated with incident delay reductions has an effect similar to changing the value of ordinary travel time, though smaller in magnitude. Increasing the reliability premium to 3.0 makes incident delay-reducing improvements relatively more valuable, thereby raising investment requirements by 1.7 percent at the Cost to Improve level. Reducing the premium to 1.0 results in a corresponding reduction of 1.4 percent in the investment estimate.

Value of a Statistical Life

HERS uses $3.0 million for the value of a statistical life, which is the USDOT's standard value for use in benefit-cost analyses. As in the case 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 Cost to Improve Highways and Bridges by 0.4 percent. HERS would find a few more projects to implement on the basis of their increased safety benefits if the value of life were increased. Reducing the value of a statistical life by 50 percent would reduce the Cost to Improve Highways and Bridges by 0.2 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 or safety-oriented projects. Improving the HERS model's capabilities in this area will be the target of future research.

Improvement Costs

The unit improvement costs used in HERS to calculate total investment costs 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 10-2 shows the impact of inflating all the improvement costs used by HERS by 25 percent on the Cost to Improve Highways and Bridges. The increase in investment requirements due to higher unit values for the improvement costs is partially offset by the elimination of some projects that would no longer be considered cost-beneficial by HERS. The net result is an increase of 16.1 percent in the estimated investment requirements.

Truck VMT Shares

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.

The HERS model includes a parameter for adjusting the truck share on each functional class over time according to an exogenously specified value, thus allowing the model to simulate changes in the vehicle mix over the 20-year forecast period. The factor used to generate the changes in HERS was drawn from a recent projection of future VMT for different vehicle classes made for FHWA (referenced in Chapter 9). The data in that study suggest that the average VMT share of trucks is expected to increase from 7.7 percent in 2000 to 9.2 percent in 2020. Exhibit 10-2 indicates that accounting for such a change within the HERS estimation procedures would increase the Cost to Improve Highways by 0.4 percent. HERS finds a small number of additional projects to be cost beneficial when the larger truck shares are accounted for.

Impacts of Alternative Parameters on the Cost to Maintain Highways and Bridges

The impacts of alternative model parameters and procedures on the estimated investment requirements are more ambiguous for the Cost to Maintain Highways and Bridges (see Exhibit 10-3) than for the Cost to Improve results reported above. This is due to the way in which the Cost to Maintain Highways and Bridges is defined 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 2020 as calculated by HERS to match the initial levels in 2000. The initial calculation of user costs, however, is directly affected by many of the parameters shown in the exhibit, including the values of time, incident delay, statistical life, and truck shares. As a result, the average user cost that is maintained will be different for alternative values of these parameters, so the reader should exercise caution in interpreting Exhibit 10-3. The impacts of alternative values on the Cost to Improve, 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, reliability premium, and value of statistical life parameters, increasing the value of these parameters also increases the initial calculated

Exhibit 10-3

Impact of Alternate Model Features and Parameters on Investment Requirements
Cost to Maintain Highways & Bridges

	($BILLIONS)	PERCENT CHANGE
Chapter 7 Baseline	$75.9	
Elasticity Values		
Use 1999 C&P Values	$73.5	-3.2%
Value of Ordinary Travel Time		
Increase 100 percent	$72.8	-4.1%
Reduce 50 percent	$78.4	3.3%
Value of Incident Delay Reduction		
3 times value of ordinary travel time	$74.5	-2.0%
Equal to value of ordinary travel time	$76.5	0.8%
Value of a Statistical Life		
Increase 100 percent	$75.7	-0.4%
Reduce 50 percent	$76.0	0.0%
Improvement Costs		
Increase 25 percent	$91.8	20.9%
Truck Shares		
Increasing by 0.9 percent annually	$83.2	9.6%

Source: Highway Economic Requirements System (HERS) value of user costs. Maintaining this higher level in the future may thus artificially require a smaller amount of future capital investment, due solely to the change in the baseline values. The effect is to lower the estimated Cost to Maintain when these parameters are increased, while the opposite is true for reduced values of the same parameters.

Increasing the share of trucks over time has the opposite effect on the Maintain User Costs scenario in HERS. 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. More investment is then required to maintain user costs at the initial level. For the elasticity parameters, a larger value will cause more travel to be suppressed in the future, thereby reducing investment requirements.

Increasing the unit improvement costs in HERS by 25 percent causes a slightly less-than-proportional increase in the estimated Cost to Maintain Highways and Bridges. The reason for this is that the Cost to Maintain includes bridge preservation investments modeled in the National Bridge Investment Analysis System (NBIAS), which are not affected by changes in the HERS parameters.

Q. Are there any sensitivity analysis results available from the NBIAS model?

A. Yes. NBIAS applies a swell factor to maintenance, repair, and rehabilitation (MR&R) needs to account for the way in which such projects are implemented in practice. When State and local governments repair or rehabilitate deficient components of bridges, they typically try to raise the standards of other components that might not yet be deficient. In other words, MR&R actions cannot be viewed in isolation, and a swell factor is applied for these related improvements. This logic was also applied to the NBIAS results in the 1999 C&P report.

For this report, a swell factor of 1.25 was assumed. Assuming an alternate value of 1.12 reduces the Cost to Improve Highways and Bridges by 10.5 percent and reduces the Cost to Maintain Highways and Bridges by 5.7 percent. A 1.0 swell factor reduces the Cost to Improve Highways and Bridges by 20.5 percent and reduces the Cost to Maintain Highways and Bridges by 15.8 percent.

NBIAS is currently being improved so that individual bridge analysis can be done for MR&R needs. This will eliminate the need for a swell factor in future reports.

Transit Sensitivity Analyses

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).
- Capital costs.
- Value of time.

These alternative projections illustrate how transit requirements 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. In fact, these forecasts are the primary driver behind TERM's estimates of the extent to which the Nation's transit system will need to be expanded in order to maintain performance. Transit 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. They implicitly incorporate assumptions about the relative growth of travel by transit and automobile. The average annual growth rate in PMT of 1.6 percent used in this report is a weighted average of the most recent, primarily 2001, MPO forecasts available from 33 of the Nation's largest metropolitan areas.

Future transit investment requirements have been estimated by TERM on the basis of three alternative projected PMT scenarios to examine the effect of variations in PMT growth on projected investment needs. *[See Exhibit 10-4].* These scenarios are:

1) PMT growth is 50 percent greater than the forecast levels.
2) PMT growth is 50 percent less than the forecast levels.
3) There is no growth in transit PMT.

Exhibit 10-4

Impact of Alternative PMT Growth Rates on Transit Investment Requirements*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
ANNUAL PMT GROWTH RATE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE
Baseline (1.60%)	$14.80	-	$20.6	-
Increased 50% (to 2.40%)	$17.40	17.6%	$23.2	12.6%
Decreased 50% (to 0.80%)	$12.10	-18.2%	$17.9	-13.1%
Decreased 100% (to 0%)	$9.20	-37.8%	$15.0	-27.2%

*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.

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 as PMT growth rates influence asset expansion costs, which comprise a larger portion of total estimated Maintain Conditions and Performance needs. A 50 percent increase/decrease in growth will increase/decrease the cost to Maintain Conditions by 18 to 19 percent and the cost to Improve Conditions and Performance by 13 to14 percent. Investment requirements decrease by over 25 percent if PMT remains constant, although this is not a likely scenario.

Sensitivity to a 25 Percent Increase in Capital Costs

Capital costs used in TERM are based on actual prices paid by agencies for asset purchases as reported to FTA in several surveys. Asset prices have been converted to 2000 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 both the costs to Maintain Conditions and Performance and to Improve Conditions and Performance by close to the full 25 percent increase. These results indicate that total benefits continue to exceed total costs for most investments, even with a 25 percent increase in costs.

Exhibit 10-5

Impact of a 25 Percent Increase in Capital Cost on Transit Investment Requirements*

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
ANNUAL PMT GROWTH RATE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE
Baseline (1.60%)	$14.8	---	$20.6	---
Increase Costs 25%	$18.2	23.0%	$25.3	22.9%

*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.

Impact of Change in the Value of Time

The value of time is a key input to TERM's benefit-cost test for all proposed capital investments. Specifically, the value of time is used to determine the total benefits accruing to transit users from transit investments that reduce passenger travel time. Hence, increases in the value of time should further multiply the estimated user benefits of such projects.

Exhibit 10-6 shows the effect of varying the value of time, assumed to be $9.85 per hour in the baseline projections. Overall, variations in the value of time have a very limited effect on investment needs. While increases in the value of time increase the benefits of transit projects that reduce travel times, it decreases the benefits of investment in transit modes that are slower than alternative non-transit modes of travel, such as the automobile. Therefore, an increase in the value of time reduces projected investment in agencies/modes with relatively slower transit service (as travel shifts from transit to automobiles) and increases projected investment requirements in agencies/modes with relatively faster transit services (as travel shifts from automobiles to transit). The opposite occurs in response to a decrease in the value of time.

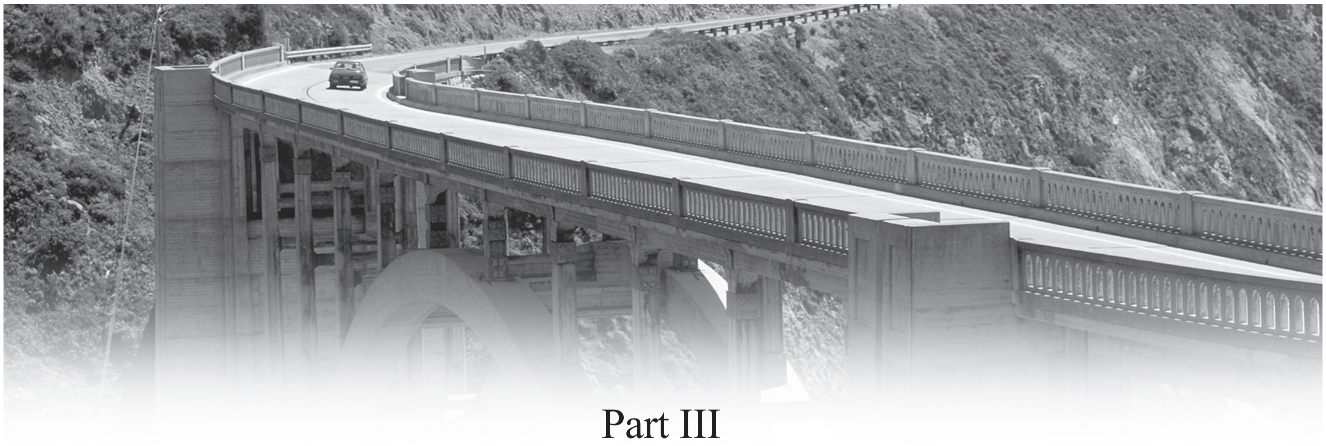
Exhibit 10-6

Impact of Change in the Value of Time* on Transit Investment Requirements

	Annual Cost to Maintain Conditions & Performance		Annual Cost to Improve Conditions & Performance	
ANNUAL PMT GROWTH RATE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE	(BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE
Baseline	$ 14.4	---	$ 19.5	---
Increase 100%	$ 14.6	0.0	$ 19.7	0.0
Decrease by 50%	$ 14.4	-0.1%	$ 19.5	-0.3%

* 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.



Part III

Bridges

Introduction

General information on the composition and conditions of the Nation's bridges was presented in Chapters 2 and 3, which focused on the highway system and provided an overview of bridge performance. This section of the report provides additional detail on the conditions, composition, and performance of bridges as well as information on Federal bridge programs.

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 able to accommodate this volume of traffic. The safety of the bridge network came into question in the late 1960s when, on December 15, 1967, the Silver Bridge spanning 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).

As shown in the tables and discussions, 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, the FHWA and the Nation need to take a closer look at transportation system preservation strategies, such as preventive 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.

Information is presented in the following order:

- Overview of the National Bridge Inspection Program and the Highway Bridge Replacement and Rehabilitation Program. The evolution of the programs is also presented and discussed.
- Additional detail on the bridge conditions and composition summarized in Chapters 2 and 3.
- Additional detail on the highway bridge network through the examination of specific functional classifications, ownership, material types, and design types.

Chapter 11

Federal Bridge Program/Status of the Nation's Bridges

Overview and Evolution of the Bridge Programs

For the last 30 years, bridges located on public roads, which are in excess of 6 meters in total length have received periodic, biennial inspections to ensure safety to the traveling public. Inspections are guided by federally defined minimum data collection requirements. Every year bridge information is submitted from the States to the Federal Highway Administration (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 $55 billion in Highway Bridge Replacement and Rehabilitation Program (HBRRP) funding has been allocated and used to improve the condition of the Nation's bridges. Other sources of funding from Federal and State programs are also used for bridge activities.

Bridges are critical elements within the highway transportation network. Deterioration of structures must be periodically mitigated through proactive interventions to ensure the 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 due to this functional obsolescence of the structure.

Programs have been developed and legislated to ensure bridge safety and provide funding for rehabilitation, improvement, and replacement of the structure. 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 in the remaining portions of the chapter.

Initiation and Evolution of the Bridge Programs:

On December 15, 1967, the Silver Bridge carrying US 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 9. 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 National Bridge Inspection Standards (NBIS). The NBIS, developed by FHWA in cooperation with the American Association of State Highway and Transportation Officials (AASHTO), was enacted as part of the Federal-Aid Highway Act of 1971. This landmark legislation was enacted on April 27, 1971 and established, for the first time in U.S. history, uniform, national 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 are 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.

Since its enactment, 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. On Interstate 95, the primary highway on the Atlantic seaboard that provides connectivity between 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 due to instantaneous fracture of a pin and hanger detail. This failure resulted in several fatalities and disrupted commerce in the Northeastern U.S. 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 5th, 1987, disaster struck again with the collapse of a bridge carrying the New York State Thruway (Interstate 90) across the Schoharie River. With rising water levels due to localized flooding, the soil around the pier was simply washed away. This was followed by the subsequent loss of bearing capacity for the foundation of the center pier, which lead to the catastrophe. Several fatalities resulted from this failure. Other notable scour-induced failures have 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 a more than 80 percent of the bridges on public roads cross over waterways. With approximately 475,000 structures crossing waterways, program enhancement was required. FHWA acted quickly by 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, such as the Mianus River and the Schoharie Creek bridges, due to scour and fatigue 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 the 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 Special Bridge Replacement Program (SBRP), created by the Federal-Aid Highway Act of 1971, which 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 of 1978 replaced the SBRP with the Highway Bridge Replacement and Rehabilitation Program (HBRRP).

The program initiated through the Federal Aid Highway Act of 1971 has been incrementally enhanced so that today all structures in excess of 6.1 meters (20 feet) on public roads receive, in general, biennial safety inspections. Notable changes in legislation can be seen in Exhibit 11-1. "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 11-1

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 systems - Established minimum data collection requirements - Established minimum qualifications and inspector training programs - Established Special Bridge Replacement Program
Surface Transportation Assistance Act of 1978 (P.L. 95-599)	- Established Highway Bridge Rehabilitation and Replacement Program (extending funding to rehabilitation) to replace Special Bridge Replacement Program - Extended inventory requirement to all bridges on public roads in excess of 6.1 m - Provided $4.2 billion for the HBRRP, over 4 years
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. - Added requirements for underwater inspections and fracture critical inspections - Allowed increased inspection intervals for certain types of bridges
Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA - 1991)	- Provided $16.1 billion for the HBRRP over 6 years - Mandated State implementation of bridge management systems
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 National Bridge Inspection Standards (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 information presented later in the chapter.

For most structures, the NBIS requires visual inspection once every two 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 (DOT). Information is collected on the bridge composition and conditions and reported to FHWA where the data is 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 FHWA provides oversight of the States compliance with the requirements of the NBIS.

Q. Are there many bridges that receive inspections more or less frequently that once every two years?

A. Eighty-two percent of all structures are inspected on the standard NBIS 2 year cycle. Four percent of structures have received an exemption to the 2-year requirement and are inspected every 4 years. The remaining 14 percent of structures are inspected more frequently that the standard 2-year cycle. The majority of these structures are inspected once every year.

The NBI database contains the following types of information: Inventory information characterizing the structure, Condition Ratings, Appraisal Ratings, and Calculated Fields.

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. The NBI database represents the most comprehensive source of information available on the National-level.

Through periodic safety inspections, data is collected on the condition of primary components of the structure. Condition ratings are collected for the following components on the 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 bridges.
- Channel/channel protective systems, for all structures crossing waterways.

The culvert condition rating describes all structural elements of culvert designs, which do not have a distinct deck, superstructure, and substructure. The channel/channel protective system rating describes the physical conditions of slopes and the channel for water flow through the bridge.

Bridge inspectors utilize a ten (10) point system, where code 9 indicates excellent, as-new condition and code 0 indicates a failed condition. Codes 7–9 indicate satisfactory to excellent conditions. Codes 5 and 6 indicate either fair or satisfactory conditions of the components. Codes 4 and less indicate poor, serious, critical conditions, conditions representing imminent failure of the component or failed conditions. The description of the condition rating codes has been illustrated in Exhibit 3-21. 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 the 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 the structure to provide the required service. Appraisal ratings are quantified for:

- Structural evaluations (load carrying capacities).
- Deck geometry (indicating constrictions which affect safety).
- Underclearances (which, if insufficient, results in detours).
- 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 and Status of Bridge System

Composition:

In describing the characteristics of the current highway system, the following information was summarized in Chapter 2:

- Number of Bridges by Owner and the changes in ownership percentages using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-4)
- Number of Bridges by Functional System for each rural and urban functional classification using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-10)
- Percentage of Deck Area by Functional Classification for each rural and urban functional classification using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-11)

This section of the chapter expands on the information presented in Chapter 2. More information is presented for specific ownership, functional classifications, superstructure materials, and designs in the last portion of the chapter.

Information is presented to highlight the details of the bridge inventory composition and to highlight conditions in greater detail. Traditionally, information is often presented by numbers of bridges and every bridge in the inventory is counted equally. Thus, large suspension bridges, such as the Golden Gate or the George Washington Bridge, are considered equivalent to small, two-lane bridges carrying low volumes of traffic. In some cases, insight into the condition or the composition may be obtained by considering the size of the structure and/or the traffic carried. Considerations of size of the structure will be incorporated through presentation of information using the deck area of the bridge. Considerations of the volume of traffic served by the structure will be incorporated through presentation of information using the Average Daily Traffic (ADT).

The NBIS contains nearly 700,000 records, which describe either the features carried by the 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 586,930 bridges over 6.1 meters (20 feet) in total length located on public roads in the United States. These bridges, on average, carry 3.8 billion vehicles per day and comprise a total deck area in excess of 315 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 majority of structures are owned by State and Local agencies (47 percent and 51 percent of the bridges respectively). Comparing bridge ownership to roadway ownership (20 percent and 77 percent State and local ownership respectively) shows that there is a much higher percentage of State ownership in the bridge network. State and local agencies, when taken together, own 97 percent of the roadways and 98 percent of the bridges by numbers. Considering functional classification, as presented in Exhibits 2-10 and 2-11, the number of rural bridges has remained relatively static, while the number of urban bridges has increased slightly from 1996 to 2000.

This information is elaborated upon in Exhibit 11-2, which presents a cross-tabulation between the functional class and the ownership. It also shows percentages of bridges weighted equally (by numbers), by Average Daily Traffic (ADT) carried, and by deck area.

Exhibit 11-2

Bridges by Ownership and Functional Classification

FUNCTIONAL CLASS	FEDERAL	STATE	LOCAL	PRIVATE	UNKNOWN	TOTAL	% BY NOS	% OF ADT	% OF DECK AREA
Rural Bridges									
Interstate	30	27,417	14	42	0	27,503	4.69%	10.25%	8.38%
Other Arterials	565	71,301	2,501	149	7	74,523	12.71%	10.18%	15.70%
Collectors	1,306	68,559	73,113	249	44	143,271	24.43%	4.76%	13.75%
Local	6,856	27,534	174,973	644	117	210,124	35.83%	1.76%	10.35%
Subtotal Rural	**8,757**	**194,811**	**250,601**	**1,084**	**168**	**455,421**	**77.66%**	**26.95%**	**48.17%**
Urban Bridges									
Interstate	1	27,058	368	354	0	27,781	4.74%	36.18%	19.24%
Other Arterials	50	44,435	17,539	479	96	62,599	10.68%	32.10%	26.27%
Collectors	22	5,000	9,690	145	85	14,942	2.55%	2.38%	2.74%
Local	110	4,675	20,440	368	66	25,659	4.38%	2.39%	3.57%
Subtotal Urban	**183**	**81,168**	**48,037**	**1,346**	**247**	**130,981**	**22.34%**	**73.05%**	**51.83%**
Rural & Urban									
Interstate	31	54,475	382	396	0	55,284	9.43%	46.43%	27.62%
Other Arterials	615	115,736	20,040	628	103	137,122	23.38%	42.28%	41.97%
Collectors	1,328	73,559	82,803	394	129	158,213	26.98%	7.14%	16.49%
Local	6,966	32,209	195,413	1,012	183	235,783	40.21%	4.15%	13.92%
Total	**8,940**	**275,979**	**298,638**	**2,430**	**415**	**586,402**			

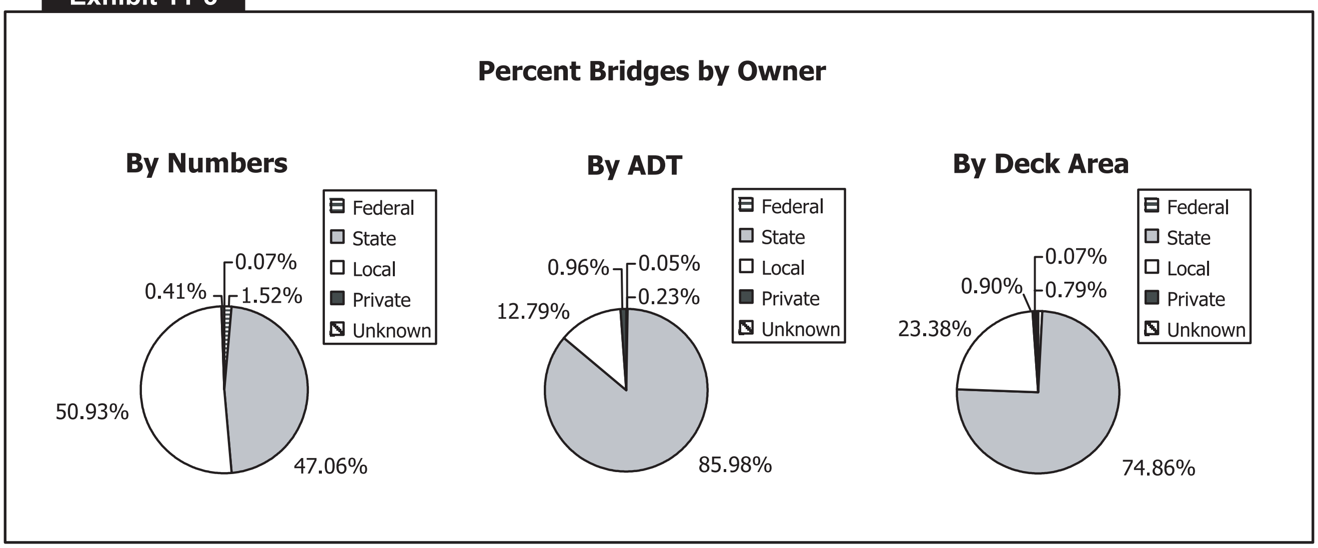
Source: National Bridge Inventory.

** Note that the table does not include structures with unknown functional classifications (528 structures).*

Exhibit 11-2 shows rural bridges make up 77.6 percent of all structures. Urban bridges comprise 22.3 percent of the inventory, carry over 73 percent of the daily traffic, and constitute 51.8 percent of all the deck area. Urban bridges tend to be larger in deck area and carry more traffic. This indicates the magnitude of the disparity between urban and rural structures in terms of traffic and size. A similar trend is found between functional classifications where Interstates and other arterials, which comprise approximately 1/3 of the inventory by numbers, but carry close to 90 percent of all the daily traffic, and have approximately 70 percent of the total deck area.

Exhibit 11-3 shows percentages by owner where the percentages are evaluated in terms of numbers, traffic carried, and deck area. By each measure, State and locally owned bridges dominate the population in terms of percentages. State bridges tend to be larger and carry higher volumes of traffic. State owned bridges are located on higher functional class roadways (Interstates and principal arterials), whereas locally owned structures tend to be located on lower functional class roadways (collectors and local roadways). The number of bridges and traffic carried are shown by functional classification for State-owned bridges in Exhibit 11-4 and for locally owned bridges in Exhibit 11-5.

Exhibit 11-3

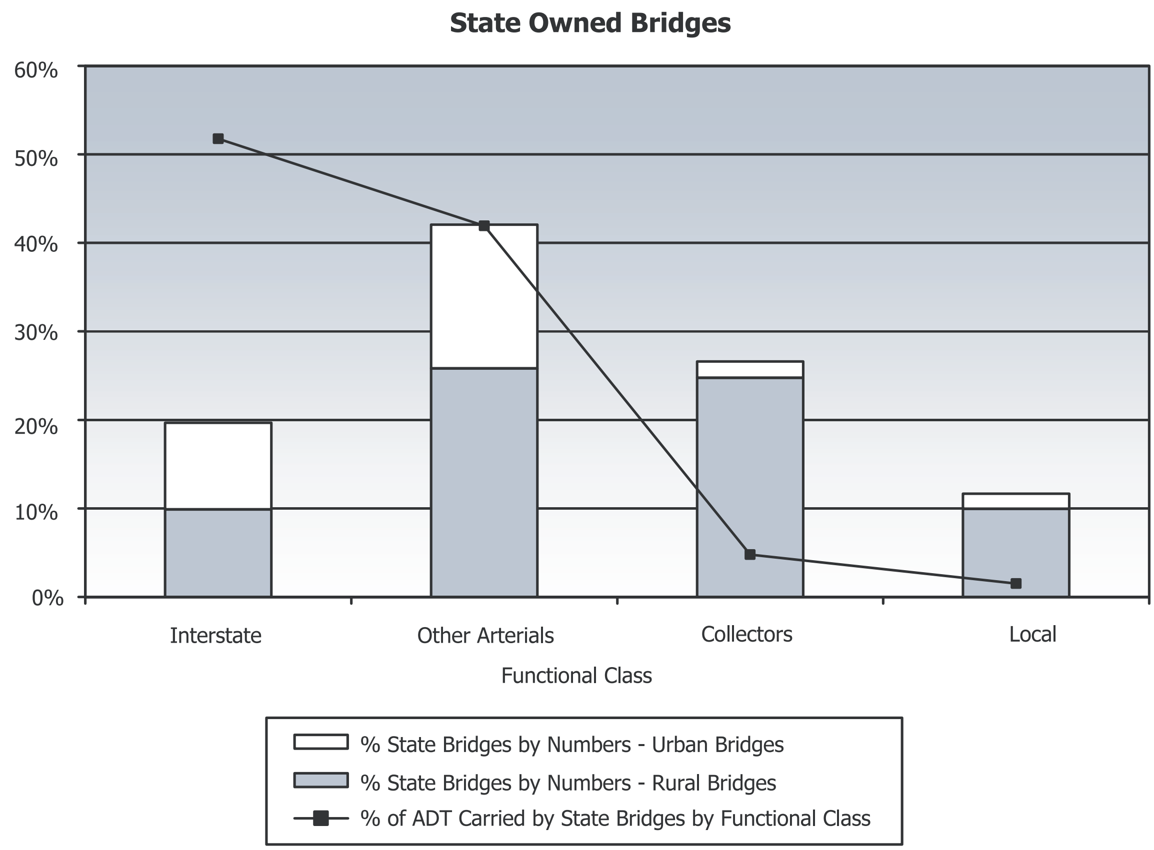


Source: National Bridge Inventory.

Bridges in the inventory are, on average, approximately 40 years old, with an average year of construction of 1963 for rural and urban structures. (See Exhibit 11-6.) The year of construction distribution and the cumulative number of structures and ADT are shown in Exhibit 11-7.

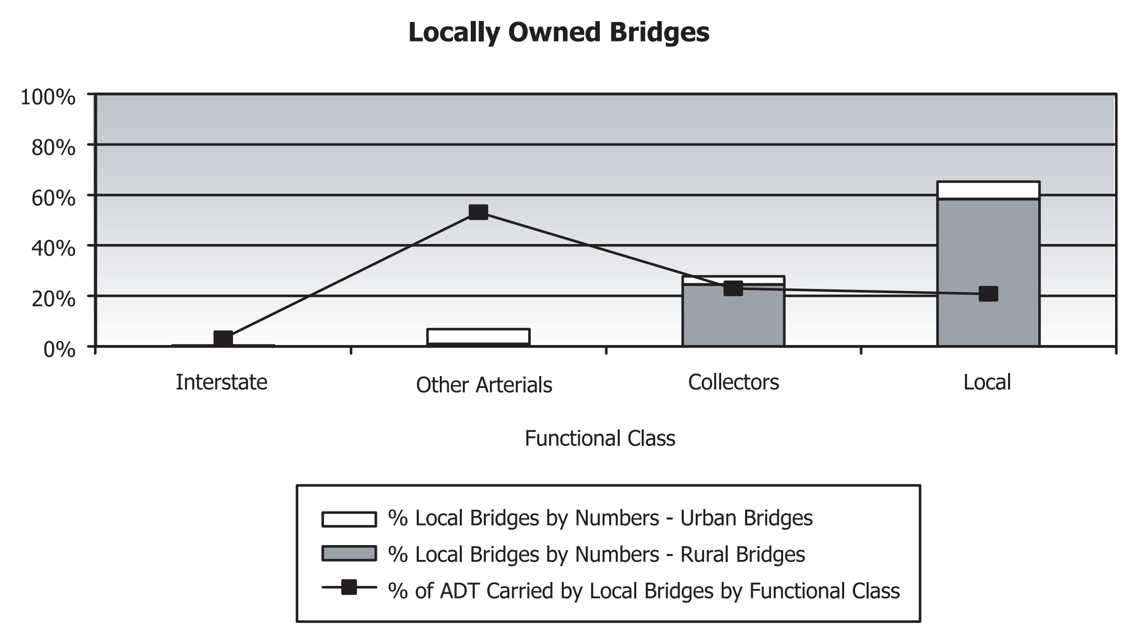
Urban structures are slightly younger than rural structures. The average age of structures does not significantly vary by ownership with the exception of private owners. The private bridge population, which includes those owned by railroads and other private owners, are on average more than 50 years old. Exhibit 11-7 shows the year of construction distribution and the cumulative percentage of bridges and ADT carried. Decreased bridge construction occurred during World War II. Following this period, there was a large increase in the number of bridges constructed. This is generally attributed to the Interstate construction "boom". The chart indicates a large increase in daily traffic on new structures. A large percentage of this traffic nevertheless utilizes older structures on a daily basis, with 50 percent of all the daily traffic in the United States using bridges that are more than 40 years old.

Exhibit 11-4



Source: National Bridge Inventory.

Exhibit 11-5



Source: National Bridge Inventory.

Exhibit 11-6

Average Year of Construction by Functional Classification and Ownership - All Structures

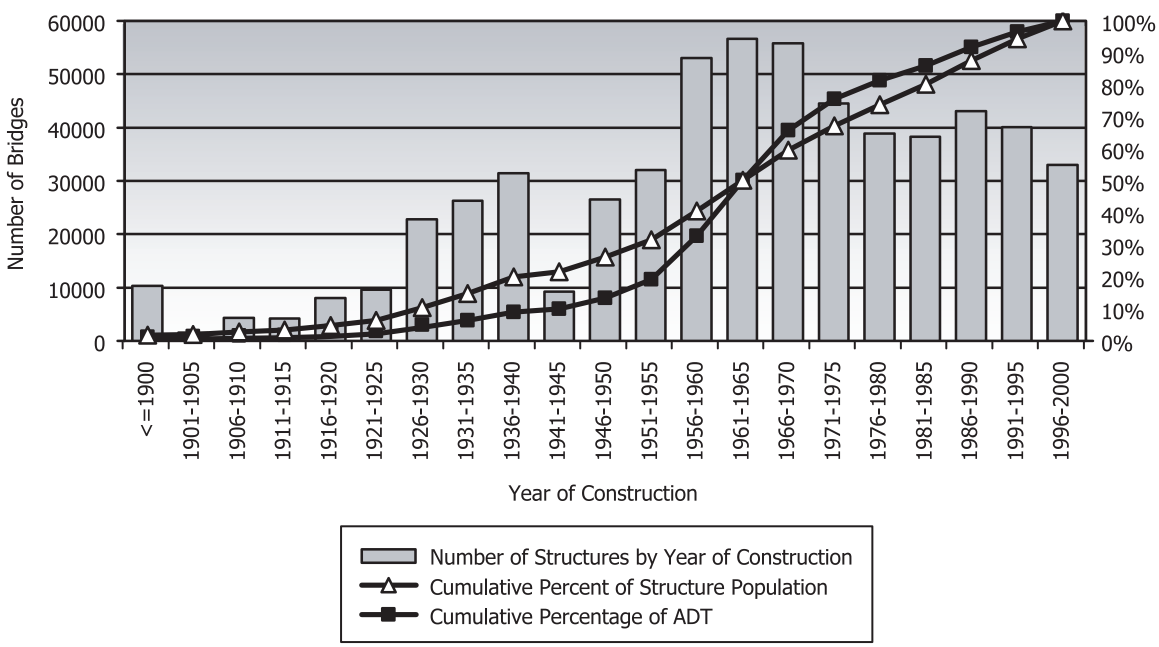
FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
Rural Bridges										
Interstate	1963	(6)	1967	(10)	1959	(34)	1964	(16)	1967	(10)
Other Arterials	1965	(20)	1961	(22)	1970	(28)	1955	(20)	1961	(23)
Collectors	1963	(18)	1960	(21)	1963	(23)	1946	(27)	1962	(22)
Local	1965	(19)	1965	(22)	1962	(28)	1941	(31)	1963	(27)
All Rural	**1965**	**(19)**	**1962**	**(21)**	**1962**	**(26)**	**1945**	**(29)**	**1962**	**(24)**
Urban Bridges										
Interstate	1967	(8)	1970	(12)	1963	(15)	1965	(14)	1970	(12)
Other Arterials	1959	(25)	1966	(20)	1963	(25)	1952	(27)	1965	(22)
Collectors	1956	(14)	1965	(22)	1964	(25)	1952	(32)	1964	(24)
Local	1957	(22)	1969	(20)	1965	(25)	1949	(33)	1965	(25)
All Urban	**1958**	**(22)**	**1968**	**(18)**	**1964**	**(25)**	**1955**	**(28)**	**1966**	**(21)**
All Structures	**1965**	**(19)**	**1964**	**(20)**	**1963**	**(26)**	**1951**	**(29)**	**1963**	**(23)**

Source: National Bridge Inventory.

Additional information on the composition of the bridge inventory is presented in the last portion of this chapter.

Exhibit 11-7

Year of Construction and Cumulative ADT - All Structures



Source: National Bridge Inventory.

Deficiencies:

In Chapter 3, an overview of the condition and performance of bridges was presented. The following information was included in that chapter:

- Bridge component condition rating distributions showing the number of bridges by the ratings for the deck, superstructure, and substructure.
- Percentage of deficiencies, in terms of the number of bridges, and the trend of deficiencies using the 1994, 1996, 1998, and 2000 NBI data.
- Numbers and percent structurally deficient and functionally obsolete by owner (Federal, State, local, private, unknown, and all owners).
- Ownership of structurally deficient and functionally obsolete bridges as a percentage of the deficiencies by numbers.
- Rural and urban deficiency trends using the number of deficient bridges from the 1994, 1996, 1998, and 2000 NBI databases.
- Numbers and percent deficiencies, structural and functional, by functional classification and rural/urban status.
- Deficiency trends, in terms of numbers and percentages, for rural and urban Interstates, other arterials, collectors, and local bridges.

Deficiencies in the bridge population occur as the result of structural or functional causes, as previously described. These types of deficiencies are not mutually exclusive and a bridge may be both structurally deficient and functionally obsolete. In general, when deficiency percentages are presented, however, the structures are indicated as structurally deficient, functionally obsolete, or non-deficient. As structural deficiencies may imply safety problems they are considered more critical and thus a bridge that is both structurally deficient and functionally obsolete is only identified as structurally deficient. A portion of the structurally deficient population will also have functional issues that must be addressed. Bridges that are indicated as functionally obsolete do not have structural deficiencies.

Overall, there are 167,566 deficient structures within the highway bridge network representing 28.6 percent of the total inventory of highway bridges. There are 90 million square meters of deck area on deficient bridges carrying over 1 billion vehicles daily. The number of deficient bridges by owner and functional classification are shown in Exhibit 11-8 by rural and urban designations. Percentages shown in this exhibit are the percentages of all structures for the owner/functional class combination, (i.e. - 16 percent of rural Interstate bridges owned by State agencies are deficient). In general, urban bridges have higher deficiency percentages than rural bridges. This is particularly evident when examining the Interstate and arterial structures. There are a significant number of deficient local bridges. Exhibit 11-8 shows the deficiency percentages, in general, are usually lower for the higher functional classification (Interstates and principal arterials). There are higher percentages of deficiencies for bridges on local roads, regardless of the owner.

The percentages of bridges with structural deficiencies, functionally obsolete conditions, and non-deficient designations are indicated in Exhibit 11-9. In general, the total percentage of deficiencies is approximately the same when the percentages are determined by numbers, traffic carried, and deck area; however, when traffic carried and deck area are considered, the impact of functional obsolescence becomes more pronounced.

Percent deficiencies for each functional classification are shown in Exhibit 11-10, including deficiencies with bridges weighted equally (by numbers), bridges weighted by the traffic carried (by ADT) and bridges weighted by the deck area. The data in this exhibit shows that there are no major differences between the

Exhibit 11-8

Number and Percent of Deficient Bridges by Ownership and Functional Class

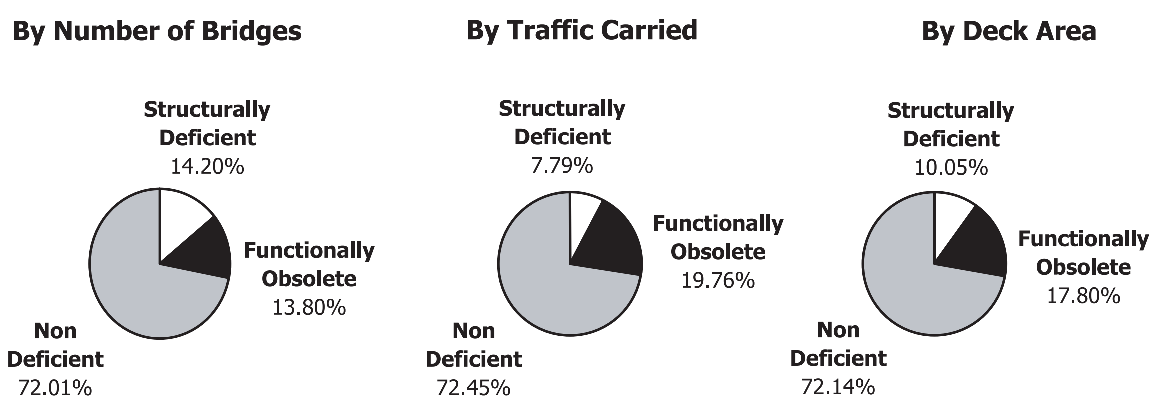
FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		TOTAL	
Rural Bridges										
Interstate	1	3%	4,380	16%	6	43%	6	14%	4,393	16%
Other Arterials	134	24%	12,881	18%	559	22%	56	38%	13,630	18%
Collectors	366	28%	17,337	25%	16,909	23%	128	51%	34,740	24%
Local	1,441	21%	8,691	32%	61,988	35%	418	65%	72,538	35%
Subtotal Rural	**1,942**	**22%**	**43,289**	**22%**	**79,462**	**32%**	**608**	**56%**	**125,301**	**28%**
Urban Bridges										
Interstate	1	100%	7,270	27%	173	47%	58	16%	7,502	27%
Other Arterials	19	38%	14,039	32%	6,343	36%	242	51%	20,643	33%
Collectors	11	50%	2,098	42%	3,363	35%	93	64%	5,565	37%
Local	62	56%	1,905	41%	5,896	29%	214	58%	8,077	31%
Subtotal Urban	**93**	**51%**	**25,373**	**31%**	**15,741**	**33%**	**607**	**45%**	**41,814**	**32%**
Rural & Urban										
Interstate	2	6%	11,650	21%	179	47%	64	16%	11,895	22%
Other Arterials	153	25%	26,920	23%	6,902	34%	298	47%	34,273	25%
Collectors	377	28%	19,435	26%	20,272	24%	221	56%	40,305	25%
Local	1,503	22%	10,596	33%	67,884	35%	632	62%	80,615	34%
All	**2,035**	**23%**	**68,662**	**25%**	**95,203**	**32%**	**1,215**	**50%**	**167,115**	**28%**

NUMBER AND PERCENTAGE OF DEFICIENT STRUCTURES

Source: National Bridge Inventory.

Exhibit 11-9

Percent Deficient - All Bridges



Source: National Bridge Inventory.

deficiency percentages whether these are based on the total number of bridges, ADT, or area. In general, there are few functionally obsolete bridges, in terms of percentages, in the rural bridge population.

Deficiencies are higher for urban bridges, which in general have a larger percentage of functionally obsolete bridges.

Exhibit 11-10

Percent Deficient Bridges by Numbers, ADT and Deck Area by Rural and Urban Designation and Functional Class

FUNCTIONAL CLASSIFICATION	BY NUMBERS Structurally Deficient	BY NUMBERS Functionally Obsolete	BY NUMBERS Total Deficient	BY ADT Structurally Deficient	BY ADT Functionally Obsolete	BY ADT Total Deficient	BY DECK AREA Structurally Deficient	BY DECK AREA Functionally Obsolete	BY DECK AREA Total Obsolete
Rural Bridges									
Interstate	3.89%	12.08%	15.97%	4.36%	11.57%	15.93%	4.50%	10.52%	15.02%
Other Arterials	7.31%	10.98%	18.30%	7.09%	13.05%	20.13%	8.00%	11.93%	19.93%
Collectors	13.22%	11.04%	24.26%	11.37%	18.61%	29.99%	11.74%	10.94%	22.68%
Local	22.88%	11.66%	34.55%	12.17%	25.97%	38.14%	16.00%	13.00%	28.99%
All Rural	**16.15%**	**11.38%**	**27.53%**	**7.14%**	**14.31%**	**21.45%**	**10.17%**	**11.63%**	**21.81%**
Urban Bridges									
Interstate	6.50%	20.51%	27.00%	7.28%	19.93%	27.21%	8.89%	22.66%	31.55%
Other Arterials	9.59%	23.45%	33.04%	9.66%	23.81%	33.47%	11.35%	22.91%	34.26%
Collectors	12.76%	24.74%	37.49%	11.73%	29.27%	41.00%	13.42%	26.52%	39.94%
Local	13.05%	18.53%	31.58%	9.20%	29.98%	39.18%	10.92%	25.35%	36.26%
All Urban	**9.97%**	**22.01%**	**31.98%**	**8.53%**	**22.27%**	**30.80%**	**10.52%**	**23.18%**	**33.69%**
All Bridges									
Interstate	5.20%	16.32%	21.52%	6.64%	18.08%	24.72%	7.56%	18.98%	26.53%
Other Arterials	8.35%	16.68%	25.03%	9.04%	21.22%	30.26%	10.10%	18.80%	28.90%
Collectors	13.18%	12.33%	25.51%	11.49%	22.17%	33.66%	12.02%	13.53%	25.55%
Local	21.81%	12.41%	34.22%	10.46%	28.28%	38.74%	14.69%	16.17%	30.86%
All Bridges	**14.77%**	**13.76%**	**28.53%**	**8.16%**	**20.12%**	**28.28%**	**10.35%**	**17.61%**	**27.97%**

Source: National Bridge Inventory.

Actions Taken to Remove Deficiencies:

Over $55 billion in HBRRP funding alone has been allocated and utilized to ensure safety and continuing functionality of the bridge network. Actions are taken on deficient bridges to mitigate the cause of the deficiency. The types of work performed were examined using summary information produced by the Federal Highway Administration. The 1998 summary of bridge construction and bridge rehabilitation activity with Federal fund participation through shows:

- 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.

In 1990, 17 percent of activity with federal fund participation involved new bridge construction. This percentage has decreased from 1990 to 1998. Currently, approximately 90 percent of all projects receiving Federal fund participation involve reconstruction or rehabilitation.

Exhibit 11-11 tabulates the number of deficient bridges reconstructed, as indicated in the NBI database. The information is presented by owner, functional classification, and rural/urban designation. The average number of years after construction before reconstruction was undertaken is also indicated. On average, Interstate bridges are reconstructed approximately 20 years after they are placed in service. The time to reconstruction is longer for other functional classifications. In general, urban bridges are reconstructed earlier, in terms of their age, than rural bridges. Progress has been made in reducing the deficiencies. Approximately 85,000 structures (15 percent of the inventory) have been reconstructed or rehabilitated. Reconstruction and rehabilitation efforts have contributed to the reduction in deficiencies shown and discussed in Chapter 3.

Exhibit 11-11

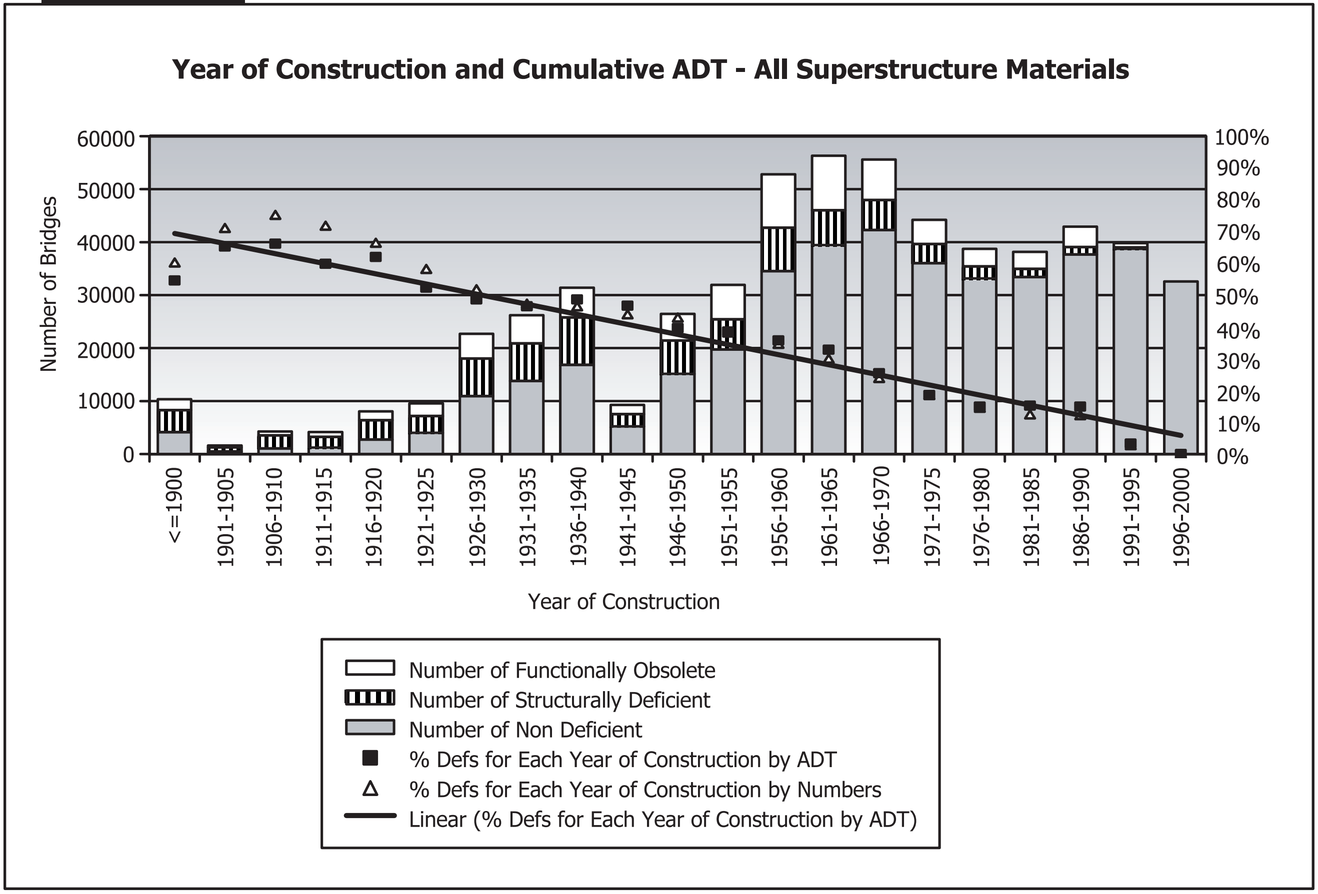
Number of Bridges Reconstructed or Rehabilitated and Average of Years Before the Action was Undertaken

FUNCTIONAL CLASS	NUMBER REHABILITATED BY OWNER (AND AVERAGE YEAR OF REHABILITATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Rural Bridges										
Interstate	1	(25)	6,155	(20)	2	(49)	1	(5)	6,159	(20)
Other Arterials	66	(32)	15,488	(31)	323	(35)	29	(38)	15,906	(32)
Collectors	66	(36)	8,121	(28)	7,302	(41)	34	(25)	15,523	(34)
Local	1,649	(19)	2,246	(32)	18,834	(42)	70	(52)	22,799	(39)
All Rural	**1,782**		**32,010**		**26,461**		**134**		**60,387**	
Urban Bridges										
Interstate	1	(23)	6,648	(23)	57	(21)	46	(22)	6,752	(23)
Other Arterials	11	(41)	9,021	(29)	3,376	(35)	113	(25)	12,521	(31)
Collectors	5	(15)	752	(32)	1,307	(35)	24	(43)	2,088	(35)
Local	47	(29)	460	(26)	2,108	(35)	58	(26)	2,673	(33)
All Urban	**64**		**16,881**		**6,848**		**241**		**24,034**	
All Bridges										
Interstate	2	(24)	12,803	(22)	59	(22)	47	(22)	12,911	(22)
Other Arterials	77	(33)	24,509	(31)	3,699	(35)	142	(28)	28,427	(31)
Collectors	71	(34)	8,873	(29)	8,609	(40)	58	(33)	17,611	(34)
Local	1,696	(19)	2,706	(31)	20,942	(41)	128	(40)	25,472	(38)
All Bridges	**1,846**		**48,891**		**33,309**		**375**		**84,421**	

Source: National Bridge Inventory.

When a structure is placed in service, the deterioration process begins on the components of the bridge. The rate of deterioration was examined by the percentage of deficiencies by year of construction. (See Exhibit 11-12.) As bridges age, increasing numbers of structures become deficient and increasing funds are required to remove the deficiency. 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, a closer look at transportation system preservation strategies including preventative maintenance and improved bridge inspection and management techniques is warranted.

Exhibit 11-12



Source: National Bridge Inventory.

Specific Bridge Types

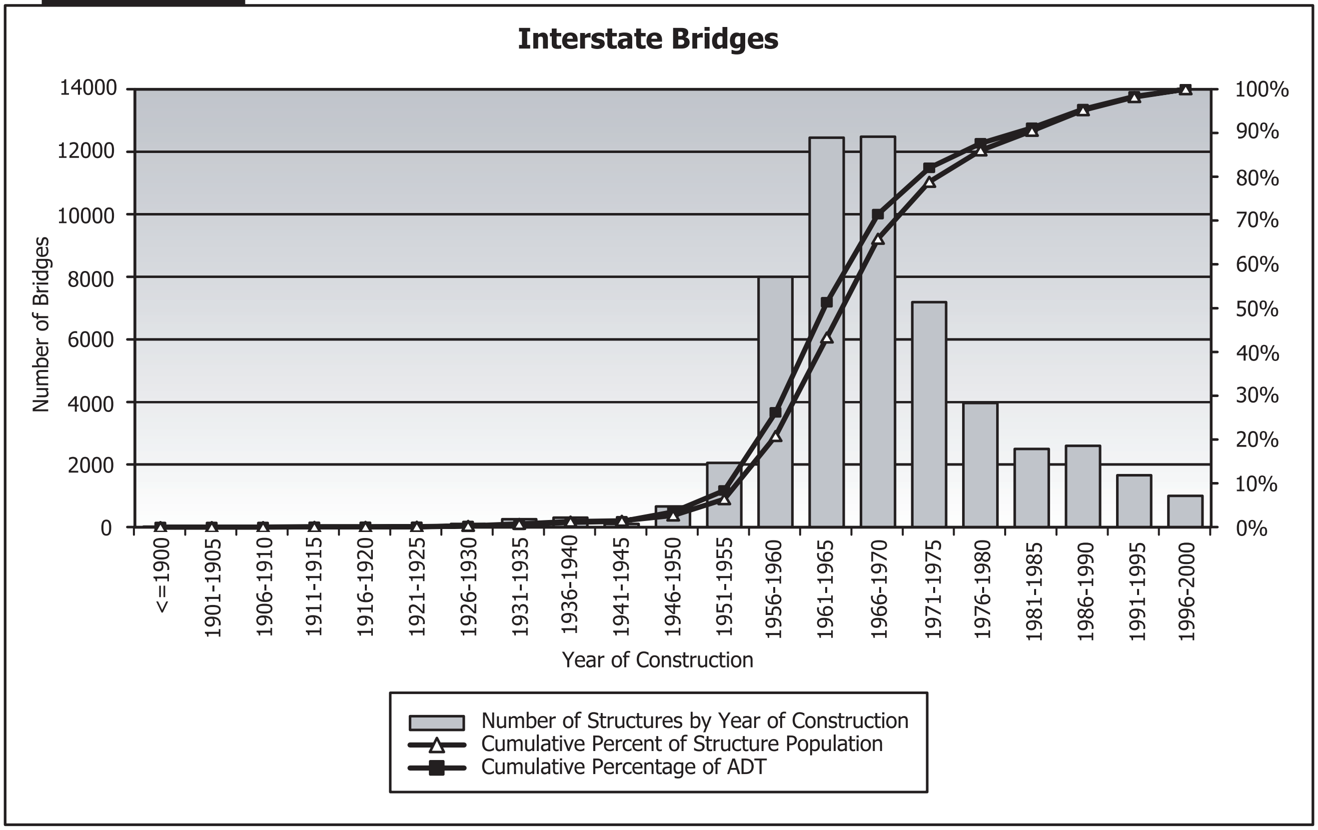
The following areas are addressed in this section of the chapter:

- Additional detail on Interstates, other arterials, collectors and local bridges.
- Characterization of the superstructure material types used in the bridge network.
- Examination of the age distribution, deficiency percentages, and deficiency trends for each superstructure material (concrete, steel, prestressed concrete, timber, and other).

Year of Construction by Functional Classification

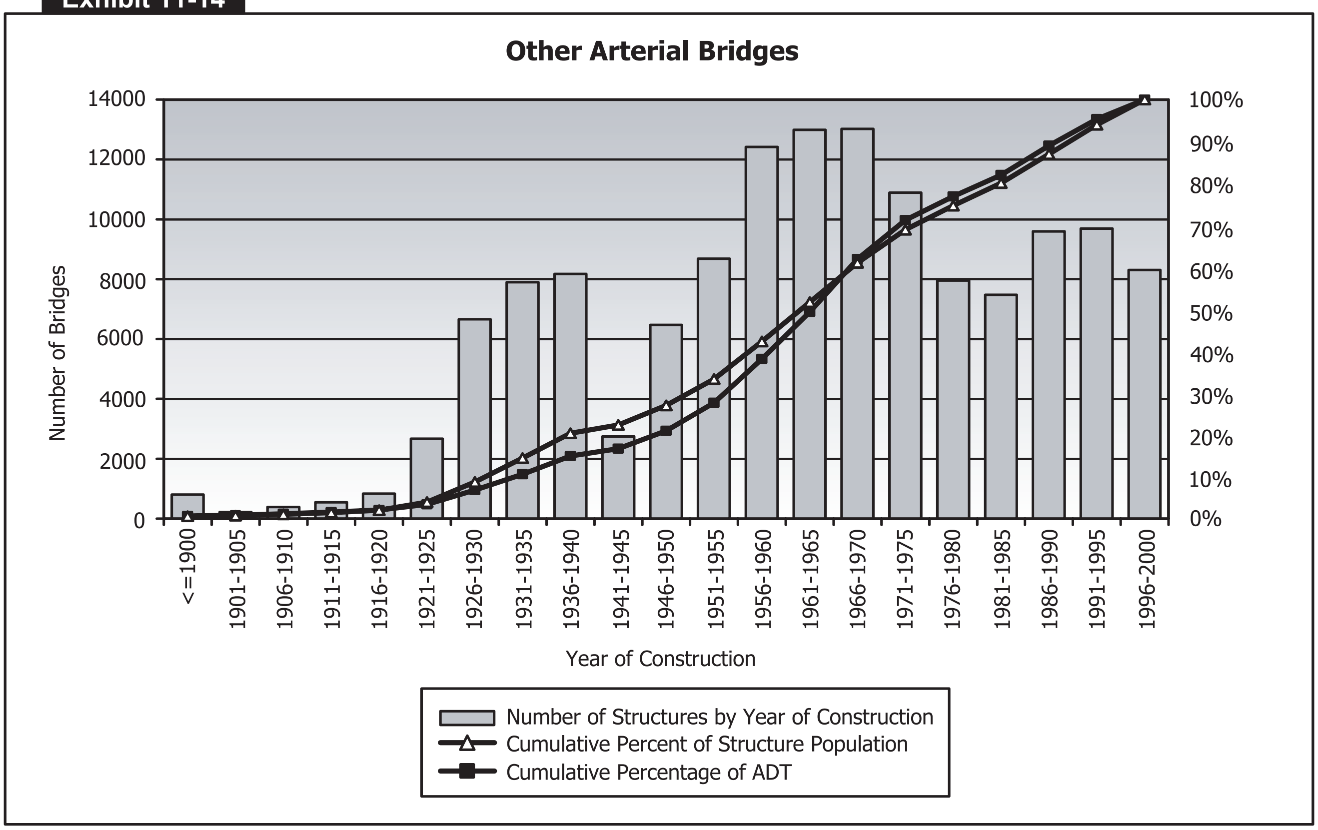
The year of construction distribution was presented for all structures in the National Bridge Inventory. Distributions were created for Interstates (see Exhibit 11-13), other arterials (see Exhibit 11-14), collectors (see Exhibit 11-15), and local (see Exhibit 11-16) bridges. There is a distinct peak in the distribution of Interstate bridges with the average year of construction in the mid 1960's. Other functional classifications have much greater dispersion in the year of construction.

Exhibit 11-13



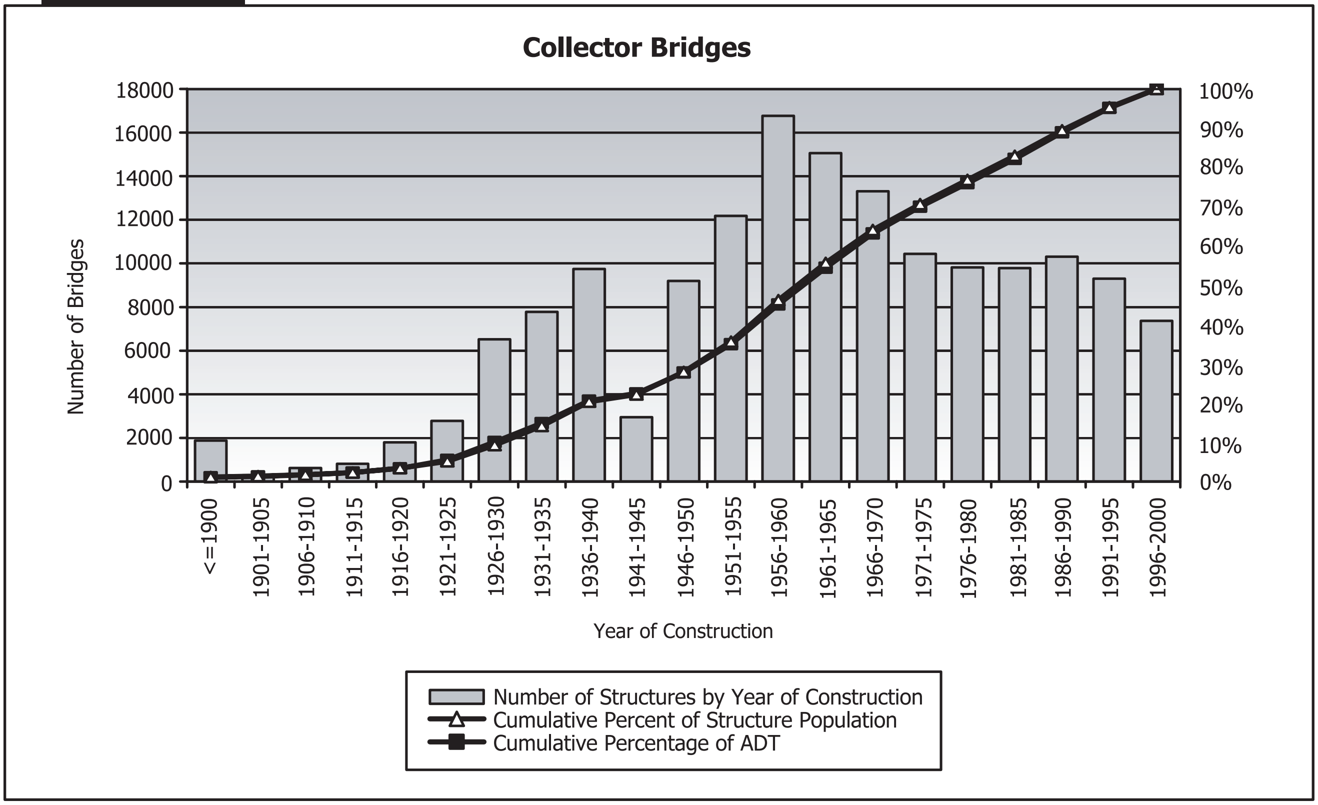
Source: National Bridge Inventory.

Exhibit 11-14



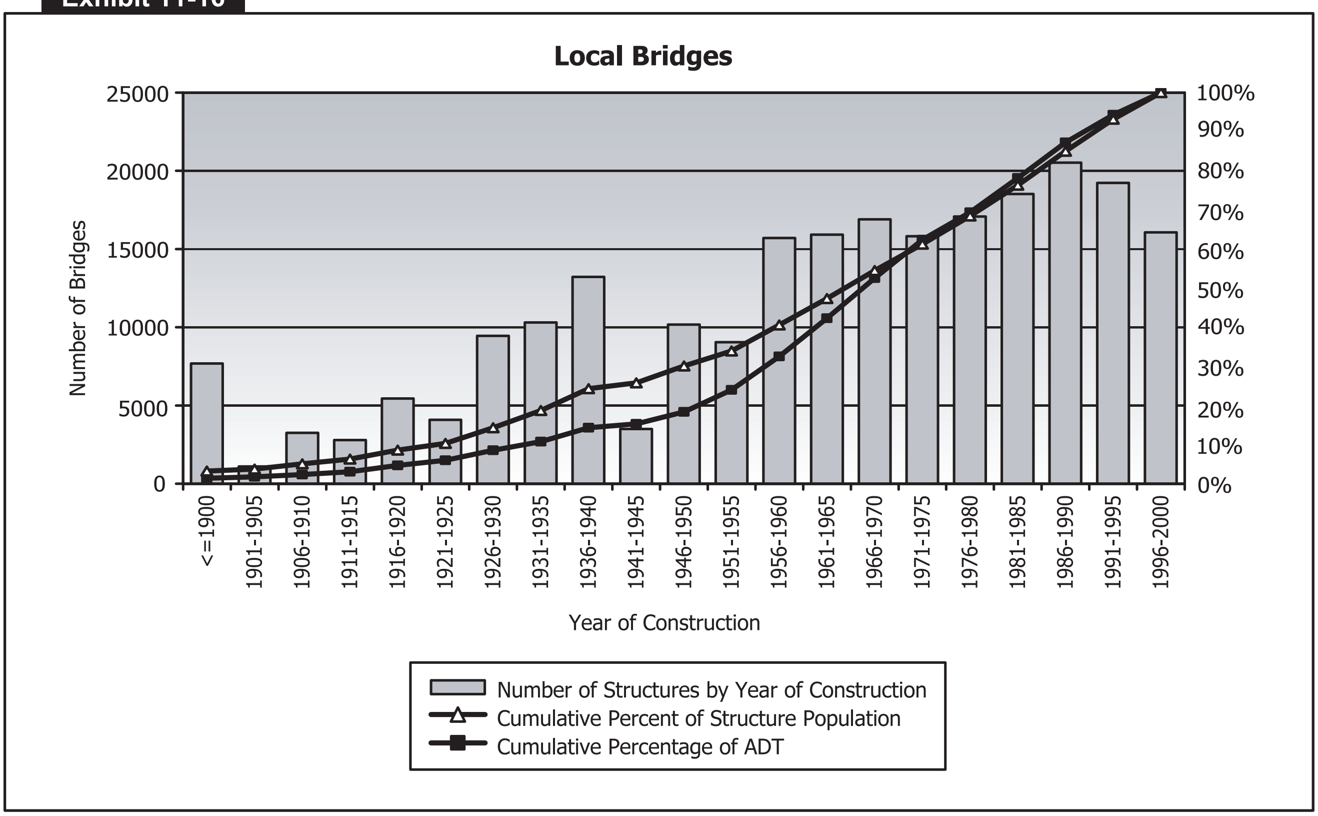
Source: National Bridge Inventory.

Exhibit 11-15



Source: National Bridge Inventory.

Exhibit 11-16

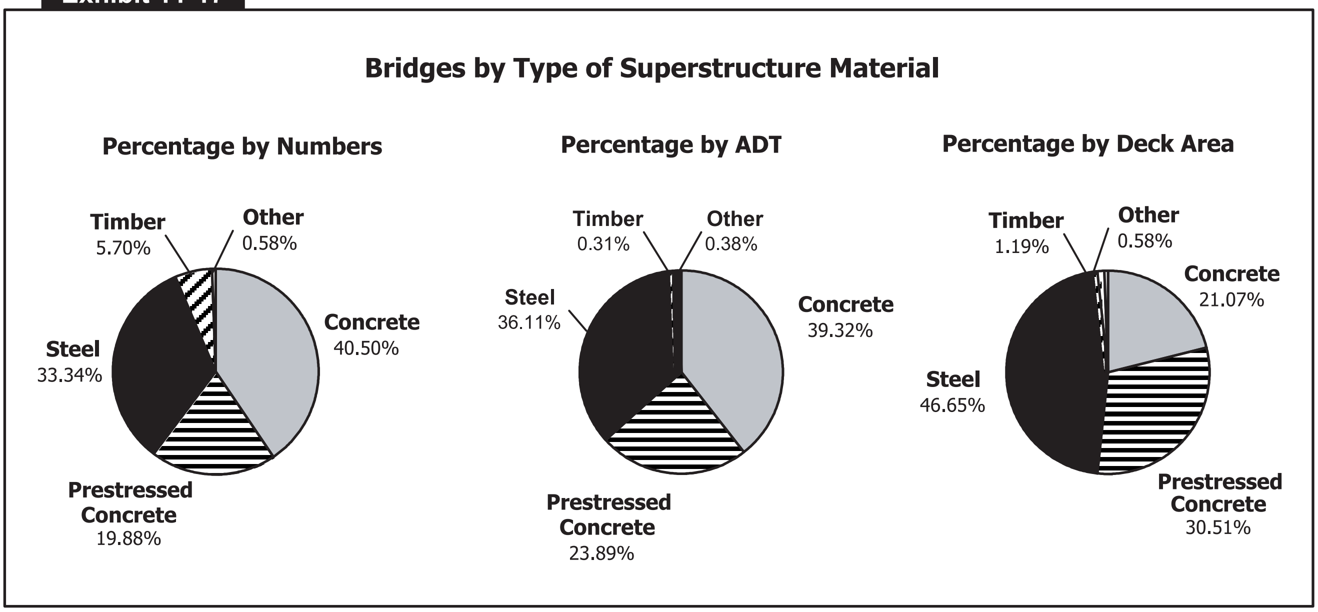


Source: National Bridge Inventory.

Superstructure Material Types

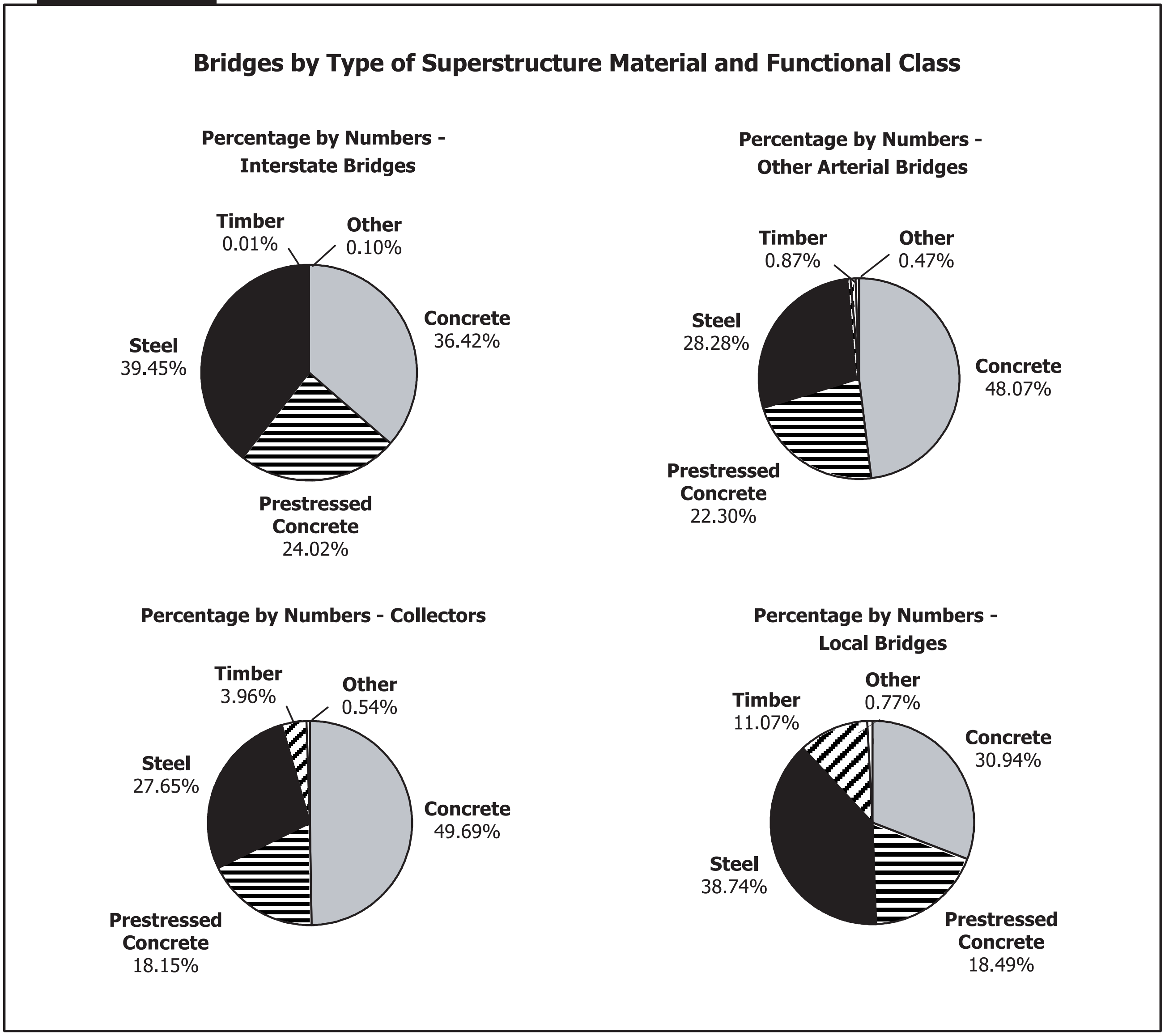
Predominant materials used for bridge superstructures are steel, concrete, prestressed concrete, and timber. Other materials, such as aluminum, iron, and composite materials, are utilized on less than 1 percent of the structures. The percentage of superstructure materials utilized is shown in Exhibit 11-17 weighting bridges equally (by numbers), weighting by the traffic carried (ADT), and weighting by the size of the structure (by deck area). Steel bridges tend to be utilized for longer than average structures carrying higher volumes of traffic than average. Timber bridges, which constitute 5.7 percent of the inventory by numbers, carry small volumes of traffic and are smaller than average in terms of deck area. Material percentages are shown for Interstates, other arterials, collectors and local functional classifications in Exhibit 11-18.

Exhibit 11-17



Source: National Bridge Inventory.

Exhibit 11-18



Source: National Bridge Inventory.

The number and percentage of bridges by superstructure material, owner, and functional classification are shown in Exhibit 11-19. Figures include both rural and urban designations. Exhibit 11-20 shows the percentages of material type used for the varying functional classifications and owners for rural bridges. Exhibit 11-21 shows the same information for urban bridges.

Exhibits 11-20 and 11-21 present the superstructure material percentages for rural and urban designations respectively. Notable differences can be seen in the Interstate bridge population with significantly higher percentages of urban Interstates constructed with steel. Prestressed superstructure bridges also constitute a higher percentage of the inventory in urban environments. Concrete (excluding prestressed concrete) is the dominant material for rural bridges. Timber superstructure bridges are prevalent in rural areas and not common in urban environments.

Exhibit 11-19

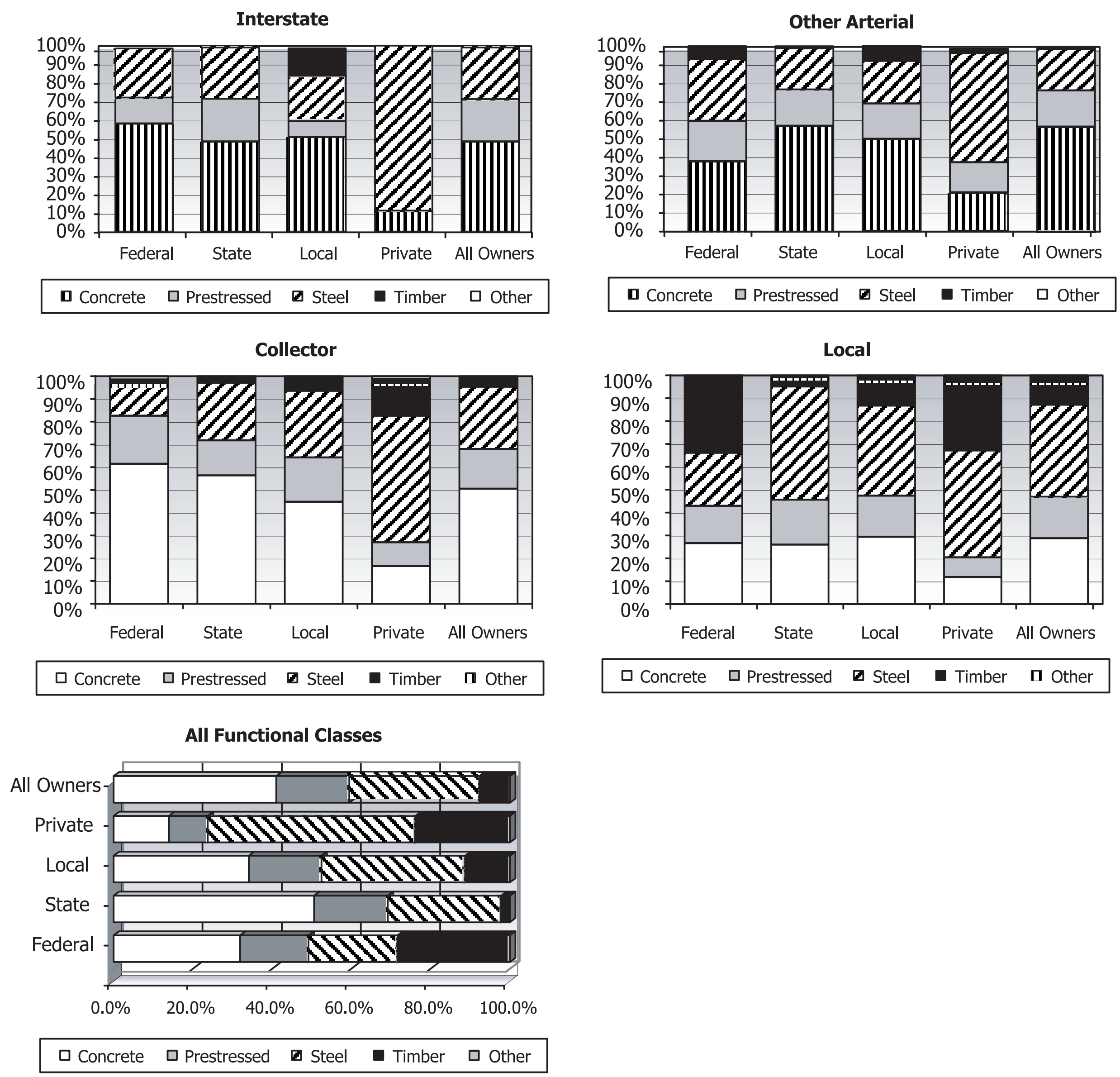
Bridges by Type of Superstructure Material, by Owner and Functional Classification

Functional Class	MATERIAL	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Interstate	Concrete	12	(52%)	20,088	(37%)	58	(20%)	40	(10%)	20,198	(36%)
	Prestressed	3	(13%)	13,288	(24%)	24	(8%)	5	(1%)	13,320	(24%)
	Steel	8	(35%)	21,295	(39%)	211	(71%)	349	(89%)	21,863	(39%)
	Timber	0	(0%)	6	(0%)	2	(1%)	0	(0%)	8	(0%)
	Other	0	(0%)	53	(0%)	1	(0%)	0	(0%)	54	(0%)
Other Arterial	Concrete	216	(37%)	56,326	(48%)	10,088	(49%)	141	(22%)	66,782	(48%)
	Prestressed	126	(22%)	25,980	(22%)	4,725	(23%)	131	(20%)	30,979	(22%)
	Steel	196	(34%)	33,556	(29%)	5,076	(25%)	352	(54%)	39,249	(28%)
	Timber	32	(5%)	825	(1%)	339	(2%)	11	(2%)	1,209	(1%)
	Other	12	(2%)	369	(0%)	264	(1%)	12	(2%)	658	(0%)
Collector	Concrete	759	(61%)	40,496	(55%)	37,686	(45%)	64	(16%)	79,014	(50%)
	Prestressed	263	(21%)	11,739	(16%)	16,735	(20%)	58	(15%)	28,836	(18%)
	Steel	170	(14%)	19,763	(27%)	23,719	(29%)	224	(57%)	43,945	(28%)
	Timber	27	(2%)	1,741	(2%)	4,508	(5%)	44	(11%)	6,324	(4%)
	Other	19	(2%)	319	(0%)	520	(1%)	6	(2%)	867	(1%)
Local	Concrete	1,957	(26%)	8,319	(26%)	62,647	(32%)	179	(18%)	73,199	(31%)
	Prestressed	1,234	(17%)	6,733	(21%)	35,537	(18%)	110	(11%)	43,651	(18%)
	Steel	1,751	(24%)	15,996	(49%)	73,284	(38%)	473	(47%)	91,592	(39%)
	Timber	2,452	(33%)	1,222	(4%)	22,423	(11%)	235	(23%)	26,350	(11%)
	Other	56	(1%)	233	(1%)	1,529	(1%)	9	(1%)	1,829	(1%)
All Urban Bridges	Concrete	2,944	(32%)	125,229	(45%)	110,479	(37%)	424	(17%)	239,193	(41%)
	Prestressed	1,626	(17%)	57,740	(21%)	57,021	(19%)	304	(12%)	116,786	(20%)
	Steel	2,125	(23%)	90,610	(33%)	102,290	(34%)	1,398	(57%)	196,649	(33%)
	Timber	2,511	(27%)	3,794	(1%)	27,272	(9%)	290	(12%)	33,891	(6%)
	Other	87	(1%)	974	(0%)	2,314	(1%)	27	(1%)	3,408	(1%)

Source: National Bridge Inventory.

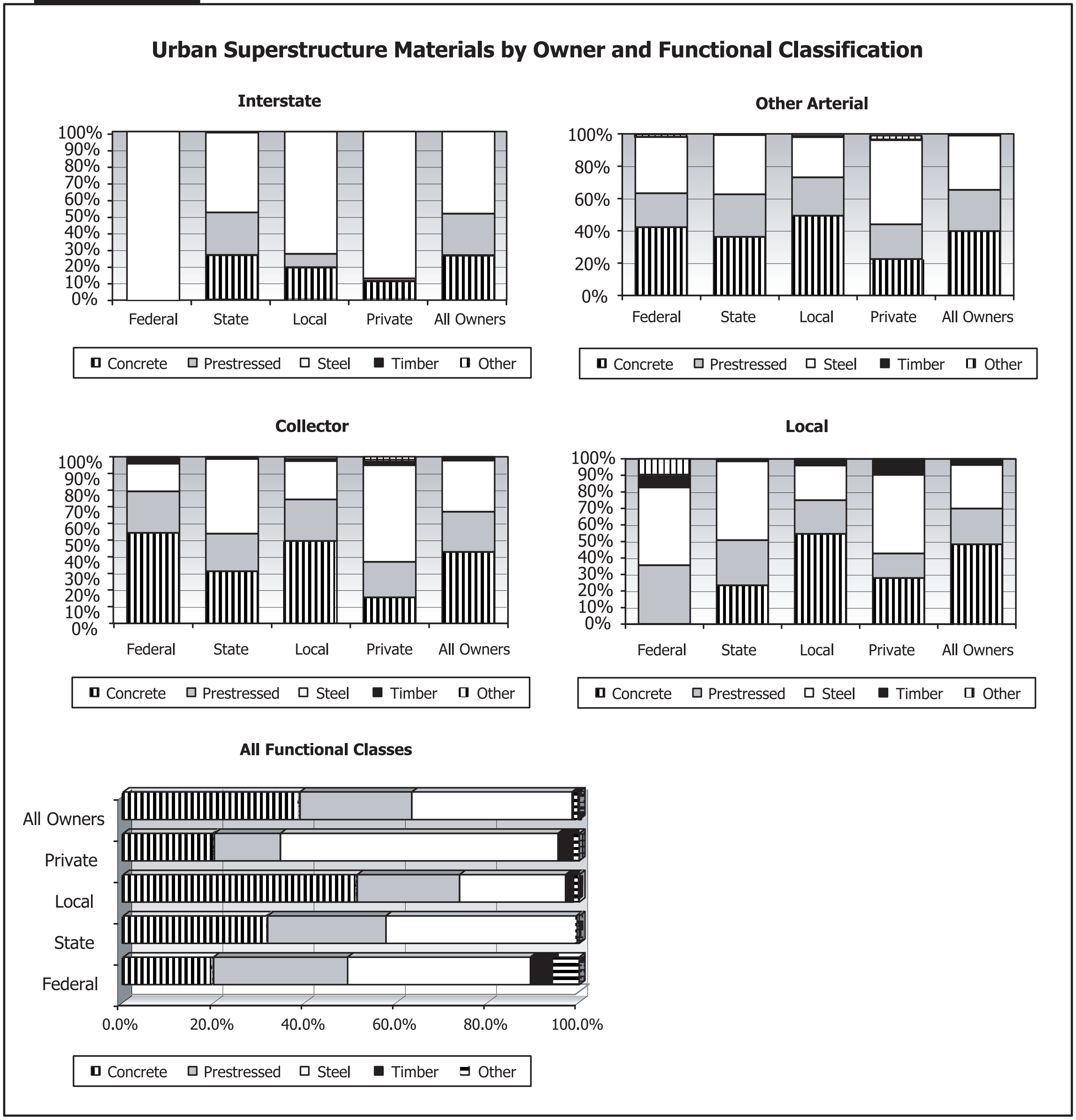
Exhibit 11-20

Rural Superstructure Materials by Owner and Functional Classification



Source: National Bridge Inventory.

Exhibit 11-21



Source: National Bridge Inventory.

Concrete Superstructure Bridges (Excluding Prestressed Concrete)

The average age of concrete bridges in the NBI is approximately 40 years with an average year of construction of 1961. The average age of bridges for each combination of ownership and functional classification may be determined in Exhibit 11-22. The year of construction distribution and cumulative ADT are shown in Exhibit 11-23 for all concrete superstructure bridges (exclusive of prestressed concrete). Deficiencies and deficiency trends are shown in Exhibits 11-24 and 11-25 respectively for reinforced concrete superstructure bridges.

Exhibit 11-22

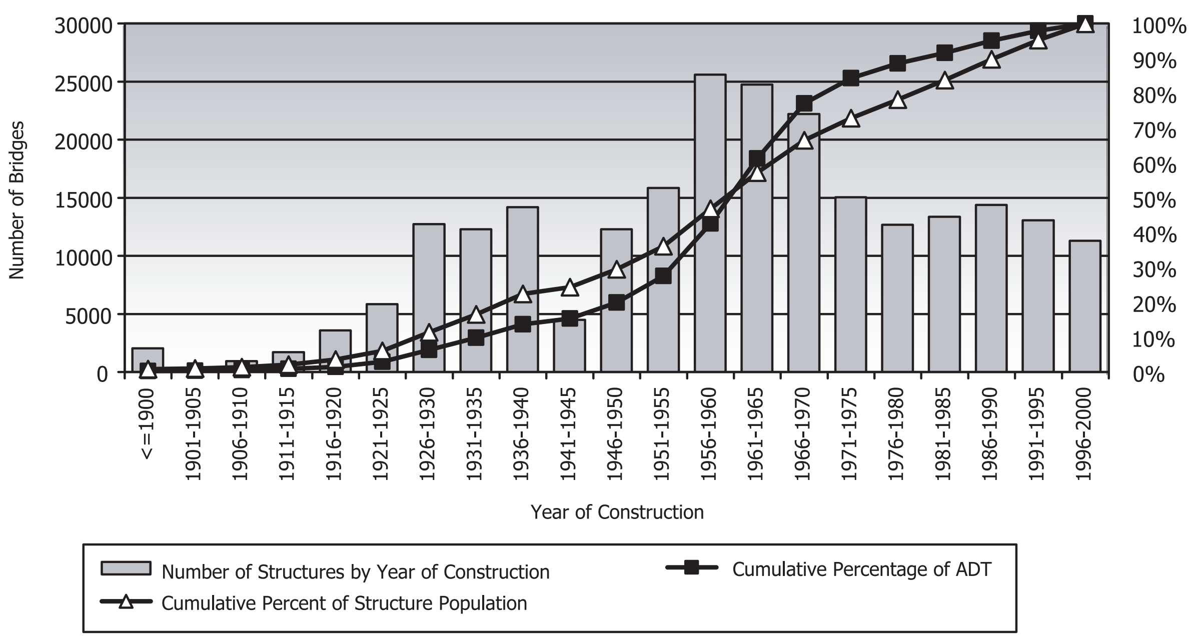
Average Year of Construction and Standard Deviation for Concrete Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
Rural Bridges										
Interstate	1964	(2)	1965	(10)	1943	(38)	1954	(9)	1965	(10)
Other Arterials	1958	(22)	1955	(21)	1971	(26)	1955	(23)	1956	(22)
Collectors	1959	(17)	1957	(20)	1962	(22)	1941	(28)	1959	(21)
Local	1960	(18)	1960	(22)	1965	(26)	1950	(36)	1964	(26)
All Rural	**1960**	**(18)**	**1958**	**(20)**	**1964**	**(25)**	**1949**	**(32)**	**1961**	**(22)**
Urban Bridges										
Interstate			1966	(10)	1968	(20)	1967	(18)	1966	(10)
Other Arterials	1962	(18)	1959	(20)	1962	(23)	1943	(24)	1960	(21)
Collectors	1950	(11)	1958	(22)	1964	(25)	1935	(25)	1962	(24)
Local	1952	(19)	1964	(21)	1965	(24)	1949	(36)	1965	(24)
All Urban	**1954**	**(18)**	**1961**	**(18)**	**1964**	**(24)**	**1948**	**(30)**	**1962**	**(21)**
All Structures	**1959**	**(18)**	**1958**	**(20)**	**1964**	**(25)**	**1948**	**(30)**	**1961**	**(22)**

Source: National Bridge Inventory.

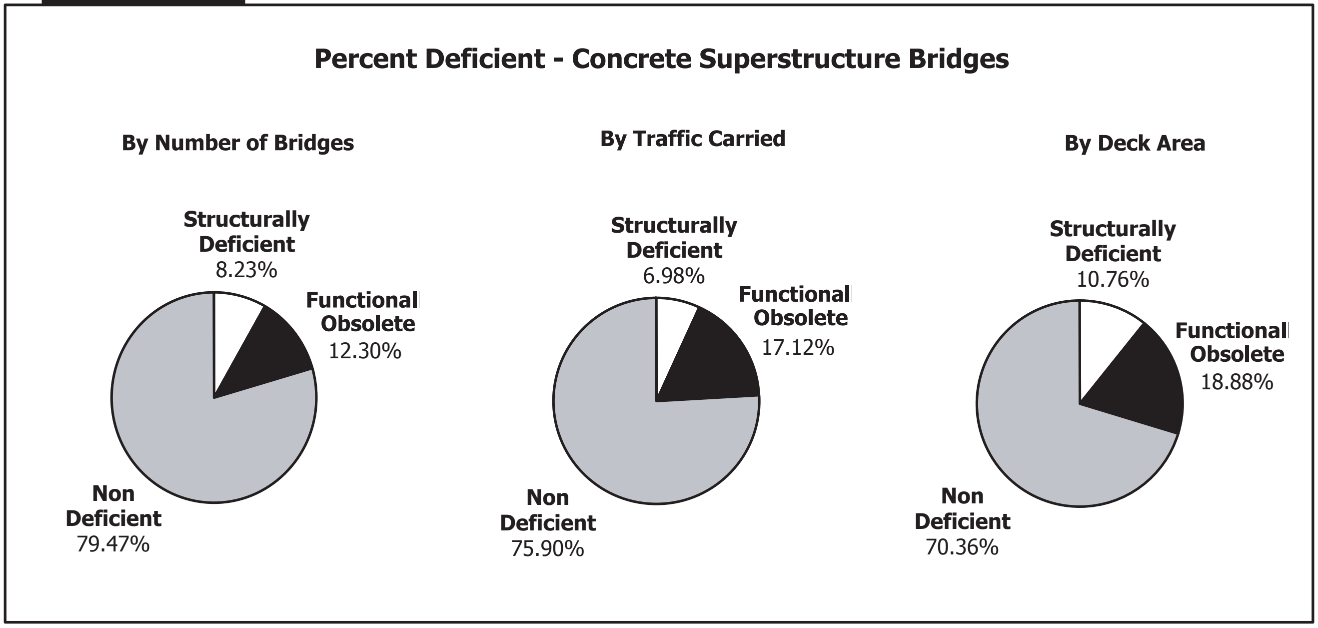
Exhibit 11-23

Year of Construction and Cumulative ADT - Concrete Superstructure Bridges (excluding prestressed concrete superstructures)



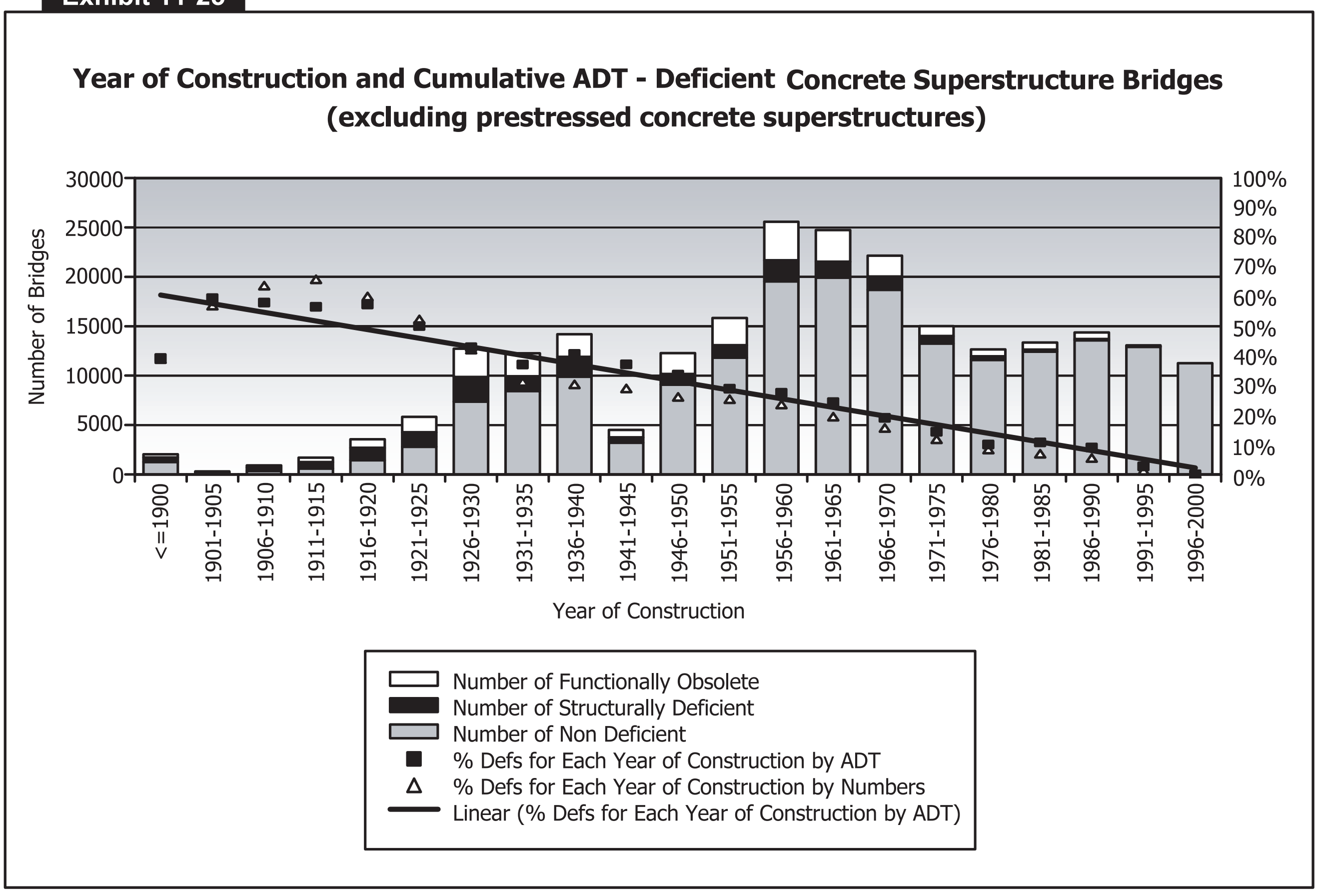
Source: National Bridge Inventory.

Exhibit 11-24



Source: National Bridge Inventory.

Exhibit 11-25



Source: National Bridge Inventory.

Steel Superstructure Bridges

The average age of steel bridges in the NBI is approximately 44 years with an average year of construction of 1958. The average age of bridges for all combinations of functional classification and ownership may be determined through examination of Exhibit 11-26. The year of construction distribution and cumulative ADT for all steel superstructure bridges are shown in Exhibit 11-27. Deficiencies and deficiency trends are shown in Exhibits 11-28 and 11-29 respectively for steel superstructure bridges.

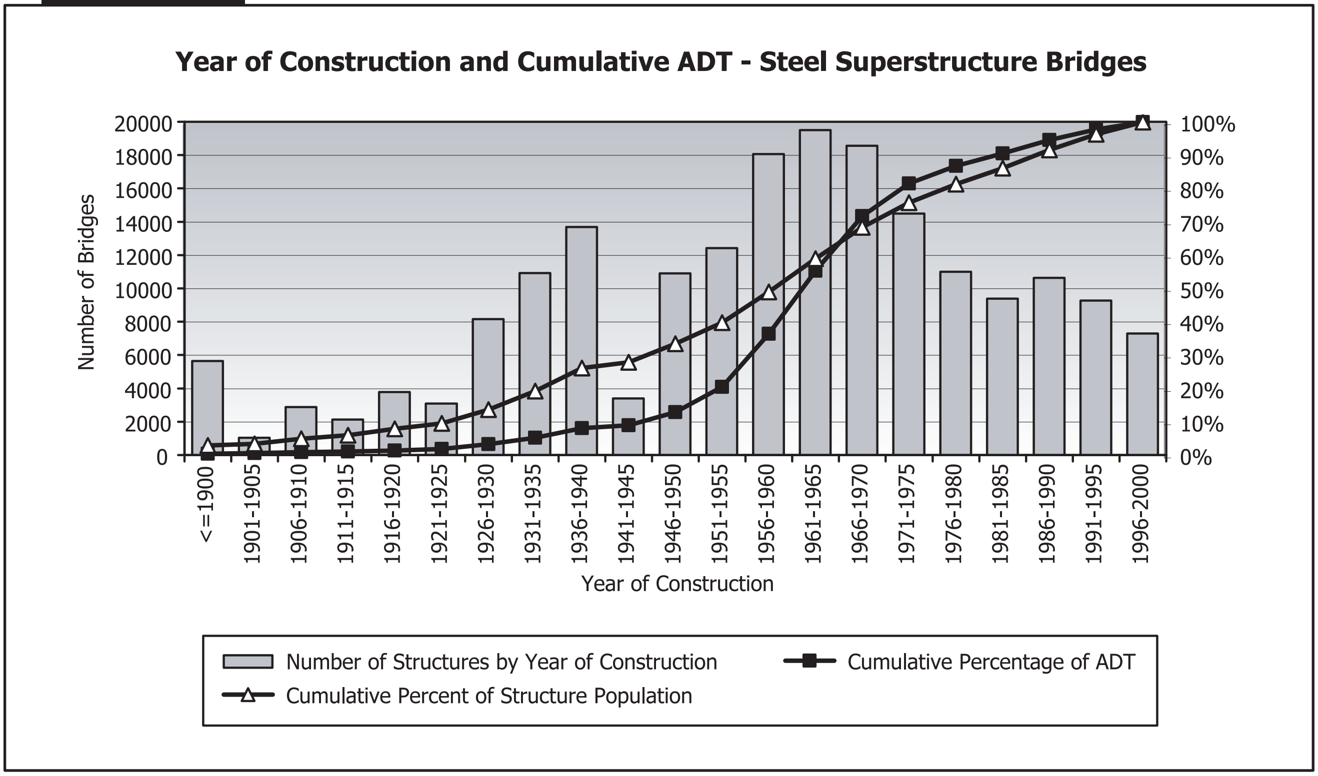
Exhibit 11-26

Average Year of Construction and Standard Deviation for Steel Bridges by Functional Classification and Owner

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
Rural Bridges										
Interstate	1960	(10)	1967	(10)	1967	(28)	1965	(16)	1967	(10)
Other Arterials	1965	(19)	1960	(20)	1961	(29)	1951	(18)	1960	(20)
Collectors	1963	(20)	1958	(20)	1956	(23)	1945	(24)	1957	(22)
Local	1964	(21)	1963	(21)	1953	(29)	1936	(28)	1955	(28)
All Rural	**1964**	**(21)**	**1961**	**(19)**	**1954**	**(28)**	**1942**	**(26)**	**1957**	**(25)**
Urban Bridges										
Interstate	1967	(8)	1969	(11)	1959	(10)	1965	(13)	1969	(11)
Other Arterials	1947	(31)	1965	(18)	1956	(25)	1947	(23)	1963	(21)
Collectors	1955	(14)	1965	(19)	1955	(25)	1949	(30)	1959	(23)
Local	1955	(20)	1967	(19)	1955	(27)	1944	(33)	1958	(25)
All Urban	**1953**	**(23)**	**1967**	**(16)**	**1955**	**(26)**	**1953**	**(25)**	**1964**	**(20)**
All Structures	**1963**	**(21)**	**1963**	**(18)**	**1954**	**(27)**	**1949**	**(26)**	**1958**	**(24)**

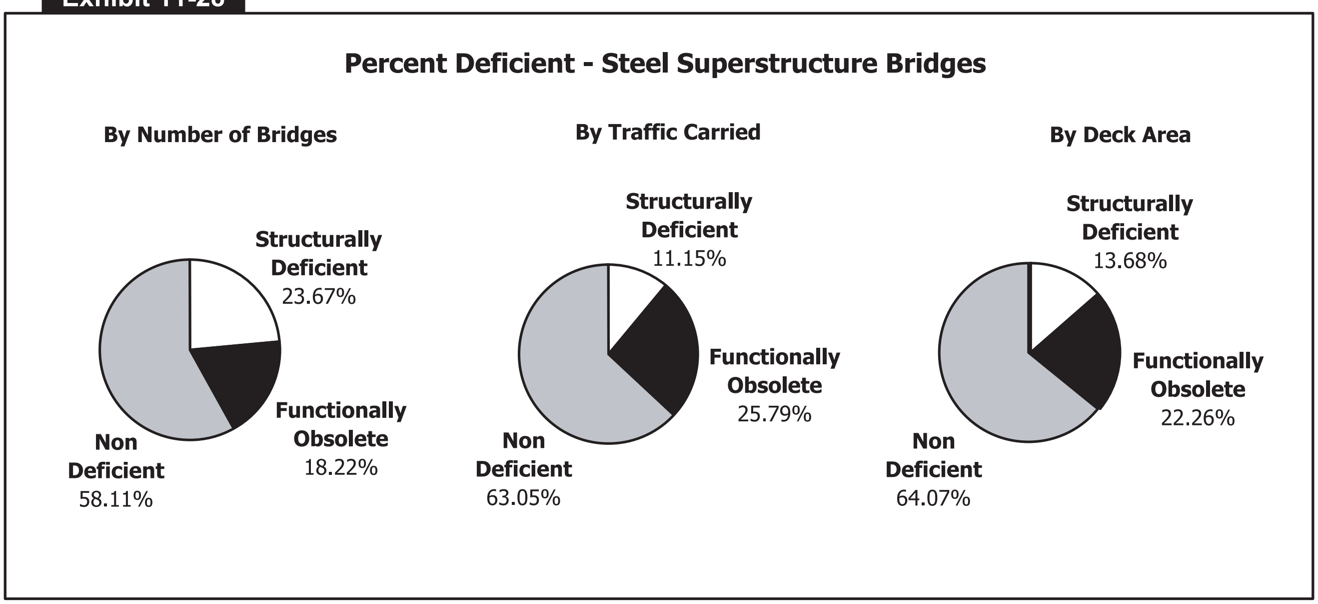
Source: National Bridge Inventory.

Exhibit 11-27



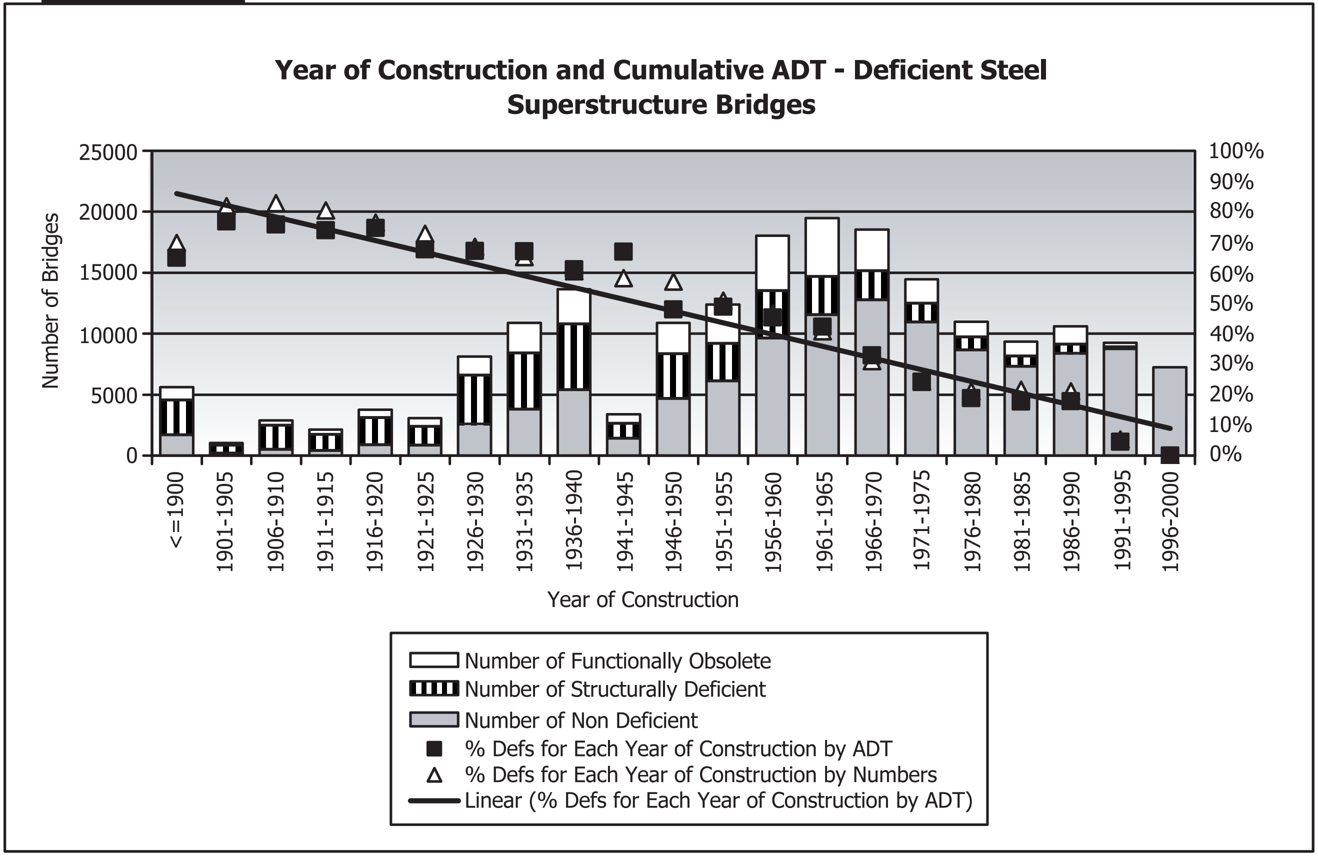
Source: National Bridge Inventory.

Exhibit 11-28



Source: National Bridge Inventory.

Exhibit 11-29



Source: National Bridge Inventory.

Prestressed Concrete

Prestressed concrete was introduced in the middle of the 20th Century, and today the majority of bridges are constructed using prestressed concrete designs. The average age of prestressed concrete bridges in the NBI is approximately 24 years with an average year of construction of 1978. There are no significant differences in the age of rural versus urban prestressed bridges. The average age of bridges for all combinations of functional classification and ownership is shown in Exhibit 11-30. The year of construction distribution and cumulative ADT are shown in Exhibit 11-31 for all prestressed concrete superstructure bridges. Deficiencies and deficiency trends are shown in Exhibits 11-32 and 11-33 respectively for concrete superstructure bridges.

Exhibit 11-30

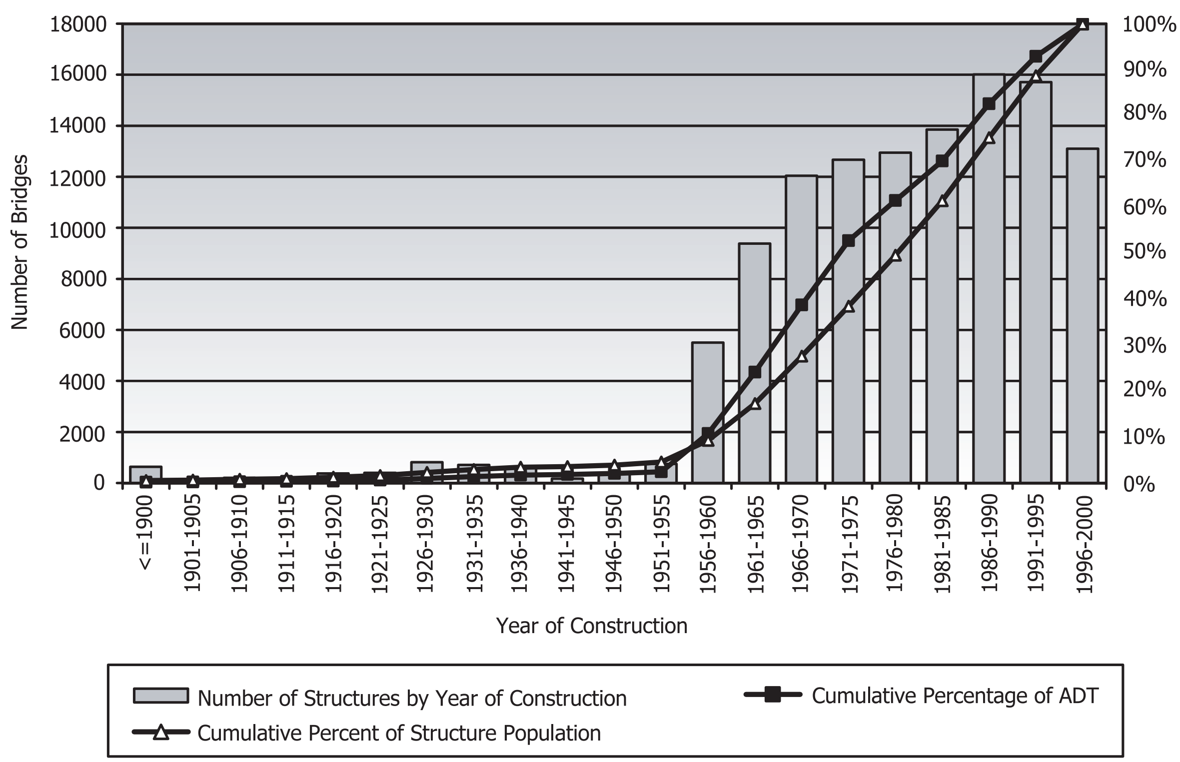
Average Year of Construction and Standard Deviation for Concrete Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
Rural Bridges										
Interstate	1968	(5)	1973	(10)	1996				1973	(10)
Other Arterials	1978	(12)	1980	(16)	1981	(17)	1972	(11)	1980	(16)
Collectors	1977	(11)	1978	(16)	1978	(17)	1982	(19)	1978	(16)
Local	1977	(13)	1979	(15)	1980	(17)	1981	(20)	1980	(17)
All Rural	**1977**	**(13)**	**1978**	**(15)**	**1980**	**(17)**	**1979**	**(18)**	**1979**	**(16)**
Urban Bridges										
Interstate			1975	(12)	1993	(6)	1973	(14)	1975	(12)
Other Arterials	1977	(11)	1979	(15)	1977	(18)	1979	(20)	1978	(16)
Collectors	1971	(13)	1975	(20)	1976	(19)	1982	(22)	1975	(20)
Local	1974	(19)	1978	(14)	1976	(19)	1975	(19)	1977	(18)
All Urban	**1975**	**(17)**	**1977**	**(14)**	**1976**	**(19)**	**1978**	**(20)**	**1977**	**(16)**
All Structures	**1977**	**(13)**	**1978**	**(15)**	**1979**	**(17)**	**1978**	**(19)**	**1978**	**(16)**

Source: National Bridge Inventory.

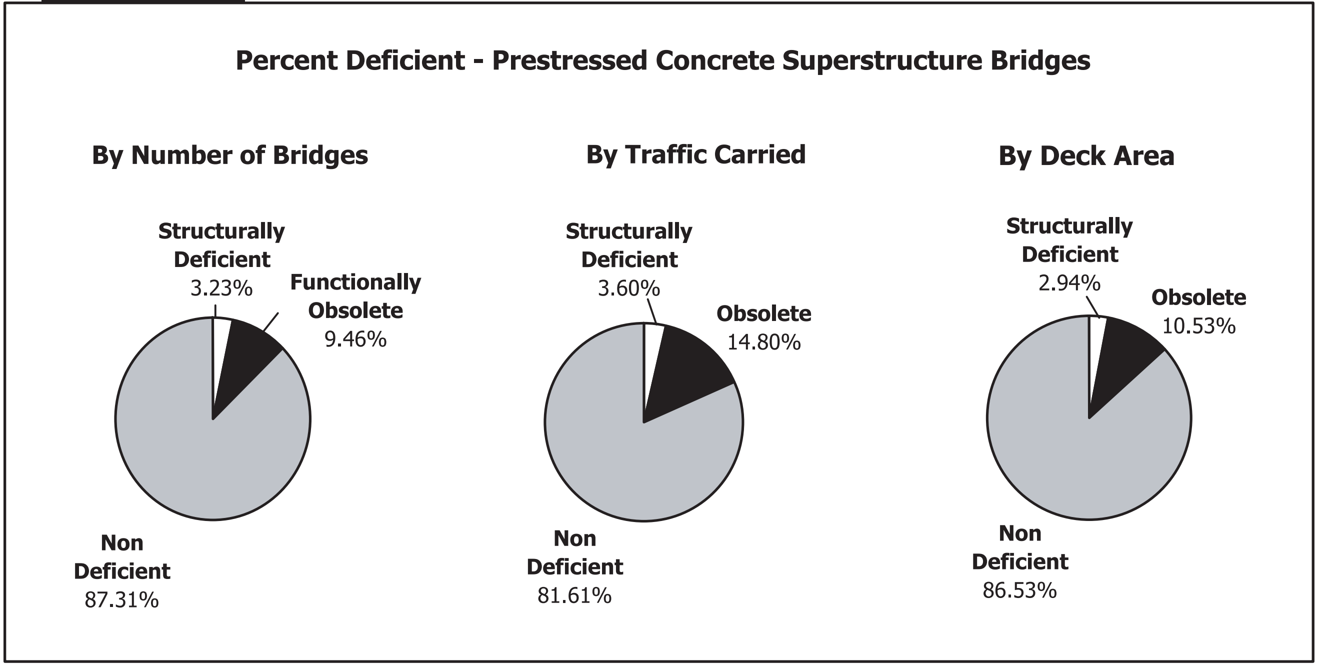
Exhibit 11-31

Year of Construction and Cumulative ADT - Prestressed Concrete Superstructure Bridges



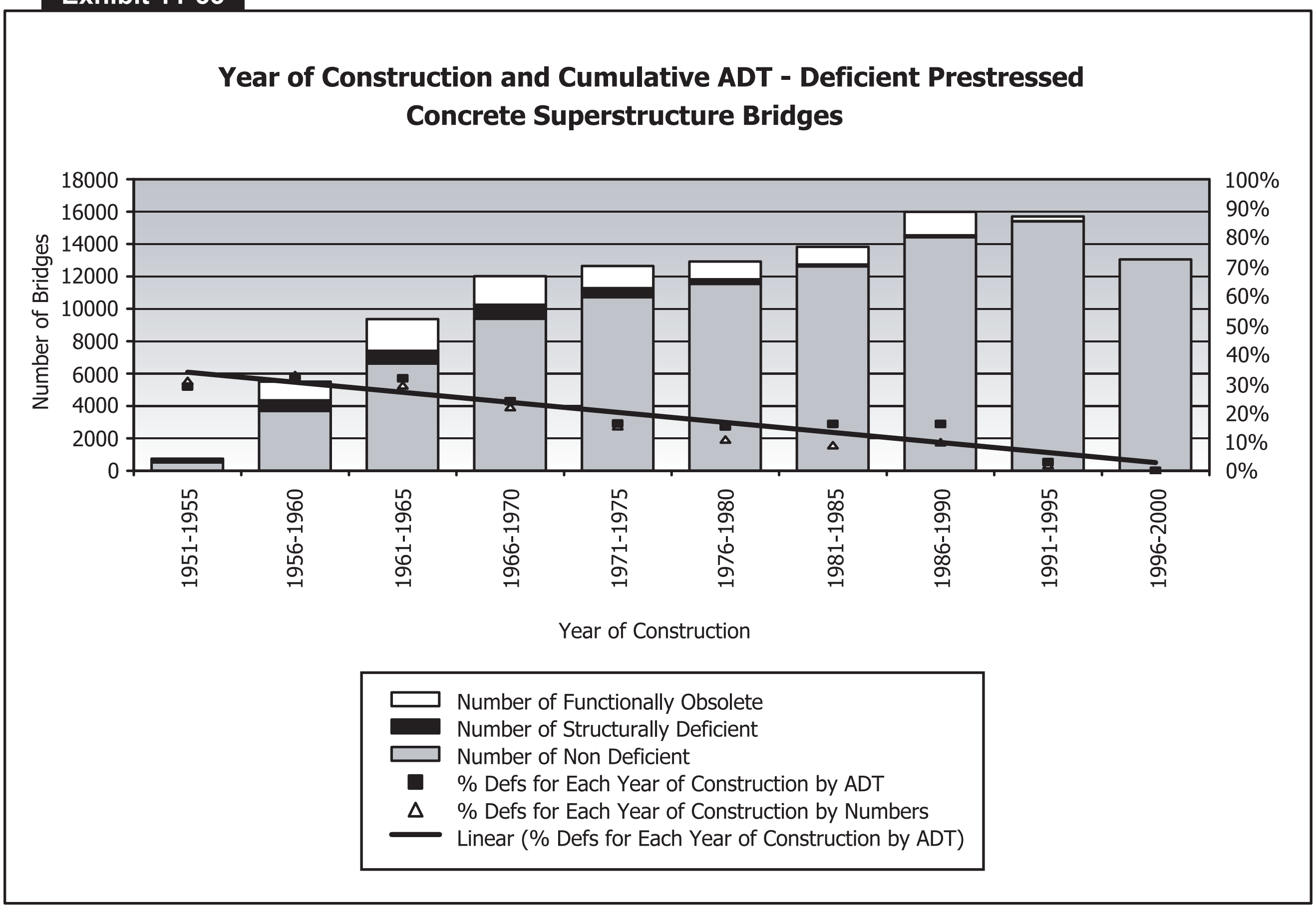
Source: National Bridge Inventory.

Exhibit 11-32



Source: National Bridge Inventory.

Exhibit 11-33



Source: National Bridge Inventory.

Timber Bridges

Timber bridges, as described previously, are primarily used in rural environments for small spans carrying small volumes of traffic. The average age of timber bridges in the NBI is 43 years with an average year of construction of 1959. There is no significant difference between the ages of the rural and the urban timber bridge populations. The average age of timber bridges for all combinations of functional classification and ownership is presented in Exhibit 11-34. The year of construction distribution and cumulative ADT are shown in Exhibit 11-35 for all timber superstructure bridges. Deficiencies and deficiency trends are shown in Exhibits 11-36 and 11-37 respectively for timber superstructure bridges.

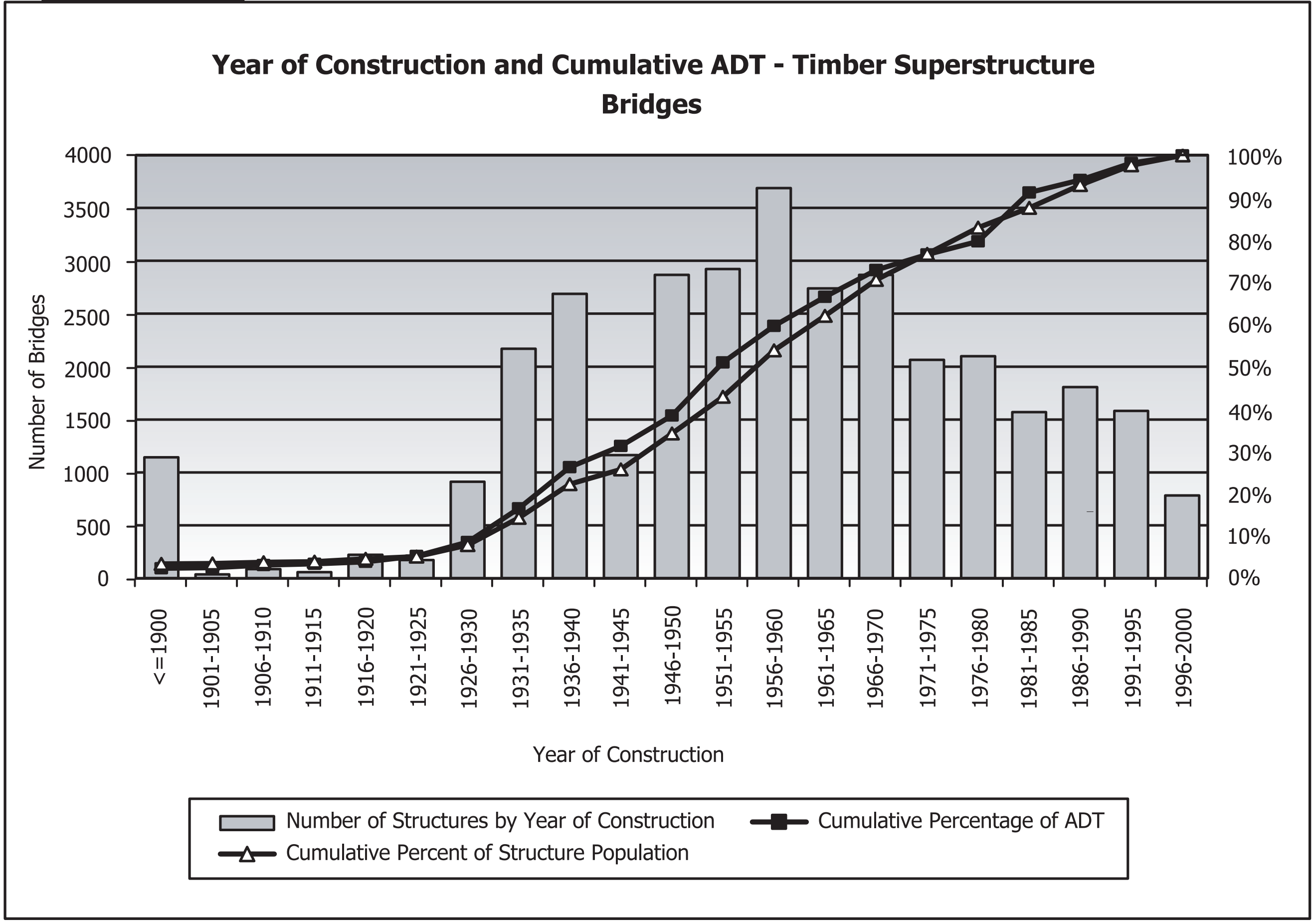
Exhibit 11-34

Average Year of Construction and Standard Deviation for Timber Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)								
	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS
Rural Bridges									
Interstate			1960	(20)	1974	(18)			1963
Other Arterials	1956	(14)	1943	(12)	1970	(30)	1956	(33)	1949
Collectors	1955	(16)	1953	(15)	1958	(21)	1933	(21)	1956
Local	1964	(18)	1960	(22)	1959	(23)	1937	(25)	1959
All Rural	**1964**	**(18)**	**1953**	**(18)**	**1959**	**(23)**	**1936**	**(25)**	**1959**
Urban Bridges									
Interstate									
Other Arterials			1946	(22)	1956	(24)	1927	(15)	1951
Collectors	1951		1937	(34)	1959	(30)	1919	(24)	1953
Local	1955	(19)	1951	(29)	1965	(24)	1931	(22)	1962
All Urban	**1954**	**(18)**	**1945**	**(28)**	**1963**	**(25)**	**1929**	**(21)**	**1959**
All Structures	**1964**	**(18)**	**1953**	**(19)**	**1959**	**(23)**	**1935**	**(24)**	**1959**

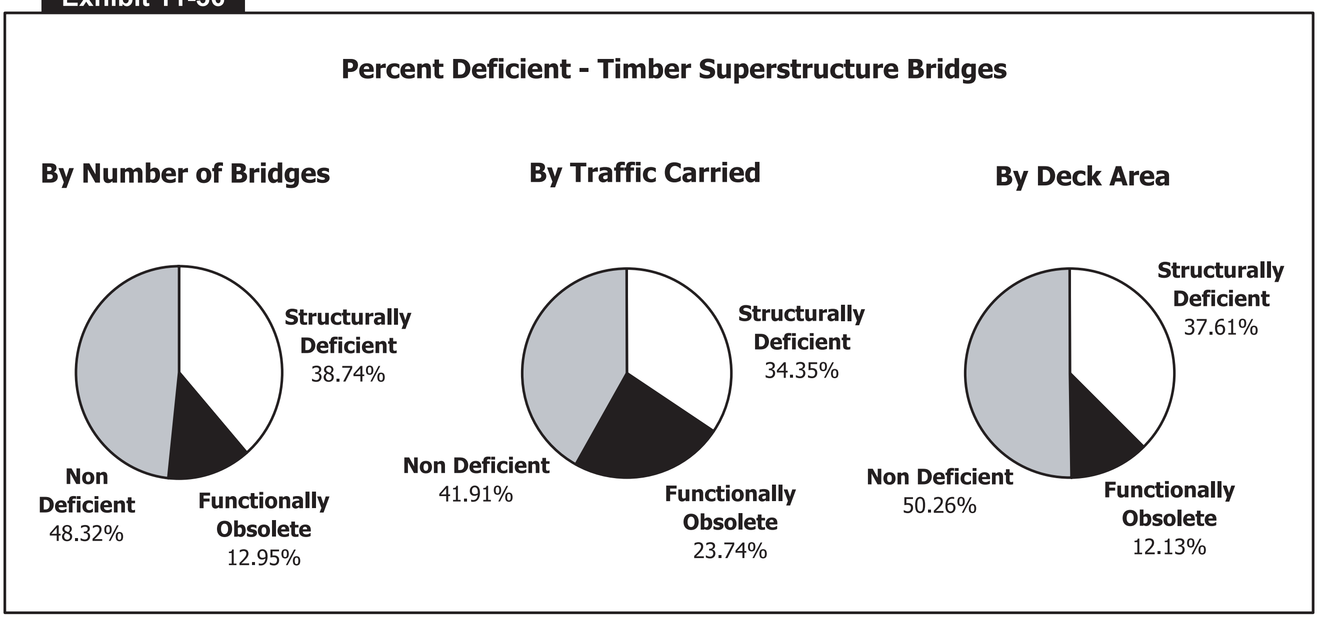
Source: National Bridge Inventory.

Exhibit 11-35



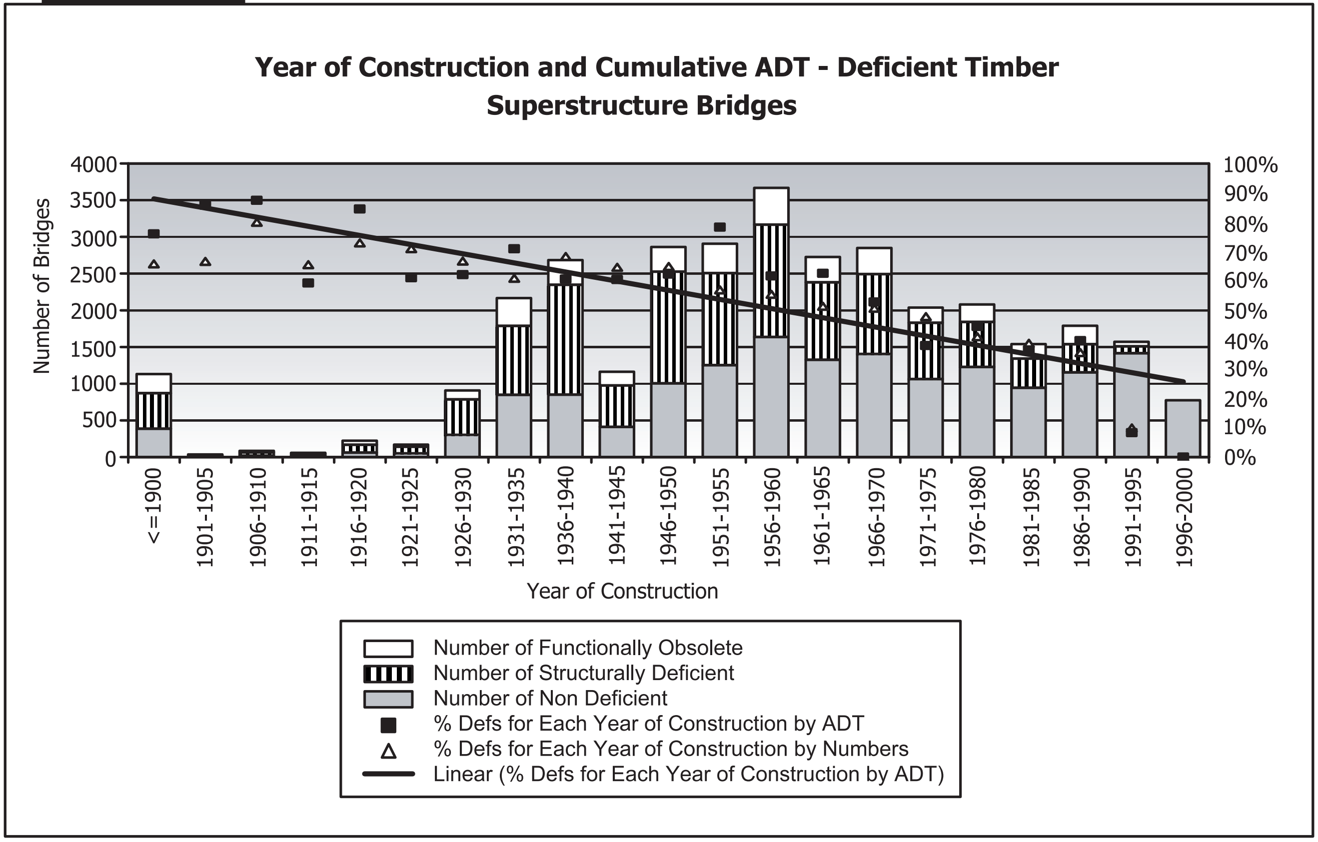
Source: National Bridge Inventory.

Exhibit 11-36



Source: National Bridge Inventory.

Exhibit 11-37



Source: National Bridge Inventory.

Other Superstructure Materials

There are a small number of bridges, in terms of percentage of the population, composed of other materials, which includes aluminum, wrought and cast iron, masonry, and other uncategorized materials. The average age of these bridges is 67 years with an average year of construction of 1935. Urban bridges are, on average, older than rural bridges constructed of these other materials. The average age of these structures is shown for all combinations of functional classification and ownership in Exhibit 11-38. The year of construction distribution and cumulative ADT are shown in Exhibit 11-39 for all structures constructed of these other materials. Deficiencies and deficiency trends are shown in Exhibits 11-40 and 11-41 respectively.

Exhibit 11-38

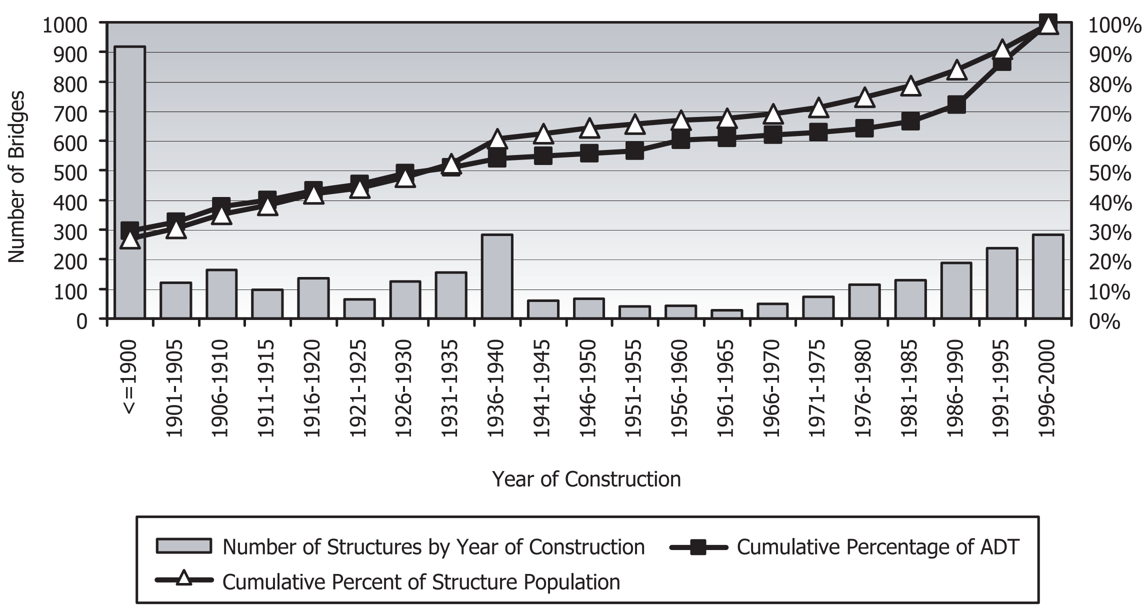
Average Year of Construction an Standard Deviation for Other Superstructure Materials Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
Rural Bridges										
Interstate			1976	(9)					1976	(9)
Other Arterials	1970	(24)	1931	(37)	1912	(61)			1929	(44)
Collectors	1952	(43)	1932	(41)	1942	(39)	1927	(38)	1938	(40)
Local	1952	(34)	1952	(52)	1938	(43)	1895	(44)	1940	(44)
All Rural	**1954**	**(36)**	**1939**	**(45)**	**1938**	**(42)**	**1907**	**(42)**	**1939**	**(43)**
Urban Bridges										
Interstate			1986	(16)	1979				1986	(16)
Other Arterials	1918		1929	(57)	1907	(38)	1923	(28)	1919	(50)
Collectors			1923	(45)	1923	(39)	1926	(16)	1923	(39)
Local	1942	(29)	1928	(50)	1925	(43)	1905	(33)	1926	(43)
All Urban	**1940**	**(28)**	**1935**	**(55)**	**1918**	**(41)**	**1921**	**(27)**	**1924**	**(47)**
All Structures	**1952**	**(35)**	**1938**	**(49)**	**1933**	**(43)**	**1916**	**(32)**	**1935**	**(45)**

Source: National Bridge Inventory.

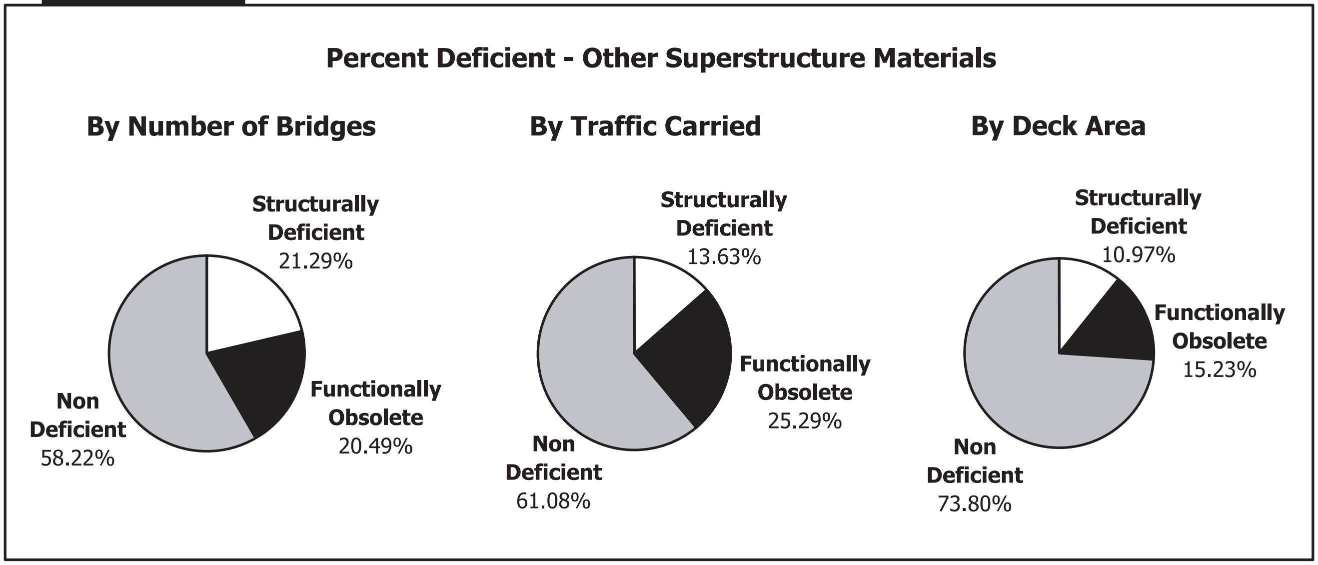
Exhibit 11-39

Year of Construction and Cumulative ADT - Other Superstructure Materials



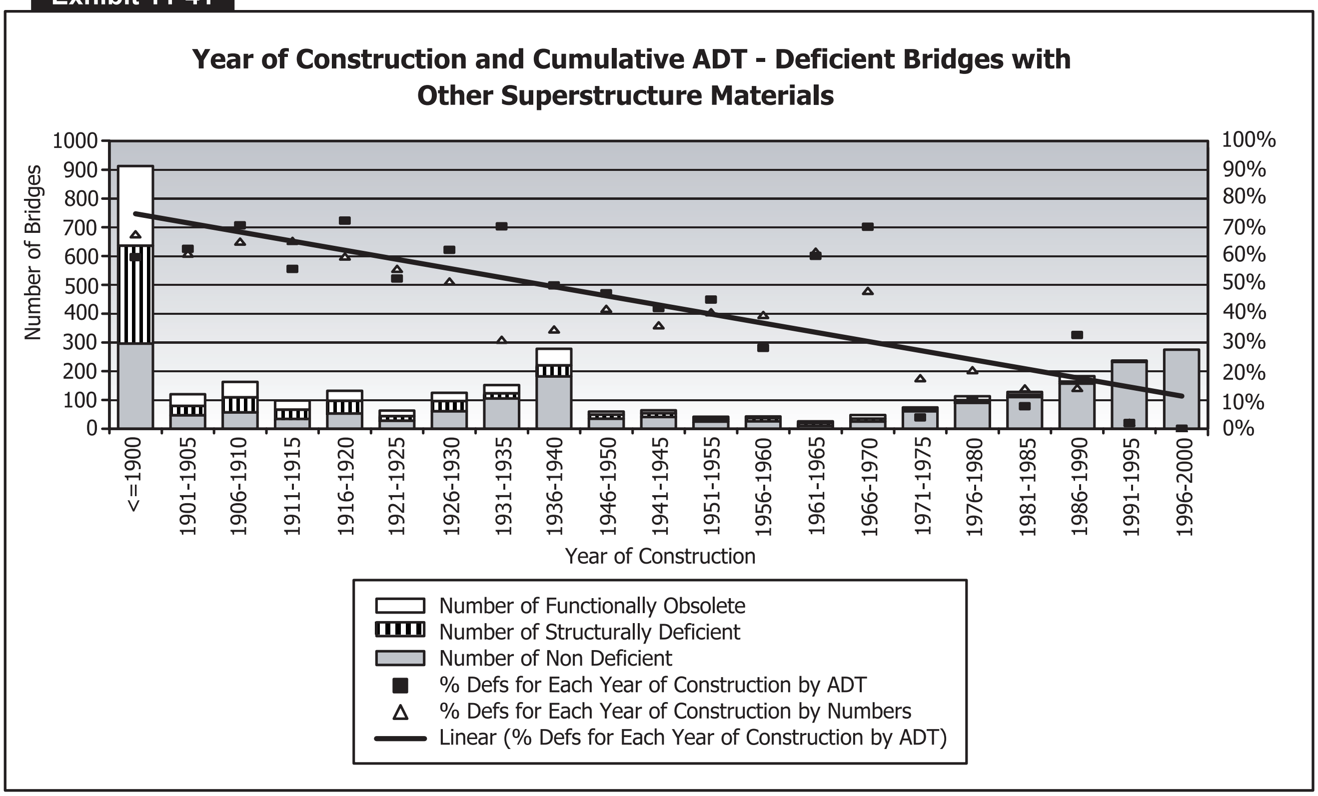
Source: National Bridge Inventory.

Exhibit 11-40



Source: National Bridge Inventory.

Exhibit 11-41



Source: National Bridge Inventory.

Culverts

In addition to examining the bridge infrastructure in terms of functional classification and ownership, it is important to examine the types of design utilized, the age of the structures, and other factors. Considering the types of design utilized, the records in the NBI describe either traditional bridge designs (80 percent—approximately 474,000 records), culverts (20 percent—approximately 117,000 records), or tunnels

(104 records). The inventory is composed almost entirely of traditional bridge and culvert designs. Both of these structures provide the same purpose of providing network connectivity. However, the design and engineering properties of bridges and culverts differ dramatically. Consider the definitions of these structures as defined in the National Bridge Inspection Standards (23 CFR 650.3):

- Bridges are defined as "supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet [6.1 meters] between undercopings of abutments or spring lines of arches." Traditional bridges will have distinct decks, superstructures, and substructures.
- Culverts are structures "designed hydraulically to take advantage of submergence to increase hydraulic capacity. Culverts, as distinguished from bridges, are usually covered with embankment and are composed of structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert. Culverts may qualify to be considered "bridge" length."

For safety assurance and funding purposes, culverts and bridges are equivalent; however, since the design characteristics are significantly different, it is expected that differences in deterioration patterns will occur between the populations. Thus, it is useful to examine differences between bridge and culvert designs. The number of records describing bridge, culvert, and tunnel design is tabulated together with the traffic carried (total ADT) and the percentage of total deck area in Exhibit 11-42.

Exhibit 11-42

Percentage of NBI Records by Design Type

Design	Records	Total ADT Carried	Total Deck Area
Bridges	80.20%	83.25%	97.90%
Culverts	19.78%	16.66%	2.05%
Tunnels	0.02%	0.09%	0.05%

Source: National Bridge Inventory.

Differences in bridge ownership and functional classification versus culvert ownership and functional classification are examined in the following figures. Examination reveals that there are only minor deviations from the overall percentages when examining alternative combinations of functional classification and ownership of bridges versus culverts. The design-type used for a particular situation is thus dependent on the conditions of the crossing and not the functional classification or jurisdictional issues.

The average age of structures in the National Bridge Inventory is approximately 40 years with an average year of construction of 1963. The age distribution of traditional bridge designs and culvert designs is examined and compared in Exhibit 11-43. Culverts tend to be younger than bridges with an average age of approximately 35 years, compared to an average age of approximately 40 years for traditional bridge designs. The average year of construction and standard deviation for traditional bridge designs and culvert designs are shown in Exhibit 11-44 and Exhibit 11-46 for all combinations of ownership and functional classification. Year of construction distributions and cumulative ADT percentages are shown in Exhibit 11-45 for traditional bridge designs and Exhibit 11-47 for culvert designs.

Exhibit 11-43

Bridges and Culverts by Functional Classification and Ownership

FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		ALL	
	BRIDGES	CULVERTS	BRIDGES	CULVERTS	BRIDGES	CULVERTS	BRIDGES	CULVERTS	BRIDGES	CULVERTS
Rural Bridges										
Interstate	13	8	21,619	5,891	12	-	35	4	21,679	5,903
Other Arterials	439	85	49,777	22,066	2,029	593	137	15	52,382	22,759
Collectors	997	217	49,662	19,287	57,071	16,074	223	17	107,953	35,595
Local	6,731	563	23,892	3,841	149,968	24,726	604	25	181,195	29,155
Subtotal Rural	**8,180**	**873**	**144,950**	**51,085**	**209,080**	**41,393**	**999**	**61**	**363,209**	**93,412**
Urban Bridges										
Interstate	2		24,966	2,238	263	20	342	13	25,573	2,271
Other Arterials	42	14	38,541	6,663	13,729	4,134	472	20	52,784	10,831
Collectors	18	6	4,580	529	7,326	2,696	151	3	12,075	3,234
Local	150	15	4,338	433	14,088	6,636	354	22	18,930	7,106
Subtotal Urban	**212**	**35**	**72,425**	**9,863**	**35,406**	**13,486**	**1,319**	**58**	**109,362**	**23,442**
Total Numbers	8,392	908	217,375	60,948	244,486	54,879	2,318	119	472,571	116,854
% of Bridges	90.24%	9.76%	78.10%	21.90%	81.67%	18.33%	95.12%	4.88%	80.17%	19.83%
% of Total ADT	85.64%	14.36%	83.98%	16.02%	77.69%	22.31%	93.17%	6.83%	83.28%	16.72%

OWNERSHIP

Source: National Bridge Inventory.

Exhibit 11-44

Average Year of Construction for Traditional Bridge Designs by Ownership and Functional Classification

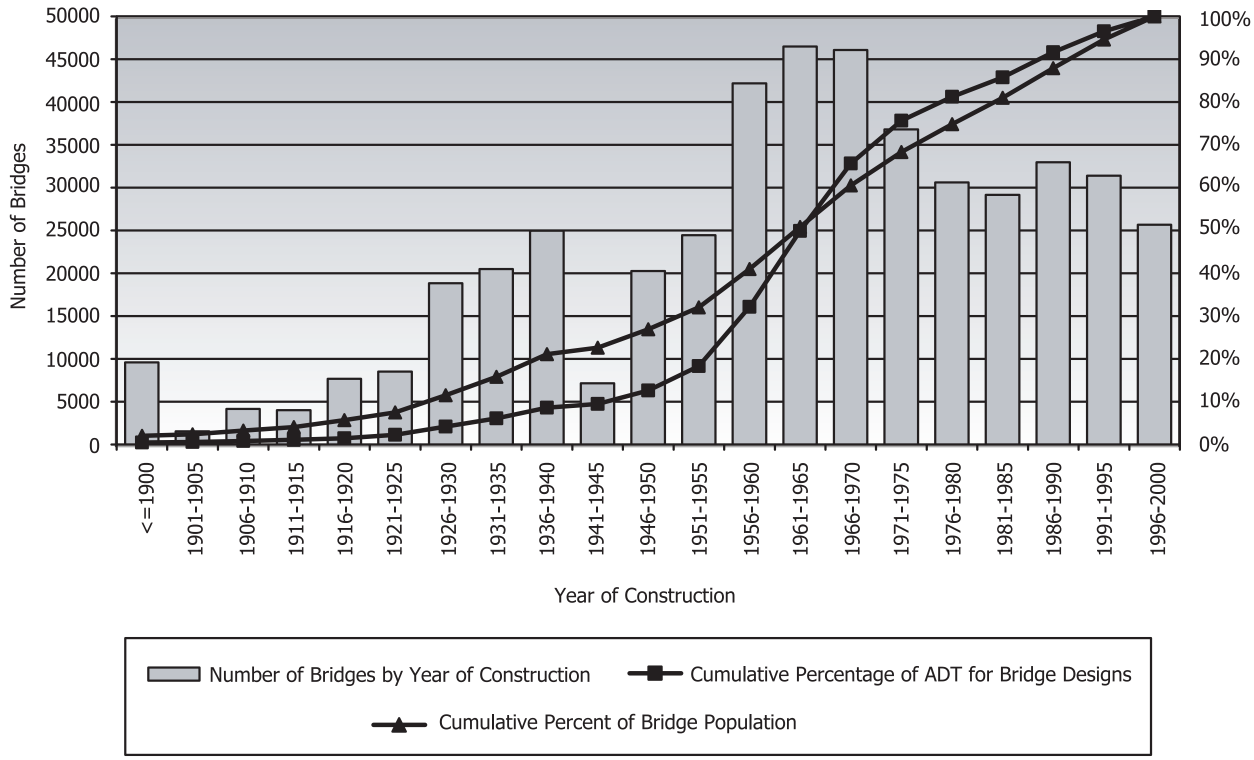
AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)

FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Rural Bridges										
Interstate	1963	-7	1968	-10	1959	-34	1964	-16	1968	-10
Other Arterials	1962	-20	1963	-22	1968	-29	1954	-19	1963	-23
Collectors	1964	-19	1961	-21	1962	-24	1945	-27	1961	-23
Local	1965	-19	1963	-21	1960	-28	1940	-30	1961	-27
All Rural	1964	-19	1963	-21	1961	-27	1944	-28	1962	-24
Urban Bridges										
Interstate	1967	-8	1970	-11	1962	-14	1966	-14	1970	-12
Other Arterials	1959	-27	1967	-20	1961	-26	1953	-27	1965	-22
Collectors	1959	-14	1964	-22	1961	-26	1952	-32	1962	-25
Local	1958	-22	1968	-20	1961	-27	1946	-33	1962	-26
All Urban	1959	-23	1968	-18	1961	-26	1954	-28	1965	-22
All Structures	1964	-19	1964	-20	1961	-27	1950	-28	1962	-24

Source: National Bridge Inventory.

Exhibit 11-45

Year of Construction and Cumulative ADT for Traditional Bridge Designs



Source: National Bridge Inventory.

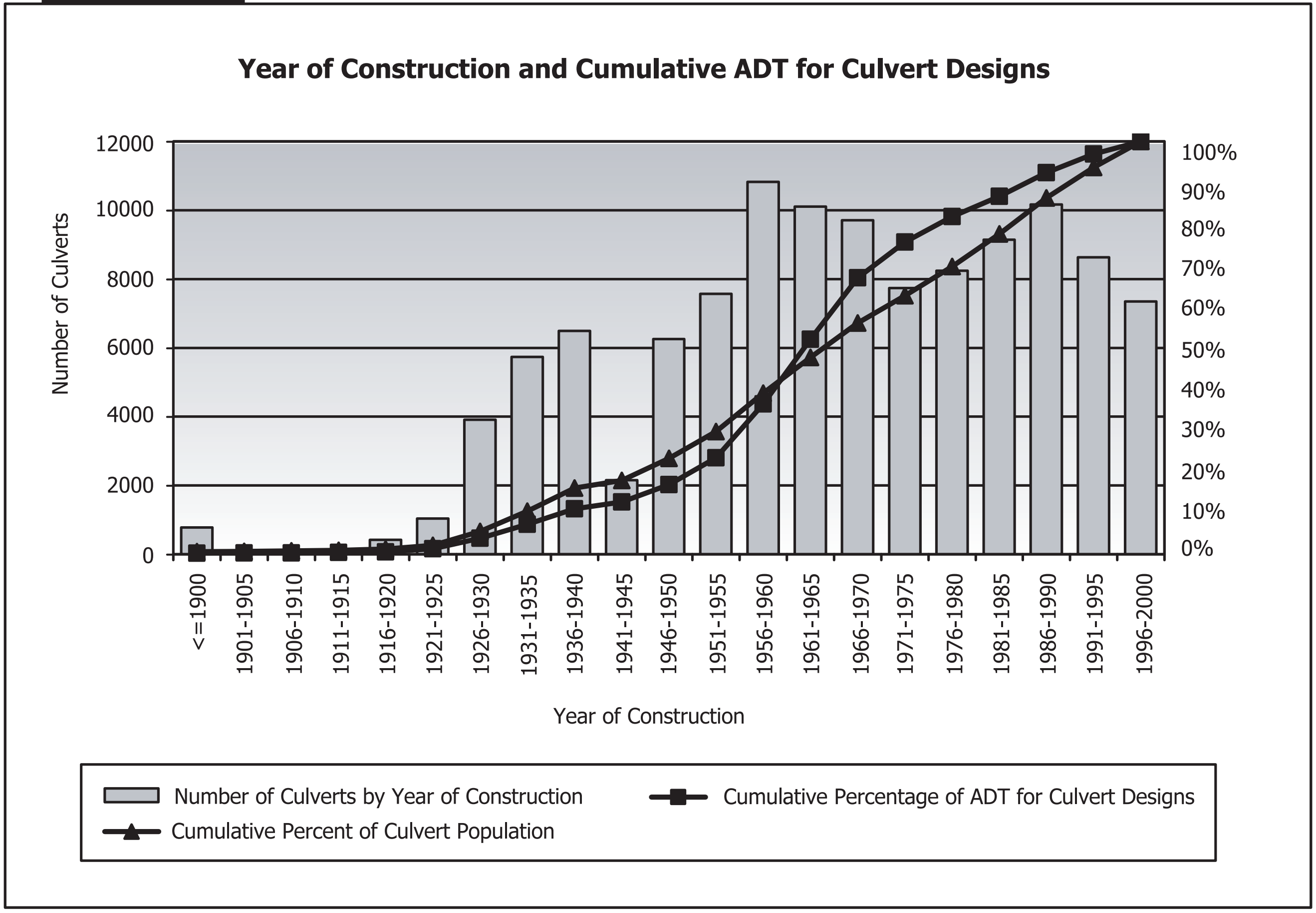
Exhibit 11-46

Average Year of Construction for Culverts by Ownership & Functional Classification

FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
Rural Bridges										
Interstate	1964	-2	1965	-11			1956	-12	1965	-11
Other Arterials	1980	-15	1957	-22	1977	-20	1972	-22	1958	-22
Collectors	1961	-17	1959	-19	1967	-20	1956	-30	1963	-20
Local	1969	-19	1977	-18	1974	-22	1975	-24	1974	-22
All Rural	1968	-19	1961	-20	1971	-22	1968	-26	1965	-21
Urban Bridges										
Interstate			1967	-11	1984	-18	1958	-9	1967	-11
Other Arterials	1962	-20	1965	-20	1970	-19	1948	-30	1967	-20
Collectors	1947	-13	1971	-20	1972	-20	1959	-45	1972	-20
Local	1949	-17	1977	-20	1973	-19	1989	-20	1973	-19
All Urban	1954	-18	1966	-19	1972	-19	1966	-29	1970	-19
All Structures	1968	-19	1961	-20	1971	-21	1967	-27	1966	-21

Source: National Bridge Inventory.

Exhibit 11-47



Source: National Bridge Inventory.

Conclusion

Bridges, as critical components of the highway system, must be maintained and preserved to ensure safety to the traveling public, support commerce and mobility within the Nation, and retain the significant accumulated asset value of the inventory. The Nation's bridges and culverts are aging and traffic demands are increasing. At the same time, funds for capital construction are becoming scarcer. Asset management principles through management systems and transportation system preservation techniques are becoming more important as the States, locals and the Federal Government struggle to maintain the safe condition of the Nation's bridges and culverts, while at the same time providing for increased demands on the highway network. Improved bridge and culvert inspection techniques, through the use of new and innovative equipment, are needed to better insure 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 functional transportation network, provide longer service life, and improve the safety of the highway network. Emphasis is needed on research so that we can continually improve the condition of the Nation's bridges and culverts.

Part IV

Special Topics

Introduction

Chapters 12 through 22 provide a more extensive discussion of topics raised in the core analytical parts of the report, Chapters 2 through 10. Some of the special topics covered in this section reflect recurring themes that have been discussed in previous editions of the C&P report. Other chapters address new topics of particular interest at this time.

- Chapter 12, **National Security**, describes the relationship between national security and the highway and transit systems.

- Chapter 13, **Highway Transportation in Society,** and Chapter 14, **The Importance of Public Transportation**, provide information on the benefits that highways and transit provide to system users and on the characteristics of these users. These chapters build on the broad concepts presented in Chapter 1, and are included to complement the primarily infrastructure-oriented analyses in Chapters 2 through 10.

- Chapter 15, **Macroeconomic Benefits of Highway Investment**, brings a broader perspective to the impacts of transportation investment, and complements the investment/performance analyses based on microeconomic models included in Chapters 7 through 10. Chapter 16, **Pricing**, presents a potential solution to some of the congestion problems identified in Chapter 4.

- Chapter 17, **Transportation Asset Management** (TAM), and Chapter 18, **Travel Model Improvement Program**, describe efforts underway to provide State and local governments with better analytical tools and conceptual approaches to help them enhance their decision-making processes. The investment/performance analyses presented in Chapters 7 through 10 are consistent with many of the fundamental concepts and principles of TAM, and are significantly affected by the accuracy of State and local travel growth forecasts.

- Chapter 19, **Air Quality**, supplements the investment requirements discussion in Chapter 7 by describing the relationship between air quality and the highway and transit infrastructure, a critical issue in assessing the desirability of future investments. Chapter 20, **Federal Safety Initiatives**, describes current efforts to address the safety performance issues discussed in Chapter 5.

- Chapter 21, **Operations Strategies**, presents possible solutions to some of the congestion problems introduced in Chapter 4. This discussion complements the investment/performance analyses included in Chapters 7 through 10, which are more infrastructure oriented. Chapter 22, **Freight**, also serves to complement Chapters 7 through 10 by focusing more specifically on the characteristics and infrastructure needs of freight transportation.

Chapter 12

National Security

Introduction

The Department of Transportation's 2000-2005 Strategic Plan includes a National Security Strategic Goal, to "ensure the security of the transportation system for the movement of people and goods, and support the National Security Strategy." The terrorist attacks on the United States on September 11, 2001, highlighted the need to improve the understanding of transportation security needs across all modes, including highways and transit systems.

The analyses in Parts I and II of this report do not specifically address security aspects of the highway and transit networks. While some investments included in the Cost to Maintain and Cost to Improve scenarios presented in Chapter 7 would result in some security-related benefits, such benefits were not directly considered in evaluating potential investments. The development of new data reporting requirements and new analytical approaches that would be necessary to estimate security-related investment needs are under consideration for future editions of this report.

This chapter broadly examines the role of highways and transit systems in enhancing the Nation's security, looking at both traditional activities of the Department in this area, and new activities that have been recently initiated.

Recovery Operations

Immediately after the terrorist attacks, FHWA and FTA officials focused on restoring the infrastructure damaged in New York City and Washington, D.C. Some of the most serious damage involved the loss of New York City's Port Authority Trans Hudson (PATH) line to the World Trade Center and two PATH stations; the temporary loss of two Manhattan subway lines; and the loss of several Manhattan subway stations. In addition, the loss of street capacity in Lower Manhattan forced restrictions and prohibitions on single occupant vehicle traffic on bridge and tunnel crossings, including the Holland Tunnel, the Lincoln Tunnel, and the Brooklyn-Battery Tunnel.

The Department of Transportation dedicated $242 million to restore highways in the State of New York. The Department also dedicated over $1.8 billion to repair and upgrade the State's transit systems.

Departmental Review of Transportation Security

With recovery operations under way, U.S. Secretary of Transportation Norman Mineta established a National Infrastructure Security Committee (NISC) to comprehensively evaluate security improvements to the surface transportation network. The NISC met with State and local officials, labor representatives, planners, industry leaders, and other transportation partners and stakeholders.

Each operating administration within the Department also sought input from major constituencies. The American Association of State Highway and Transportation Officials (AASHTO), for example, established a security task force that included FHWA representation. The task force produced two handbooks for AASHTO's members. One described "best practices" for identifying critical infrastructure, and the other dealt with emergency response. Similarly, soon after the terrorist attacks, the American Public Transportation Association (APTA) established an Executive Committee Security Task Force. The Task Force worked closely with FTA and developed recommendations for enhancing the security of the Nation's transit systems.

The Department of Transportation also contributed to the Administration's broad homeland security program. Departmental staff, for example, shared information with the Office of Homeland Security. The Federal Highway Administration continued to work closely with the Military Traffic Management Command (MTMC) within the Department of Defense's U.S. Transportation Command (USTRANSCOM). FTA strengthened its ties with such agencies as the Federal Bureau of Investigation and the Department of Energy.

Military Mobilization

MTMC is a longtime FHWA partner. Through contracts and other arrangements, MTMC provides the means by which the military services, the Defense Logistics Agency, and other military components move tanks, fuel, ammunition, vehicles, repair parts, food, and other commodities. Once the freight leaves the United States, MTMC also coordinates its unloading at worldwide ports. MTMC is the manager for numerous ports worldwide. This is an extensive operation, making MTMC a major player in freight transportation. In FY 2001, MTMC contracted for the loading and unloading of over 3.1 million tons of cargo.

MTMC executes the Highways for National Defense program on behalf of USTRANSCOM. This program is designed to ensure that the American road network can support military deployments. This program recognizes that, first and foremost, highways are a key part of the strategic military transportation system. One of the original purposes of the Interstate System was to improve the Nation's readiness during the Cold War, and highways still provide that same function.

The Strategic Highway Network (STRAHNET) is critical to the Defense Department's domestic operations. STRAHNET is a 61,044-mile system of roads deemed necessary for emergency mobilization and peacetime movement. Even though the U.S. Department of Defense primarily deploys heavy equipment by rail, highways play a critical role.

Exhibit 12-1

Strategic Highway Corridor Network (STRAHNET) Mileage, 2000

Interstate	45,376
Non-Interstate	15,668
Total	**61,044**

Source: Military Traffic Management Command.

Exhibit 12-1 describes the extent of the Strategic Highway Network. Most of the STRAHNET miles in 2000 were on Interstate highway routes.

Exhibit 12-2 describes the condition of the Strategic Highway Network. In 2000, 96.3 percent of all the mileage in the Strategic Highway Network had a measured pavement roughness (using the International Roughness Index [IRI]) less than or equal to 170 inches per mile. Pavement with an IRI less than or equal to 170 is considered acceptable in the FY 2003 FHWA Performance Plan.

Exhibit 12-2

Strategic Highway Corridor Network (STRAHNET) Condition, 2000

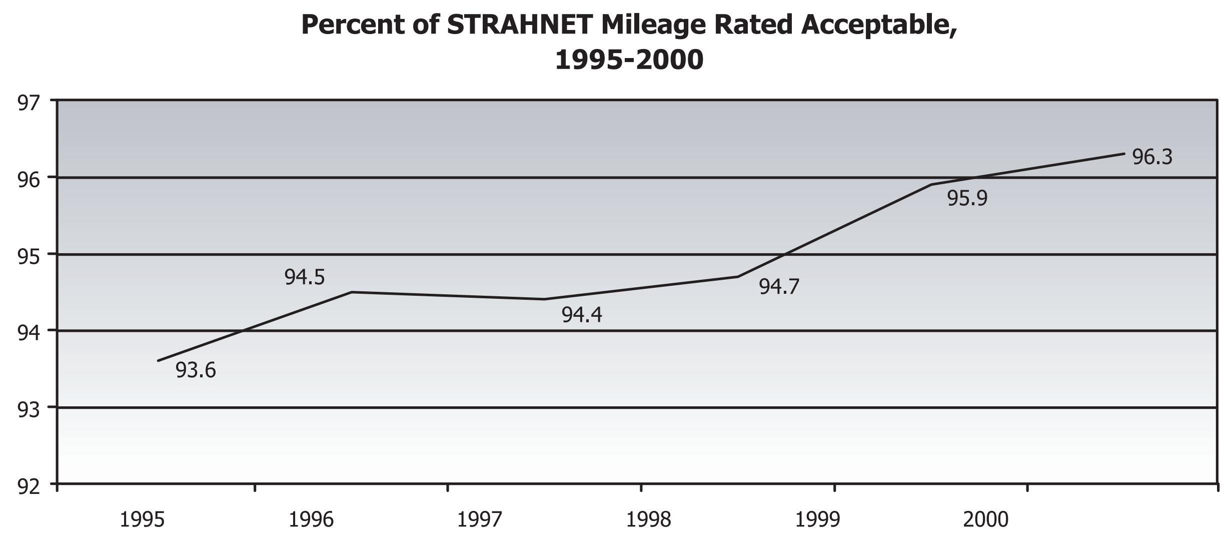
(Percent STRAHNET Miles with Measured Pavement Roughness <=170)

Interstate	96.6
Non-Interstate	95.6
Total	96.3

Source: Military Traffic Management Command.

The FY 2003 FHWA Performance Plan identifies the condition of the Strategic Highway Network as a national security performance measure. The percent of STRAHNET miles with acceptable ride quality has steadily increased since 1995. This improvement is described in Exhibit 12-3.

Exhibit 12-3



Source: FY 2003 FHWA Performance Plan.

Q. Are most STRAHNET routes on rural or urban highways?

A. In 2000, 72.8 percent of STRAHNET mileage was in rural communities. Rural Interstates comprised more than 53.5 percent of total STRAHNET mileage.

Additionally, there were 102,859 bridges on the Strategic Highway Network in 2000. The next section of this chapter describes bridge quality using indicators from Chapter 3 and performance measures from the FY 2003 FHWA Performance Plan.

Exhibit 12-4 describes the condition of STRAHNET by the percent of deficient bridges on STRAHNET routes. About 21.5 percent of STRAHNET bridges were deficient in 2000. About 6 percent were structurally deficient, and 15.5 percent were functionally obsolete. By comparison, about 28.5 percent of all bridges nationwide were deficient in 2000, while roughly 14.8 percent were structurally deficient and 13.8 percent were functionally obsolete. Exhibit 12-5 shows how the percent of deficient STRAHNET bridges has dropped since 1995. This is a performance measure in the FY 2003 FHWA Performance Plan.

Exhibit 12-4

Number of Deficient STRAHNET Bridges, 2000

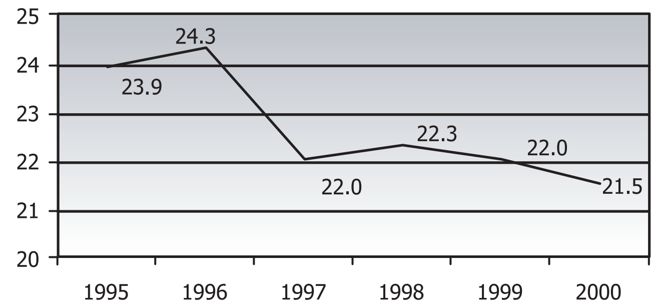
	Number of Deficient Bridges	
	NUMBER	PERCENT
STRAHNET Bridges	102,859	
Deficient Bridges	22,132	21.5%
Structurally Deficient Bridges	6,215	6.0%
Functionally Obsolete Bridges	15,917	15.5%

Source: National Bridge Inventory.

Exhibit 12-6 describes the percent of deficient deck area for STRAHNET bridges. In 2000, 26.7 percent of the deck area on STRAHNET bridges was deficient. By comparison, about 27.9 percent of bridge deck area nationwide was considered deficient.

Exhibit 12-5

Percent of STRAHNET Bridges Rated Deficient, 1995-2000



Source: FY 2003 FHWA Performance Plan.

Finally, Exhibit 12-7 describes the percent of STRAHNET routes under bridges with vertical clearance greater than 16 feet. This is a performance measure from the FY 2003 FHWA Performance Plan. In 2000, about 70.8 percent of STRAHNET routes under bridges met this threshold, an indicator that has steadily improved 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 12-6

Percentage of Deficient Deck Area on STRAHNET Bridges, 2000

All STRAHNET Bridges	26.7%
Structurally Deficient Bridges	8.0%
Functionally Obsolete Bridges	18.7%

Source: National Bridge Inventory.

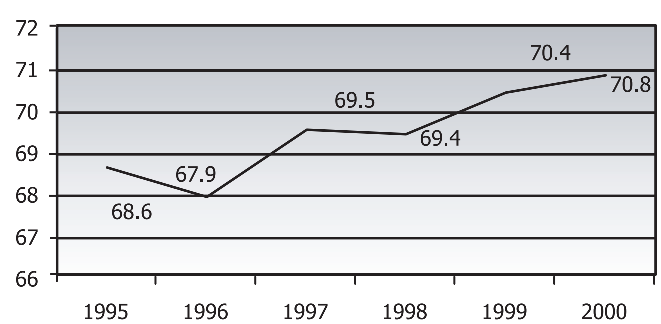
Another important element of the STRAHNET system is the network of STRAHNET connectors. There are 1,700 miles of STRAHNET connectors that link over 200 military installations and ports to the network. There are 17 key power projection platforms (PPPs) in the continental United States that are essential to rapid military deployment, and the condition of STRAHNET connectors is as important as the quality of the main STRAHNET routes. Recently, the Federal Highway Administration has encouraged States to use their apportioned funds to upgrade "fort to port" connections, especially those STRAHNET routes that link to power projection platforms.

Emergency Response Activities

The new security environment makes *redundancy* even more important. In this context, redundancy refers to a transportation system's ability to accommodate increased demands through excess capacity. The highway system needs redundancy to accommodate a sudden flow of vehicles in one direction and to simultaneously allow the quick movement of emergency vehicles in the opposite direction. Transit systems must develop and test operational plans to quickly move people and have alternative operational plans

Exhibit 12-7

Percent of STRAHNET Routes Under Bridges with Clearance Greater Than 16 Feet, 1995-2000



Source: FY 2003 FHWA Performance Plan.

prepared to deal with the potential loss of key components of the system. Effective emergency response, however, also depends on operations strategies to better manage traffic flow. FHWA and FTA recognize these challenges and are working with other Federal, State, and local agencies to improve emergency response capabilities, as described below.

Many States and localities are redesigning their emergency response plans, some of which were designed during the Cold War. In 2002, for example, the Federal Highway Administration sponsored a series of regional emergency management workshops that attracted officials from around the country. These workshops brought together Federal, State, and local transportation agencies from all surface modes with their partners from public safety, emergency management, public health, ports, intelligence, and defense to jointly work on strategies and tactics for dealing with transportation aspects of a major terrorist event.

In May 2002, the Federal Transit Administration launched its "Connecting Communities: Emergency Preparedness and Security Forums." Forums were scheduled for 17 cities around the Nation through January 2003. The two-day forums were intended to help metropolitan areas and their surrounding communities become better prepared to respond to emergency situations in the coordination, communication, planning, and practice of safety and security measures. The forums were designed for transit agency management and security personnel; police and fire personnel responsible for emergency management coordination; emergency medical services and hospital disaster relief coordinators; and State and local government emergency management coordinators.

Emergency plans are being modified to address traffic control, interagency communications, hurricane evacuation routes and destinations, and public information. Intelligent Transportation Systems (ITS) are increasingly included in these plans. The ITS unit within the Florida Department of Transportation, for example, is involved in all types of transportation planning. ITS technologies such as variable message signs, ramp and access controls, and radio broadcasting play an important role in evacuation plans for the Florida coast during natural disasters, and these can also be used during manmade disasters.

ITS surveillance resources can be an important tool in monitoring highway and transit bridges and tunnels. Real-time ITS data on traffic conditions and the location of transit vehicles can assist agencies in conducting rapid, orderly evacuation along all available routes and modes in a threatened area. Some trucking firms and automobiles can now receive traffic conditions and navigation information, making it possible that ITS operations centers could one day guide millions of vehicles away from dangerous areas. Intelligent Transportation Systems are described more fully in Chapter 21.

Since the terrorist attacks, FTA has accelerated the implementation of the Project PROTECT chemical detection system, which is being prototyped in the Washington, D.C. subway system. FTA has also devoted funding to test this system in an older subway environment. In order to assist all systems in the near term, FTA has issued guidelines for the handling of chemical and biological incidents in a subway environment and will soon issue guidance for all transit modes, including buses and light rail.

Truck and Container Security

Although the terrorists who orchestrated the September 11 attacks used airplanes as weapons, attention is now being focused on the openness of the entire U.S. transportation system and its relationship to systems in Canada and Mexico. Every year, for example, an estimated 19 million cargo containers enter the United States through land borders, seaports, and airports. Those same containers move throughout the United States with little attention to their movement. In some cases, containers entering the U.S. are processed through Customs stations without inspection and can spend more than a month getting to a final destination. Additionally, there are several million domestic containers that travel on the same transportation system with international containers. Altogether, these international and domestic containers represent more than 700,000 intermodal movements each day as freight managers move the containers by trucks, rail lines, or barges to their final destinations.

The U.S. Department of Transportation is exploring how to create a system to track containers and identify the custodians of the cargo as it moves from origin to destination. Partners in this effort include the Transportation Security Administration and the U.S. Customs Service.

Highways and Transit Systems as Strategic Assets

Highways and transit systems are essential strategic assets. An attack on a highway or transit system would not only have human costs, but it could paralyze regional or national economies. The 1995 chemical gas terrorist incident in the Japan subway system illustrated the openness of transit systems to chemical and biological attacks. The U.S. Department of Transportation is focusing on strengthening highway and transit assets across the Nation.

FHWA is taking steps to harden the most sensitive elements of the national highway system—bridges and tunnels. Strengthening these structures could reduce the potential damage of any terrorist attacks much as facilities in earthquake-prone areas have been modified to improve their survival of seismic events. FHWA has issued guidance that clarifies the eligibility of Federal-aid funding should States wish to strengthen these structures.

A bridge or tunnel can be physically hardened in several ways. Piers, cables, and cable anchorages could be strengthened. Redundant configurations could increase a structure's mass, and high-performance materials could increase its durability. Additionally, technology could be added to better monitor the structure's critical components.

For transit structures, FTA security assessments have confirmed that there is no substitute for effective security awareness training. To assist in this regard, FTA and the National Transit Institute have launched comprehensive security awareness courses targeted to front-line transit employees and supervisors. These courses and the accompanying materials are available to transit organizations free of charge. The practices help transit systems harden the target relative to terrorism, but will also improve transit organization's overall security—helping to reduce all levels of crime.

FHWA and FTA are continuing to explore new ways to "harden" transportation assets through research. Coordination between FHWA, FTA, the Transportation Security Administration, and the Office of Homeland Security will help identify important parts of a security research agenda.

Conclusion

The September 11 attacks prompted an assessment of security across all transportation modes. While much attention has been focused on aviation security, equally important steps have been taken to reduce the openness of highways and transit systems. Some of these improvements may not be widely publicized, but they are essential parts of an improved security network across the United States.

Chapter 13

Highway Transportation in Society

Introduction

The extensive U.S. transportation system connects markets and people across the continent. Its quality and pervasiveness are almost transparent to us as we move between jobs, markets, education, healthcare, and leisure activities. An efficient transportation system has always been central to economic, social, and cultural development.

The affluence and mobility of our society has resulted in a demand for travel and access that often outstrips the supply. As income rises, travel increases and the range of goods and services accessible to the public increases. Increased travel has the potential of creating greater congestion on the transportation system thereby threatening its efficiency. The forecasting of the changes required to provide an efficient transportation system able to meet the Nation's future demands requires an understanding of the current system, its strengths and weaknesses, and the key factors shaping future demands and needs.

Changes in Travel Demand

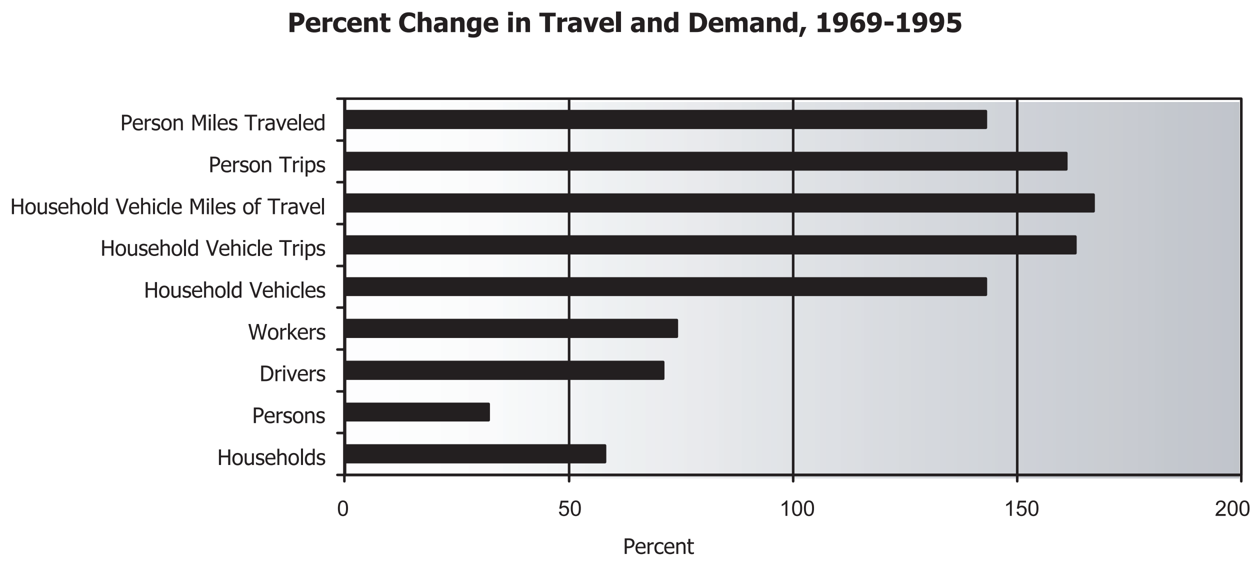
Chapter 2 describes the extent of the Nation's highway and transit systems and the continuing growth of travel occurring on them. In both passenger and freight activity, the demand for highways has grown faster than the systems designed to serve that demand. The general effects of this disparity between transportation supply and transportation effects are highlighted in Chapter 4, while related issues pertaining to freight transportation are discussed in Chapter 22.

Each man, woman, and child in this country, spends, on average, an hour a day traveling in cars and buses or walking. 100 million U.S. households generate more than a billion person trips and over nine billion person miles of travel in a typical day. It is not surprising that a small delay in travel, when multiplied by the tremendous number of people affected, can result in vast amounts of wasted time, energy, and fuel.
The United States has grown by about 25 million people per decade since 1950, but the decade between 1990 and 2000 added 32.7 million. During these years, the increase in the rate of travel has been even more dramatic. Since 1969, the number of people in the United States grew by 32 percent, while person miles of travel increased by 143 percent. U.S. households grew by 58 percent over the same period, while the rate of household vehicle travel grew nearly twice as fast—163 percent. (See Exhibit 13-1.)

Many factors have contributed to the explosive growth in personal travel, including the population surge of the baby boomers, high levels of immigration, increases in the number of households as household size declines, greater rates of participation of women in the labor force, increased rates of vehicle use by older drivers, improved incomes, and continued diffusion of residential, work, service, and recreational locations into the suburbs and beyond. Whether these and other factors will continue to fuel growth in travel at high levels into the 21st Century remains to be seen.

Freight transportation has also experienced major growth. Between 1993 and 1997, the weight of commodities shipped by truck from U.S. establishments increased 20.6 percent, equating to an average annual rate of 4.9 percent per year (National Transportation Statistics 2000, Table 1-48, p. 72). Total miles traveled by larger trucks increased even faster at an average annual rate of 6.2 percent per year. The average miles traveled by trucks grew at an average annual rate of 4.0 percent per year during this period (USDOC Census 1997). Recent economic prosperity has generated more goods to ship. Economic integration on a global scale increased the quantity of goods moved and greatly extended shipping distances. The value of goods being transported has increased, while the weight of goods shipped has declined. These trends are explored in Chapter 22.

Exhibit 13-1



Source: 1995 Nationwide Personal Transportation Survey.

Together, increasing demand for transportation, growing affluence of travelers, and increasing value of goods being shipped have placed a premium on fast, reliable transportation. The vast majority of households and businesses depend on highways to meet their needs and are willing to pay for premium service. This is demonstrated by the dramatic growth of nationwide overnight delivery services that charge far more than traditional carriers who took days or weeks to reach their final destination.

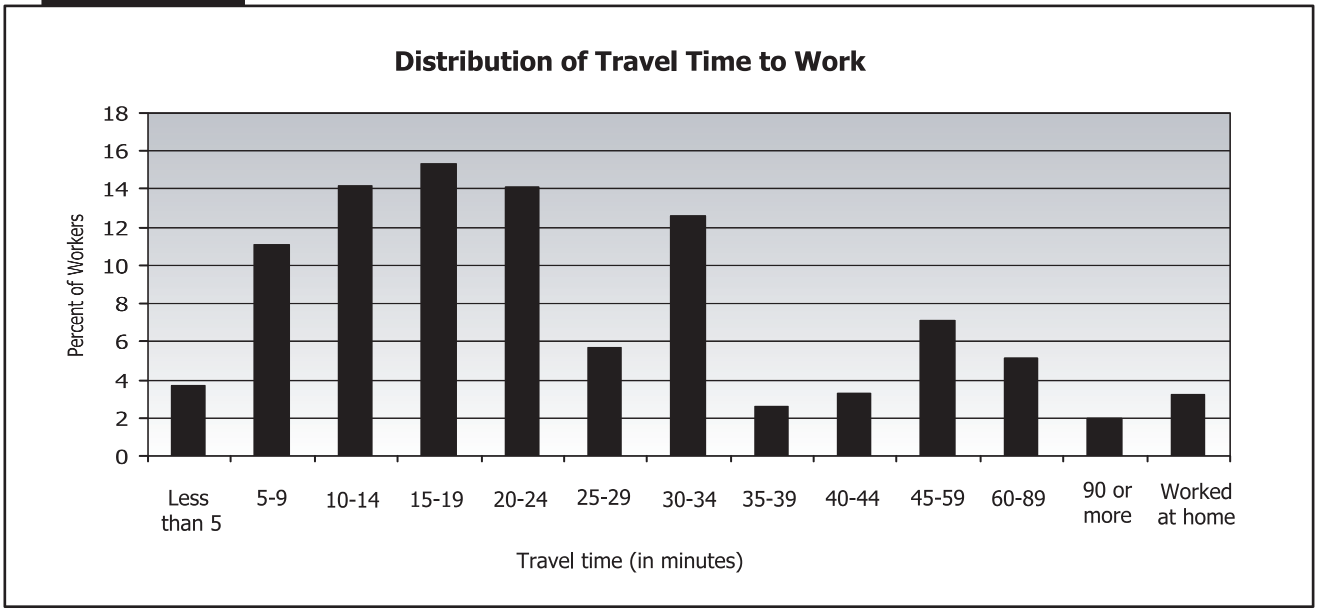
Commuting

One of the primary functions of the transportation system in the economy is to provide access to producers, retailers, and consumers. But just as important is a worker's ability to efficiently get to work. For example, welfare reform effectiveness is limited by the extent to which people moving off public assistance who require public transportation are provided such transportation. Working-age immigrants living in suburban communities with transportation limitations often experience difficulties in finding employment. The transportation system provides a direct bridge into the economy and society by providing the stability and connection of access to a daily job for workers.

For many Americans, the trip to work is the dominant focus of travel each day. According to the U.S. Census Bureau's American Community Survey, approximately 123 million people in the United States commuted to work outside the home in 2000. Of these commuters, 76 percent drove alone, 11 percent carpooled, 5 percent took public transit, and the remainder worked at home or walked. The distribution of their travel times is shown in Exhibit 13-2 and discussed in Chapter 4.

Between 1960 and 1990 the numbers of workers in the U.S. increased 78 percent, twice as fast as the population as a whole. This was partly due to more women entering the workforce. Nearly 15 percent of commuters travel more than 45 minutes. The number commuting more than 60 minutes has reached 9 million workers or about 7 percent of commuters. On the other hand, 30 percent of workers commute less than 15 minutes one-way. (See Exhibit 13-2.)

Exhibit 13-2



Source: Census 2000 Supplementary Survey (C2SS).

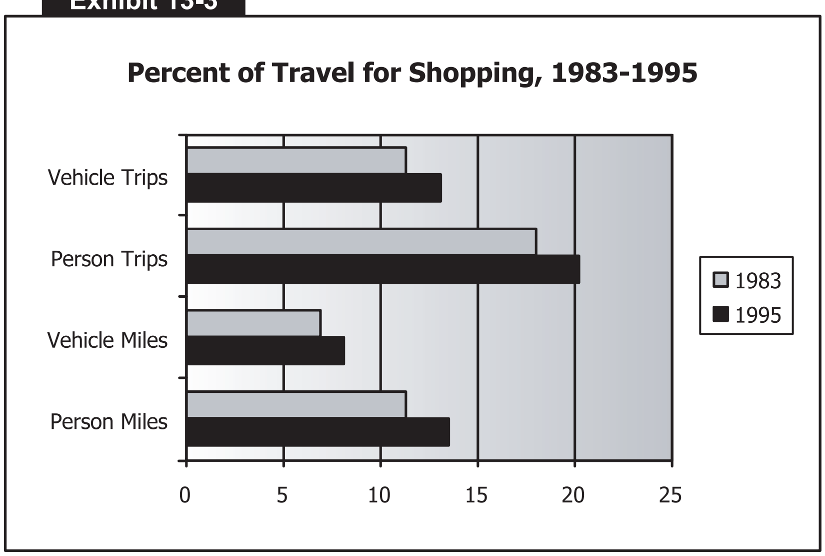
More workers in the service sector with its non-traditional hours, and greater flexibility in traditional workplaces lead to new patterns and schedules of work. Nearly 15 percent of all the trips made on the weekend are work trips (8.4 on Saturday and 6.4 percent on Sunday) compared to just over 20 percent of trips on an average weekday.

Shopping-related Travel

Consumer purchases are a central part of the U.S. market economy. Thus, it is no surprise that shopping trips account for a large portion of daily travel. Shopping trips are considered part of household maintenance, regardless of the type of store. Moreover, as income rises, so do discretionary trips for specialty purchases.

Shopping comprises one out of every five person-trips and one out of every seven person miles traveled. Virtually every household—whether or not it includes workers—makes shopping and household serving trips, such as buying groceries or meals, buying household goods and supplies, and conducting other family errands. (See Exhibit 13-3.)

Exhibit 13-3



Source: 1995 Nationwide Personal Transportation Survey.

Our very mobile populace has access to far-flung specialty stores and niche markets, as well as large supermarkets and discount stores. The average American makes 4 shopping trips a week. Overall, more than 3 1/2 hours per week are spent in traveling to shops and shopping. The number of separate person trips to shop grew by 12 percent in the last 20 years, and the number of miles traveled to shop increased by nearly 20 percent.

Women make more total trips per day than men, on average, because they make more stops for day care and school drop-offs, shopping, and other family errands. This means that women are more likely to chain these errands to their commute trips. Almost two-thirds of working women make at least one stop on the way home on an average weekday. The data show that the vast majority of shopping trips, 77 percent, take place on weekdays, although nearly 30 percent of all the trips taken on a Saturday are to shop. Trip chaining will continue to be a significant and growing feature of the way Americans travel.

In addition, Internet shopping is rapidly becoming a vibrant marketplace for buyers and sellers of a fast-growing pool of consumer goods and services. However, early data indicate that shopping via the internet does not diminish daily travel—people who report more internet shopping make more trips overall within the same income and age groups.

Education-related Travel

Every day, about 450,000 school buses carry 23 million children to school nationwide. Today, a little more than one-third of all schoolchildren take a bus to school. But the proportion of children who travel to school by bus and walking has declined in the last 20 years. More than half of America's school children ages 5 to 15 arrive at school in a car, and just one out of ten students walks to school. Trips to and from school account for about a quarter of the trips made by children ages 5 to 15 years old. (See Exhibit 13-4.)

Exhibit 13-5 shows that the amount and type of school trips vary greatly by age. In the United States, children under 16 years old are mandated to go to school. In recent decades, higher education has become common among adults as a life-long pursuit. Many adults go to school as part of their continuing education in their current professions, to train for career changes, to learn languages and hobbies, and for other reasons. About the same percent of school trips are made by middle-aged people (35 to 64 years of age) as are made by those aged 25 to 34 years.

Exhibit 13-4

Trends in Means of Transportation to School (Percent)

MEANS OF TRANSPORTATION:	1983	1990	1995
School Bus	45.7	40.7	34.7
Private Vehicle	39.7	40.1	52.3
Walk	13.8	17.9	11.8
Bike	0.9	1.2	1.3

Source: 1995 Nationwide Personal Transportation Survey.

The transportation system provides access to colleges and universities for a larger proportion of Americans simply because highway facilities are better. A two-hour commute to the university two or three times a week is not impossible for students who want to continue to live at home. Many senior citizens also are continuing their education as part of their retirement plans. There are about 300 "learning in retirement" programs in the country, most of which are affiliated with colleges.

Rural areas are consolidating grammar schools because of the access afforded by better transportation facilities—in the past children had to be able to walk to school. The consolidated schools offer a broader education, and often better education, than the old "one-room" schoolhouses.

Exhibit 13-5

Percent of School Trips by Age Group

AGE GROUP	PERCENT OF ALL SCHOOL TRIPS
5 – 15 years	66.0
16 – 24 years	23.4
25 – 34 years	5.1
35 – 64 years	5.2
65 years and older	0.4
All	100.0

Source: 1995 Nationwide Personal Transportation Survey.

Leisure and Recreation Travel

An increasing amount of travel, both long and short trips, is made for recreation. Congestion around attractions and leisure spots can be worse than congestion in a city center at rush hour.

More person hours are spent in a car (by passengers and drivers) on the weekends than any weekday—two and a half hours on average for Saturday and Sunday versus two hours on average on weekdays. Many weekend trips are made for local shopping and errands, but many miles are also traveled for recreation and social purposes.

Travel for leisure and recreation can encompass trips to a weekend cabin or trips across country. About 28 percent of all longer-distance travel by U.S. residents is for recreation and leisure (trips of 100 miles or more). That is a higher percentage than any other single purpose trip except for visiting friends and relatives.

Exhibit 13-6

Person Trips by Means of Travel for Leisure

MODE:	PERCENT OF LEISURE TRIPS
Personal Vehicle – Drive Alone	22.9
Personal Vehicle – Drive w/ Others	61.3
Air	11.6
Inter-city Bus and Rail	4.1
Other	0.2

Source: 1995 American Travel Survey (ATS).

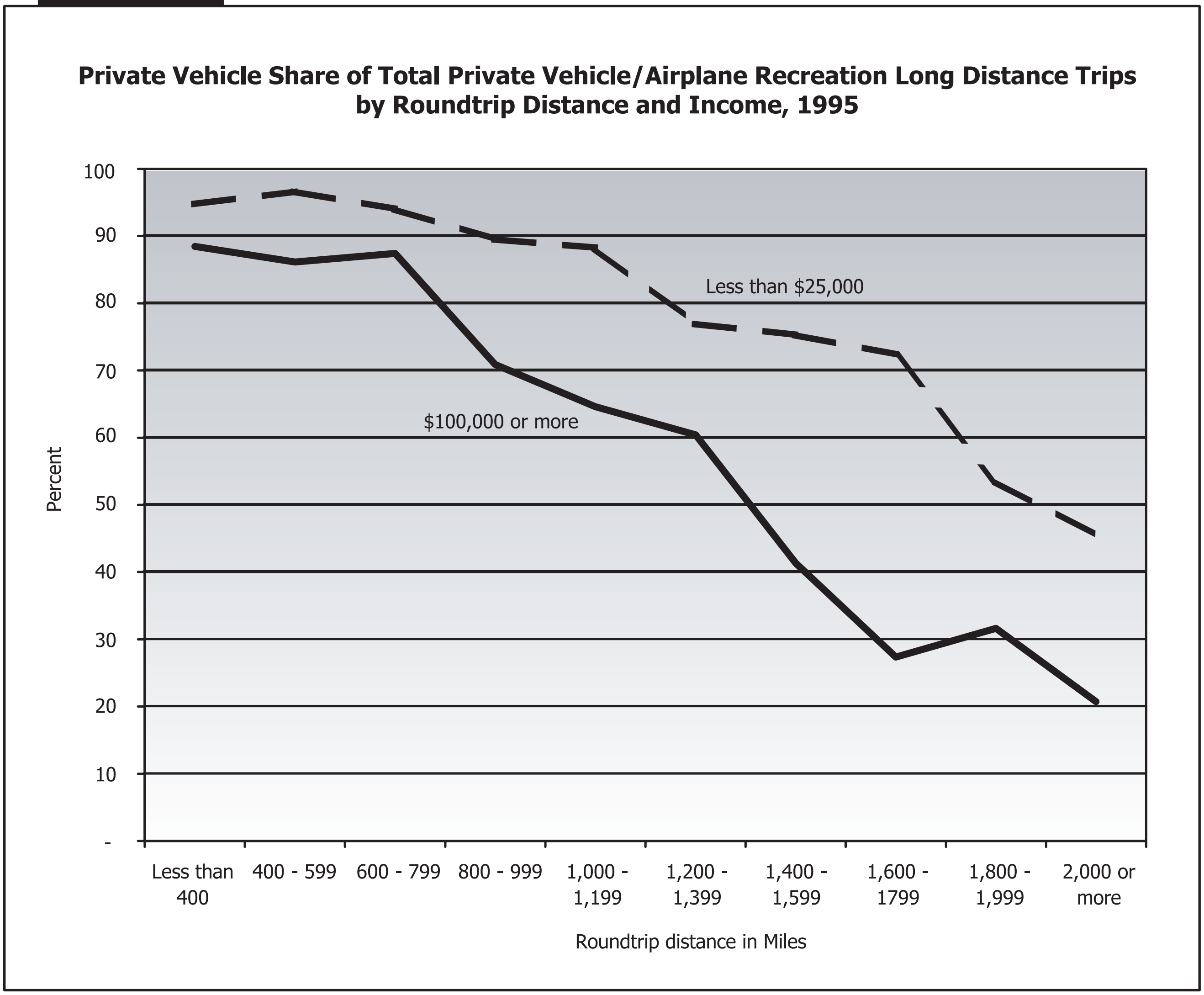
Trips for leisure are generally longer than other trips—42 percent of recreation and leisure trips are to places 500 miles away or more and the average trip length is 415 miles. More than 84 percent of recreational travelers use a personal vehicle for the trip, and if they travel on a weekend trip, more than 90 percent are in cars. (See Exhibit 13-6.)

Average travel party size is greater for recreation and leisure trips. For trips over 100 miles, 35 percent were made by two people, and 37 percent were made by three or more people.

People in low-income households (less than $25,000/year) are more dependent on private vehicles to make longer-distance recreational trips than those in higher-income households ($75,000 or more). The gap widens as trip length increases. For families who travel together, the auto is convenient and additional passengers (kids, neighbors, pets) add no extra transportation cost. (See Exhibit 13-7.)

Exhibit 13-8 shows that leisure travel is also very seasonal, with the majority of recreational trips made in the spring and summer. In the winter season, New Year's is a more popular time for leisure travel than either Thanksgiving or Christmas. During the five days surrounding New Year's Day, Americans make an average of 6.3 million trips per day.

Exhibit 13-7



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey, 1995.

During the coming years, a large segment of U.S. residents will retire from daily work, increasing the demand for more access to leisure activities. If today's mobile and affluent baby boomers insist on maintaining their mobility, high rates of leisure travel could occur. Future recreational travel may have a negative effect on the system. Therefore, our current strategies for coping with congestion may not be adequate since travel for recreation can occur at any hour of the day and in places that may not be prepared for large amounts of auto traffic.

Exhibit 13-8

Long-distance Travel by Season

	PERCENT OF ALL TRAVEL MILES
Winter	17
Spring	25
Summer	38
Fall	20

Source: American Travel Survey.

Household Transportation Expenditures

Highway transportation meets many household needs and represents a major household expense. Households spend more money, on average, on transportation than any other expenditure category except housing. Exhibit 13-9 shows that in 1999, households, on average, spent about

Exhibit 13-9

Consumer Expenditure Trends

YEAR	1984	1990	1999
Household Expenditure Categories			
Housing	30.4%	30.7%	32.6%
Transportation	19.6%	18.0%	18.9%
Food	15.0%	15.1%	13.6%
Personal insurance and pensions	8.6%	9.1%	9.3%
Apparel and services	6.0%	5.7%	4.7%
Health care	4.8%	5.2%	5.3%
Education	2.0%	2.0%	1.7%
Other	13.7%	14.1%	13.9%
Average annual household expenditures (current $)	$21,975	$28,381	$37,027

Sources: U.S. Department of Labor, Bureau of Labor Statistics, " Consumer Expenditure Survey," 1984– 1999.

$7,000 on transportation, or 18.9 percent of their total spending. This share was slightly lower than that in 1984 (the first year for which data are available).

Roughly 94 percent of household transportation expenditures went to purchase, maintain, and operate cars and other private vehicles. Purchased transportation services, including airline, intercity train and bus, and mass transit, accounted for less than 6 percent of household transportation expenditures in 1999. (See Exhibit 13-10.)

Measured in constant 1982 dollars, household transportation expenditures decreased 2 percent between 1984 and 1998. During the same period, vehicle-miles traveled per household increased about 27 percent, indicating that transportation had become cheaper to consumers.The age of the head of the household also influences transportation spending. Household transportation expenditures rise as the age of the head of the household increases, peaking between 45 years and 54 years of age and then decreasing. In 1999, for example, households in which the head of the household was between 45 years and 54 years of age spent, on average, $9,028 on transportation. Households in the under 25 years of age category spent a little more than half of that amount. Spending on transportation was lowest in households headed by people 75 years of age or older. However, transportation as a share of total household expenditures was highest in young households, averaging 23.2 percent. The percentage decreased gradually as age increased, reaching its lowest point at 14 percent for households in the 75 years and over age category.

Half of the transportation expenditures in young households went to purchase vehicles, compared with 37 percent for households in the oldest age group. Moreover, younger households spent a smaller share of transportation

Exhibit 13-10

Household Transportation Expenditures, 1999

Average annual household transportation expenditures (current $)	$7,011
Components and their shares	Percent
Vehicle purchases	47.1
Cars and trucks, used	23.4
Cars and trucks, new	23.2
Other vehicles	0.5
Gasoline and motor oil	15.0
Other vehicle expenses	32.1
Vehicle insurance	10.8
Maintenance and repairs	9.5
Vehicle rental, lease, license, and other charges	7.3
Vehicle finance charges	4.6
Purchased transportation services	5.7

Source: U.S. Department of Labor, Bureau of Labor Statistics, " Consumer Expenditure Survey," 1999.

expenditures on purchased transportation services, such as air travel, mass transit, and taxi fares.

Truck Travel

The logistical needs of business establishments are met by about 21 million trucks traveling more than 412 billion miles annually. The number and mileage of trucks by industry is shown in Exhibit 13-11.

Exhibit 13-11

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	0.0
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	14.0
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	0.0
For hire transportation	1,059.4	19.1	72,854.9	40.5	68.8	18.0
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.

In addition to truck travel, business make extensive and unmeasured use of automobiles and station wagons for sales and a host of other activities. Rental cars and taxis are the dominant mode of local travel in distant locations for business travelers once they leave the airport, and private vehicles are used heavily on business trips to reach destinations between 50 miles and 500 miles from home.

Future of Mobility

Society benefits from having a range of transportation choices. System diversity can help solve many specific transportation problems and create a more efficient, equitable, and robust transportation network. As our society addresses mobility, congestion, air quality and climate change issues, it is vital that research and innovation continues and that investments are made in new and existing infrastructure and operations.

The opportunities offered by transportation research include understanding the complex role travel plays in the American economy and society, the public's travel needs and behavior, and the effects of technology on travel and related behavior. Two sets of factors are worth highlighting: social and demographic changes, and environmental impacts.

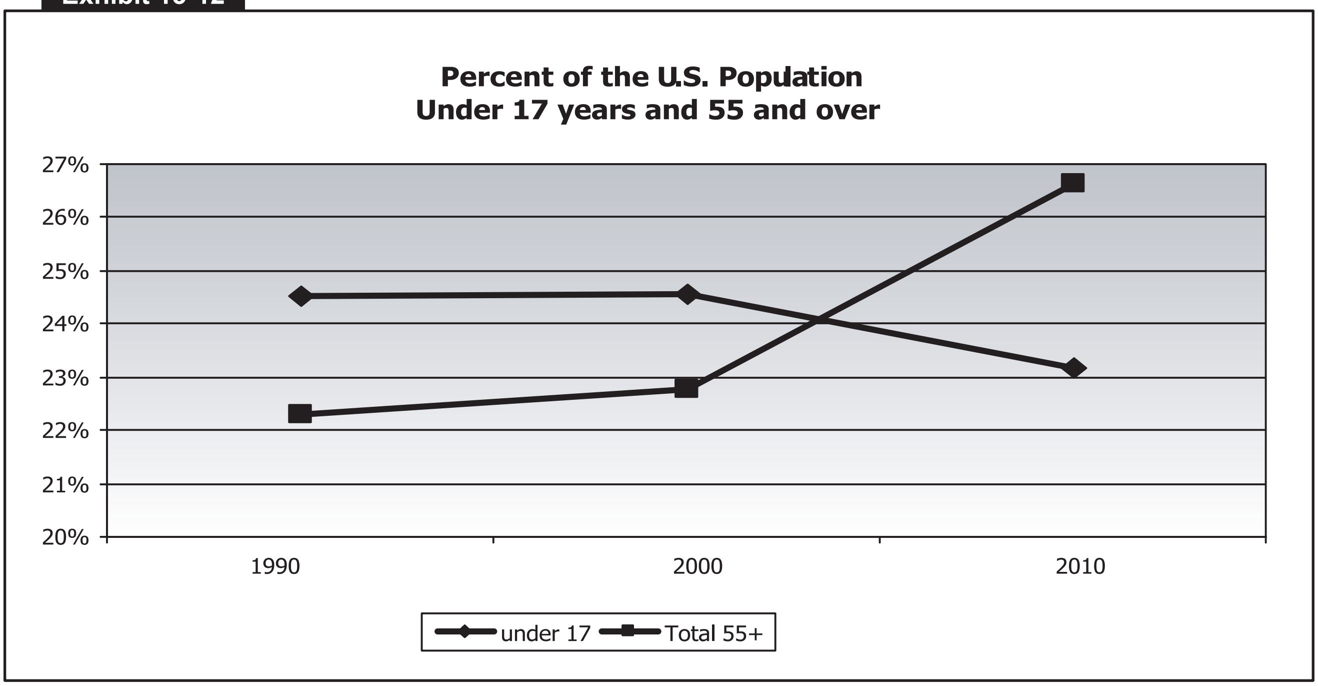
Societal and Demographic Factors

An Aging Population

In 2000 there were 55 million children under the age of 17 in the United States. Although children represent a smaller percentage of the population than they did during the peak of the baby boom, they account for a substantial portion of the population.

In contrast, there are 51.5 million people aged 55 and over—almost one out of four people in the United States. The median age of the American population rose form 28 in 1970 to 37 years old in 2000. The proportion of the population over 55 years old is projected to be nearly 30 percent by 2020.
(See Exhibit 13-12.)

Exhibit 13-12

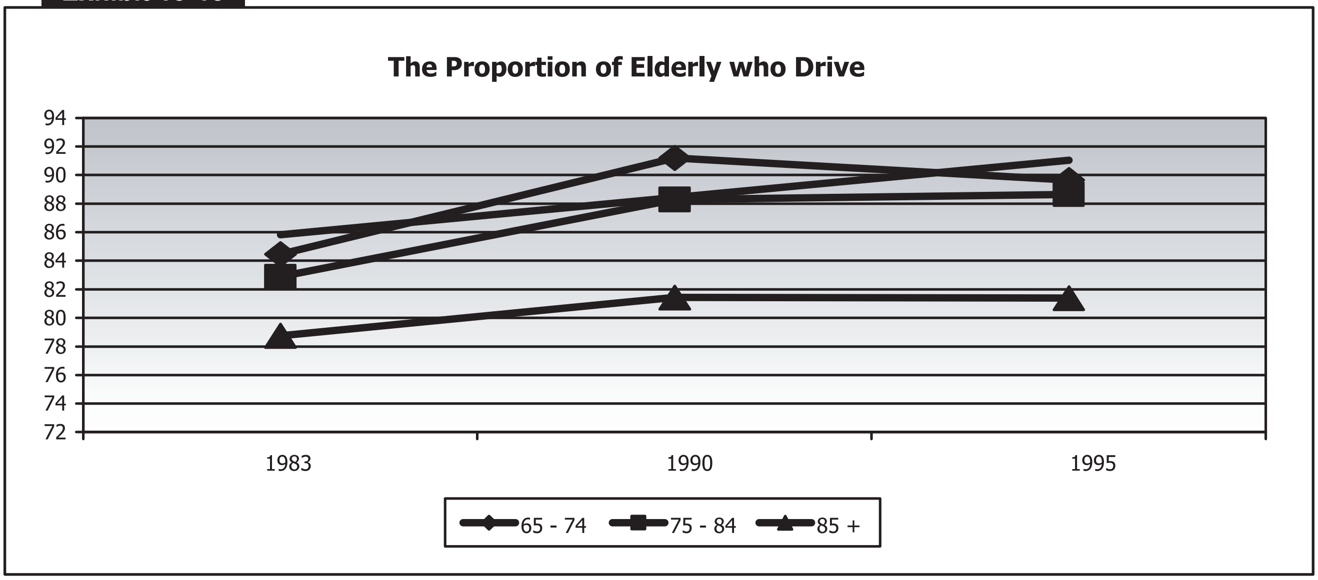


Source: Statistical Abstract of the U.S. 2001 U.S. Census Bureau.

The Nationwide Personal Transportation Survey (NPTS) describes the remarkable mobility that is part of the fabric of U.S. society. Much more needs to be done to ensure that all U.S. citizens have access to this mobility. Some groups continue to be disenfranchised from certain social and economic benefits. The survey data and related data sources show that less mobile groups—low-income, elderly, recent immigrants, physically handicapped, and, to some degree, people of color—do not have the same access to the range of goods and services that are available to groups with greater travel choices.

The NPTS shows that more elderly are driving well into their eighties and nineties. The aging of our population has profound implications for safety and travel. (See Exhibit 13-13.)

Exhibit 13-13



Source: Nationwide Personal Transportation Survey data series.

Furthermore, most people retire in their own neighborhoods. Therefore, the majority of elderly people now live in the suburbs and are more dependent on cars than previous generations. As driving skills decline with age, the vulnerability to injury in a collision increases. The mobility needs of older people will require alternatives to the automobile.

Environmental Factors

Changing personal travel and vehicle ownership patterns have profound implications for air quality, global climate changes, and energy policies. The effects of transportation on the natural environment have been a topic of much public discussion and debate in recent years. At the heart of the debate are air quality issues associated with the use of private vehicles.

The use of private vehicles has expanded over the last quarter century, particularly for single-occupant trips. In addition, two trends may have an impact on safety, air pollution, and energy consumption. They are the aging of the fleet and the substitution of vehicles classified as light duty trucks—pick-up trucks, vans, and sport/utility vehicles (SUVs)—for automobiles in household travel. The average household car is more than eight years old. The continued tendency to maintain older vehicles increases the time for market penetration by newer and cleaner cars. Exhibit 13-14 shows the average age of the vehicle fleet by vehicle type from 1977 to 1995. Average ages for individual light truck classes (vans, SUVs, and pick-ups) are not available.

Increased vehicle age can be attributed to the longer life span and greater durability of vehicles produced in the last decade and the significant price difference between new and used vehicles. As a result, the progressively tighter safety, fuel economy, and emissions standards that passenger vehicles are required to meet have been incorporated into the Nation's fleet more slowly than originally anticipated. These standards have typically been more stringent for automobiles than for light trucks, therefore the greater use of vans and SUVs also may affect these policies.

Air quality issues are discussed in more depth in Chapter 19.

Exhibit 13-14

Age of Household Vehicle Fleet by Vehicle Type (Years)

	1977	1983	1990	1995	PERCENT CHANGE 1977 - 1995
Auto	5.5	7.2	7.6	8.2	50%
Light Truck/Van	6.4	8.8	8.0	8.3	30%
Total Fleet	5.6	7.6	7.7	8.3	49%

Source: Nationwide Personal Transportation Survey data series.

Research Opportunities

This chapter highlights the importance of highway transportation as a share of household expenditures and as a component in the output of American businesses. These contributions are built on an effective transportation system that gets people and goods to desired destinations quickly and efficiently. As described elsewhere in this report, this quickness and efficiency is being challenged by delays from congestion, temporary losses of capacity, and the new focus on security measures. Additional research on the travel patterns of specific subsets of the traveling public can help transportation agencies to better anticipate and react to changing trends and meet public demands for efficient, equitable, and safe transportation mobility and access.

Q. Can We Walk to Get There?

A. Health specialists encourage walking as a method of incorporating activity into daily life. But, land use in most areas discourages walking: long distances to reach destinations, few continuous sidewalks, difficulty battling traffic, and perhaps the fear of crime may keep many people from walking for even short trips.

Trips of ½ mile or less in length account for 14.5 percent of all trips. Of these trips, 56.0 percent are made by private vehicle, 24.0 percent by walking, and the remainder by other means. Trips between ½ mile and 1 mile account for 27.3 percent of all trips. Of these trips, 69.5 percent are by private vehicle, 14.5 percent are by walking, and the remainder by other means.

Even so, walking is the second most common form of travel after auto travel. Society benefits from walking through reduced traffic congestion, environmental improvement, and consumer cost savings. Individuals benefit from walking through stress reduction and increased daily activity. Improving pedestrian conditions can benefit our nation as a whole.

Chapter 14

The Importance of Public Transportation

The Role of Mass Transit

Public transportation provides people with mobility and access to employment, community resources, medical care, and recreational opportunities in communities across America. It benefits those who choose to ride, as well as those who have no other choice: over 90 percent of public assistance recipients do not own a car and must rely on public transportation. Public transit provides a basic mobility service to these persons and to all others without access to a car.

The incorporation of public transportation options and considerations into broader economic and land use planning can also help a community expand business opportunities, reduce sprawl, and create a sense of community through transit-oriented development. By creating a locus for public activities, such development contributes to a sense of community and can enhance neighborhood safety and security. For these reasons, areas with good public transit systems are economically thriving communities and offer location advantages to businesses and individuals choosing to work or live in them. And in times of emergency, public transportation is critical to safe and efficient evacuation, providing the resiliency American needs in its emergency transportation network.

Public transportation also helps to reduce road congestion and travel times, air pollution, and energy and oil consumption, all of which benefit both riders and non-riders alike.

Transit Performance Monitoring System (TPMS)

To analyze the characteristics and benefits of transit, the Federal Transit Administration conducted surveys on car ownership, frequency of transit use, and transit trip purpose through the Transit Performance Monitoring System (TPMS). These surveys were conducted between 1996 and 1998 to gain information on how transit differs across geographic regions and cities of varying sizes. These surveys, or case studies of individual transit operators, were not designed to be statistically representative of national transit use or trends. Instead, what is presented here is an aggregation of the results of these case studies of 19 public transit authorities. The data collected have been analyzed on an aggregate basis as well as according to the subcategories of small, medium, and large cities, and large suburban areas. Statistics are trip-based and reflect a choice only for a particular trip. *[See Exhibit 14-1].*

Exhibit 14-1

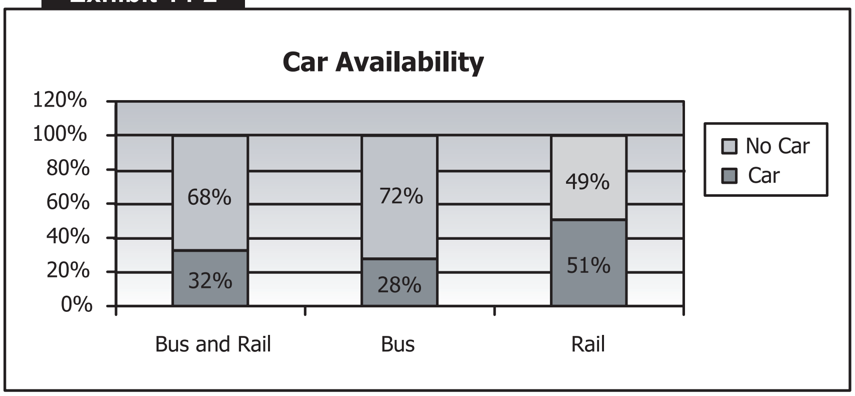
Categorization of Transit Authorities by the TPMS Project

CATEGORY	POPULATION	NO. OF VEHICLES	NUMBER OF PARTICIPATING AGENCIES
Small city	Less than 500,000	Less than 100	6
Medium city	500,000 - 1,500,000	100 - 500	5
Large city	1,500,000 +	500 +	5
Large Suburban area	Areas adjacent to a large city. Not determined on the basis of population and number of vehicles.		3

User Characteristics

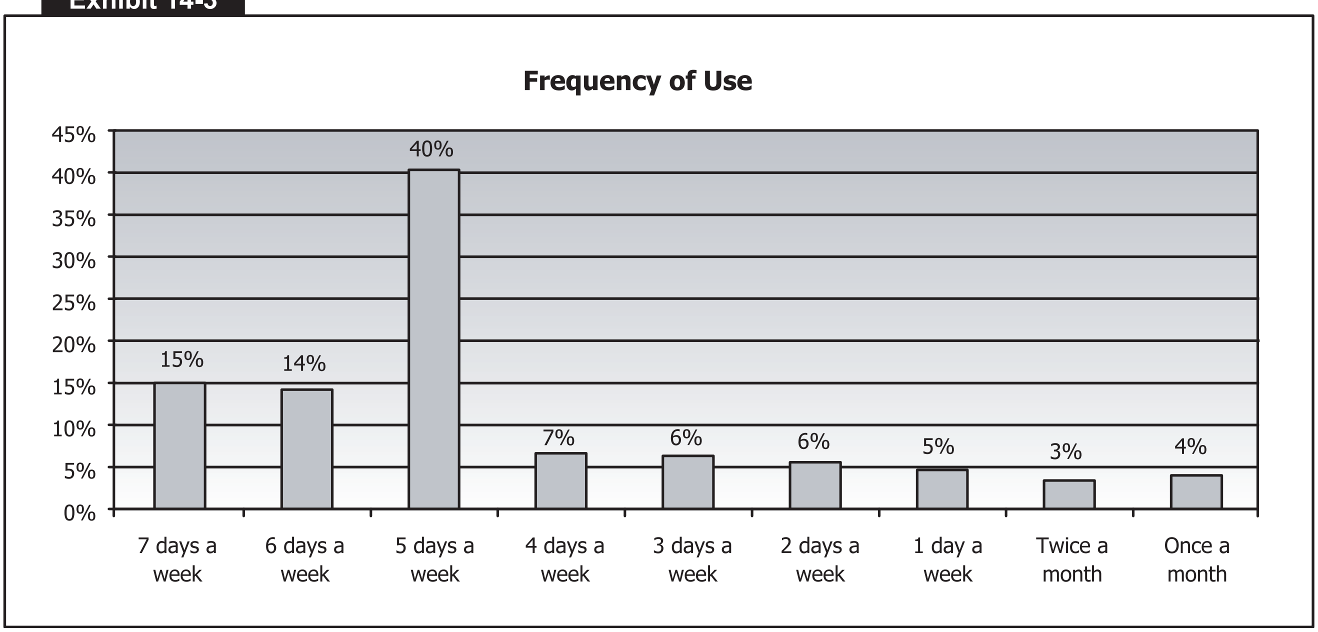
***Car Availability*—Many transit users do not have access to a car at the time they use transit.** Seventy-two percent of bus users, 49 percent of rail users, and 68 percent of all users surveyed did not have access to a car at the time the trip was made. The lower percentages for rail suggest that the existing rail services capture a higher percentage of choice riders, i.e., people with a car available at the time the trip was made. *[See Exhibit 14-2]*.

Exhibit 14-2



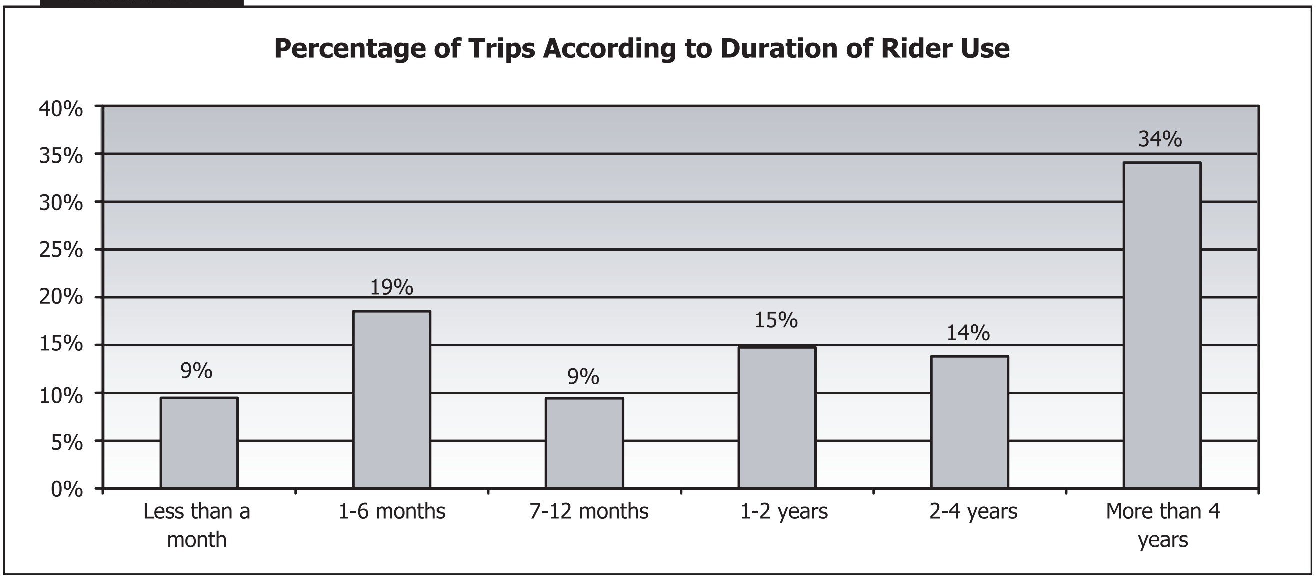
***Frequency of Use*—Most transit trips are made by riders who use transit frequently.** Slightly more than 70 percent of all the transit trips in the TPMS surveys were made by passengers using transit 5 days or more a week. Forty percent of the trips surveyed were made by passengers using transit 5 days a week, 14 percent by passengers using transit 6 days a week, and 15 percent by passengers using transit 7 days a week. **However, the majority of transit riders use transit infrequently.** Almost 70 percent of the people who had used transit during the month had ridden on it 4 days or less per week. These infrequent riders, though numerous, make less than 30 percent of all transit trips. *[See Exhibit 14-3]*.

Exhibit 14-3



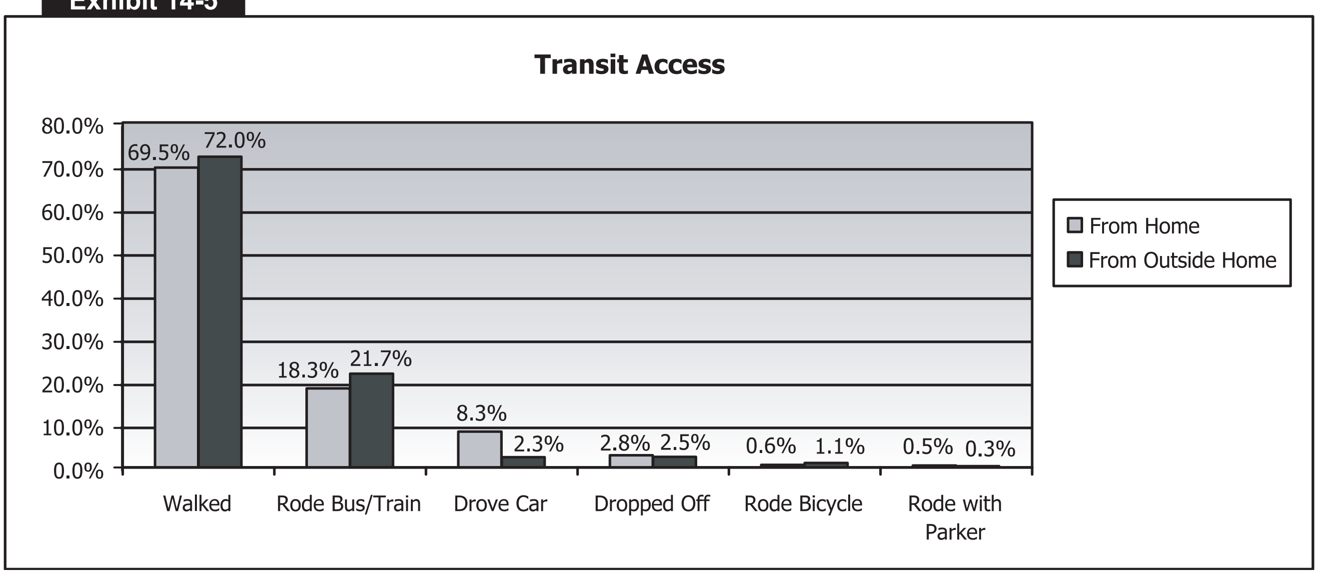
***Duration of Use*—Passengers making thirty-five percent of the trips surveyed reported that they had been using transit for more than 4 years.** This suggests that thirty percent of all transit trips provide a level of service that is better than or comparable to the automobile. However, most transit trips (65 percent) are by passengers who have been using transit for less than four years. Thirty percent of all trips were by passengers who had been using transit for less than one year, and 10 percent by passengers using transit for less than a month. For these persons, transit may be serving as a temporary means of transportation until they are able to purchase a car. Transit may also serve as a temporary means of transportation to persons having their private vehicles repaired. *[See Exhibit 14-4]*.

Exhibit 14-4



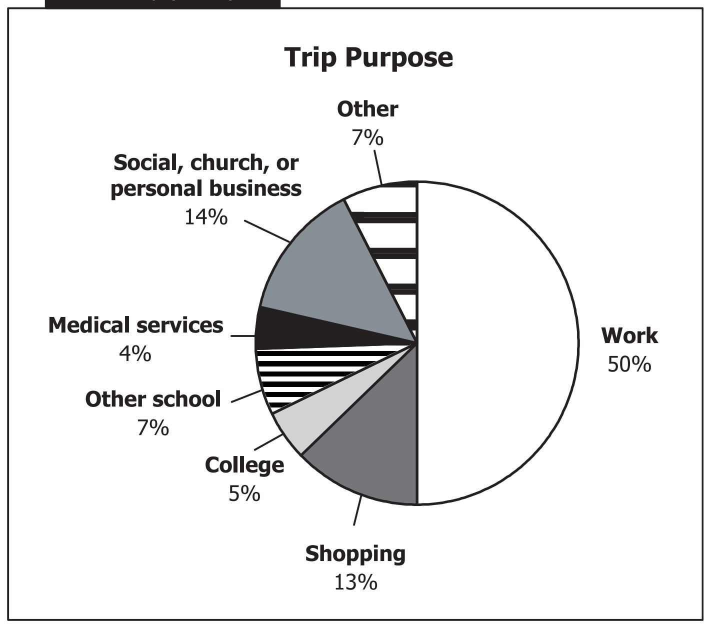
***Transit Access*—Transit principally serves those within walking distance of a transit line**. The most frequently reported way of reaching transit was by walking, with about 70 percent of all those surveyed starting their transit trip in this way. Eighteen percent of those surveyed were continuing a trip that had begun on a bus or train, 8 percent drove a car to access transit, and 3 percent were dropped off. Transit use was less frequent and travel by car more frequent for passengers accessing transit from home compared to those that were accessing it away from home, although the differences were small. *[See Exhibit 14-5]*.

Exhibit 14-5



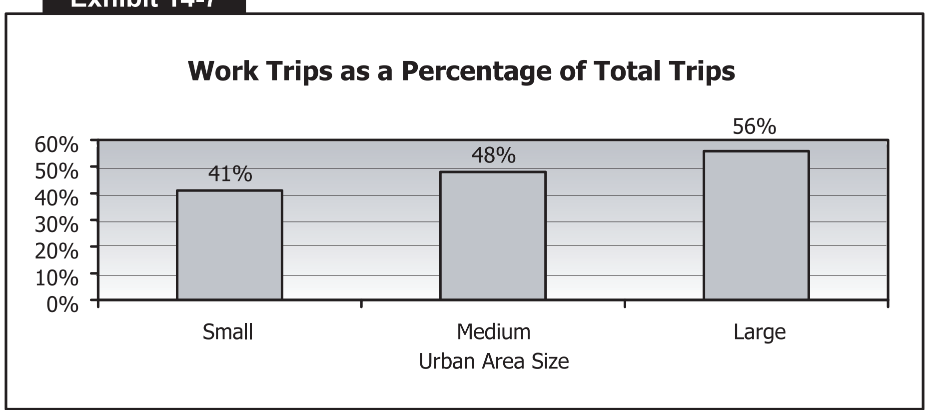
***Trip Purpose*—Work accounts for the largest percentage of transit trips.** Fifty percent of all passengers surveyed were on their way to or from work. Transit also enables people to pursue educational opportunities; 12 percent of all users surveyed were on their way to or from college or other type of school. Four percent were traveling to obtain medical services, 13 percent to go shopping and 14 percent were on their way to or from a social event or place of worship or attending to other personal business. *[See Exhibit 14-6]*.

Exhibit 14-6



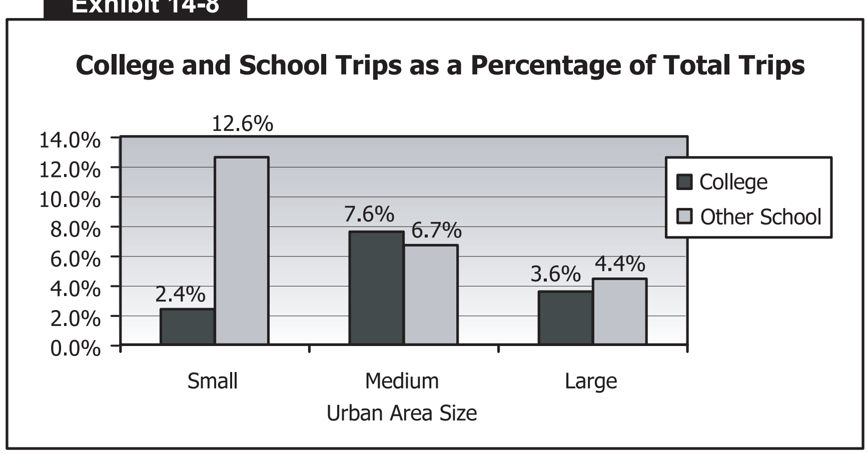
Work Trips—Although transit provides a principal means of traveling to and from work in all urban areas, **transit trips for work purposes appear to account for a an increasingly larger percentage of total transit trips as the size of an urban area increases.** Fifty-six percent of all transit passengers surveyed in large urban areas were using transit for work purposes compared with 48 percent in medium, and 41 percent in small urban areas. In larger urban areas, transit is more likely to offer residents with transit accessibility a better level of service than an automobile during congested commuting time periods. (Note that the 1995 Nationwide Personal Transportation Survey reported that thirty-five percent of all transit trips were for work and two percent for work-related business.) *[See Exhibit 14-7]*.

Exhibit 14-7



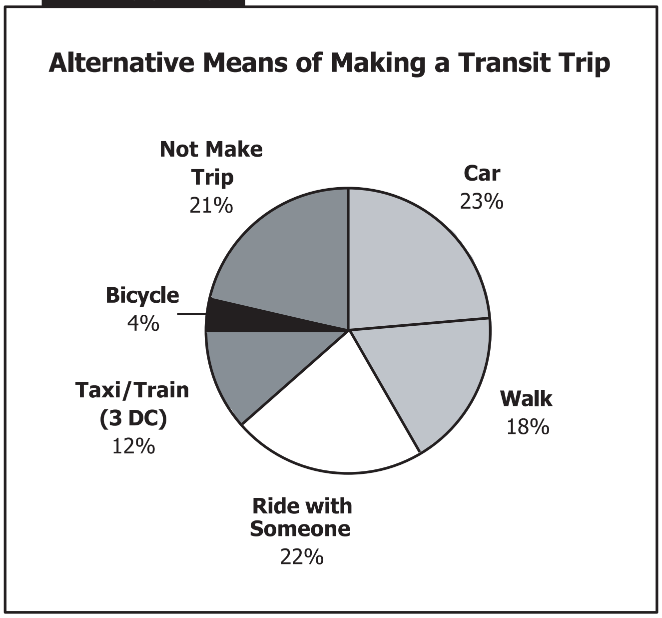
Transit Trips to College or Other School—Transit appears to be a more important means of traveling to and from college and school in small and medium sized urban areas and a less important means in large urban areas. *[See Exhibit 14-8]* Fifteen percent of all users surveyed in small urban areas and 14.3 percent of all users surveyed in medium urban areas were

Exhibit 14-8



traveling to or from college or other schools compared with 8 percent in large urban areas. Passengers surveyed in small urban areas made far more trips to other schools as opposed to college, while in medium-size and large urban areas trips were split more evenly between the two.

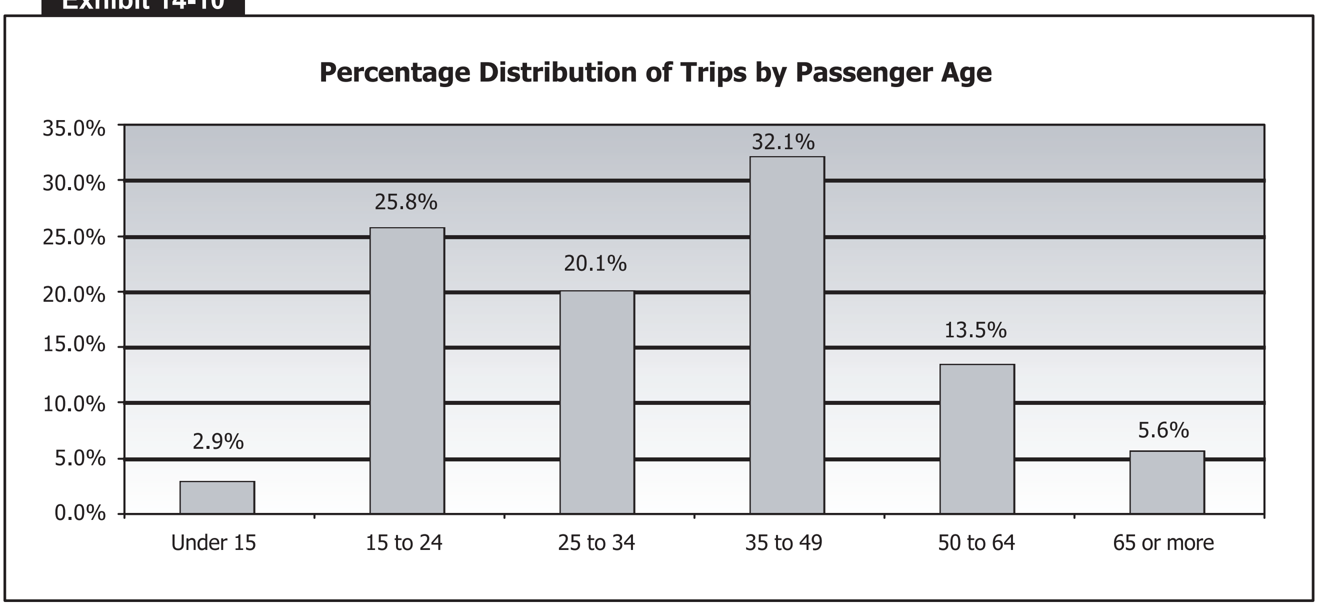
Exhibit 14-9



Alternative Mode of Travel—Users surveyed were asked how they would have made their trip if transit had not been available. Eighteen percent of the passengers surveyed would have walked. Forty-five percent responded that they would have taken a car, of which about half would have driven themselves and half would have driven with someone else. These numbers indicate that transit makes an important contribution to mitigating road congestion. **The availability of transit was particularly crucial to the 21 percent who reported that without transit they would not have made the trip at all.** This result demonstrates the importance of transit in providing certain segments of society with basic mobility. *[See Exhibit 14-9]*.

Gender and Age—Women appear to use transit on a slightly more frequent basis than men. Fifty-five percent of the trips surveyed were by women and 45 percent by men. Fifty-nine percent of all bus users and 52 percent of all rail users were women. Transit also appears to serve those with sufficient personal independence to travel on their own, although it should be noted that passengers under the age of 12 were not surveyed. More than 90 percent of trips were made by passengers between the ages of 15 and 64. Sixty-six percent of the trips surveyed were made by passengers between the ages of 25 and 64, the period of life during which labor force participation rates are highest. Twenty percent were by passengers between the ages of 15 and 24, most likely for work, school or social purposes. *[See Exhibit 14-10]*.

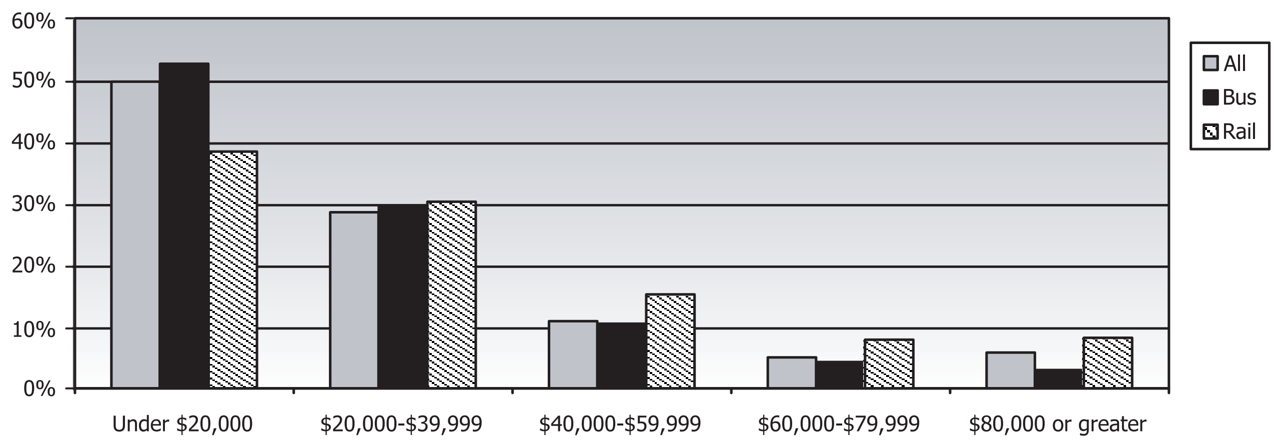
Exhibit 14-10



***Income Distribution*—The availability of public transportation is particularly important to people with limited incomes.** In 2000, the U.S. Bureau of the Census reported a poverty level income threshold for a family of four of $17,600, and for a family of one, $8,794. Since information on household size was not collected as a part of the TPMS along with household income, it is impossible to say what percentage of passenger trips were accounted for by people from households below the poverty line. It is clear, however, that transit plays a more important role for people with limited incomes. Fifty percent of the trips surveyed were by passengers from households with incomes of $20,000 or less. These users (with incomes under $20,000) account for a larger percent of users of small transit systems (63.3 percent), than of medium (50.6 percent) and large (41.0 percent) systems. This may reflect the ability of large systems to attract "choice" riders—people with cars available—who typically have moderate to high incomes. Bus service is relatively more important than rail service at lower income levels, while the reverse is true as incomes increase. Twelve percent of the rail trips were by passengers with household incomes of $80,000 or more compared with 3 percent of the bus trips. *[See Exhibit 14-11].*

Exhibit 14-11

Distribution of Trips by Passenger Household Income Level
All Trips, Bus Trips and Rail Trips



Public Policy Benefits of Transit

As discussed the first paragraph of this chapter and in Chapter 1, transit provides a wide range of benefits to communities, including access to employment and a wide range of community resources and services. Public transportation contributes to a healthier environment by improving air quality and reducing oil consumption, and through better land-use policies. It also helps to expand business development and work opportunities. And, it is critical for emergency situations requiring safe and efficient evacuation.

Data gathered through TPMS are unable to characterize the full contribution of public transportation to the Nation and all of the associated benefits that it provides. However, TPMS is able to provide additional insight into how transit provides one or more of a much more narrowly defined set of benefits to individual transit riders. Transit may provide ***basic mobility*** to a rider who has no other means of transportation available; it may provide ***location efficiency*** through easy access to employment or other community resources; or it may provide ***congestion mitigation*** during peak work travel times. To determine how transit benefited riders, 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, each transit trip provided more than one benefit. *[See Exhibit 14-12].*

Exhibit 14-12

Classification of Transit Trips by Public Benefit Provided

PUBLIC BENEFIT	CAR	WORK	MAKE TRIP WITHOUT TRANSIT
Congestion Mitigation	Yes	Yes	Yes
Congestion Mitigation	Yes	Yes	No
Congestion Mitigation & Location Efficiency	Yes	No	Yes
Congestion Mitigation & Location Efficiency	Yes	No	No
Mobility & Congestion Mitigation	No	Yes	Yes
Mobility	No	Yes	No
Mobility & Location Efficiency	No	No	Yes
Mobility & Location Efficiency	No	No	No

On the basis of these categorizations:

- Thirty six percent of all transit trips provided mobility and location efficiency benefits to passengers without cars who chose to make a non-work trip by transit because they lived in an area with highly accessible transit services. *[See Exhibit 14-13].*

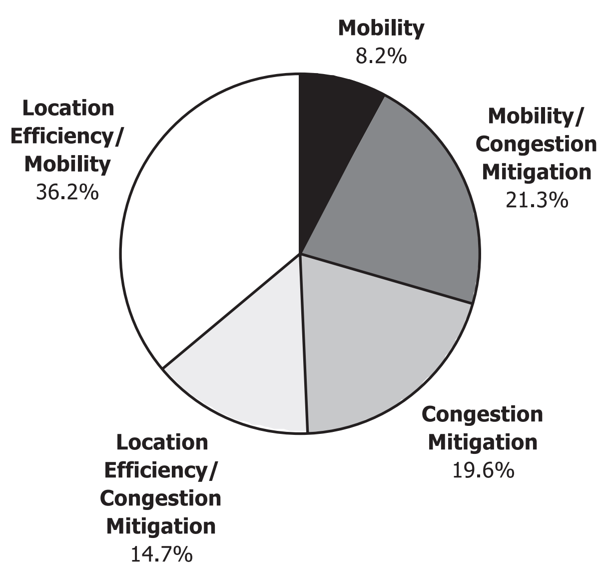
- Twenty one percent of all trips provided basic mobility and congestion mitigation to passengers without access to a car, traveling during peak travel times, and congestion mitigation only to non-transit travelers traveling in the same corridor at the same time.

- Twenty percent of all trips provided congestion mitigation only. These were work trips, some of which would have been made and some of which would not have been made without transit. This measure may overstate the congestion mitigation benefit as not all work trips are made at peak travel times. Transit trips made during congested periods provide benefits not only to transit passengers, but to other people traveling by road in the same corridor at the same time.

- Fifteen percent of all trips provided congestion mitigation and location efficiency. These trips were made because the passenger lived in an area highly accessible to transit. In these

Exhibit 14-13

Benefits of Transit to Riders



cases, the passenger traveling had access to a car, but would have chosen to miss work without the availability of transit. These transit trips also provided congestion mitigation benefits to people traveling by car at the same time in the same corridor.

- Eight percent of all trips have been categorized as providing basic mobility. These passengers reported that they had no access to a car, but would have made the trip even if transit services were not available. (No information is available on what mode of transport these passengers would have used without transit.)

Exhibit 14-14

Participating Transit Systems
(Round 1 = non-Italics; Round 2 = *Italics*)

Service Area Population	REGION: WEST	MIDWEST	EAST
Less than 500,000	*Juneau, Alaska* [1] *Corpus Christi, Texas* [1]	Grand Rapids [1] Michigan [1] Kenosha, Wisconsin [1] Lincoln, Nebraska [1]	*Huntington, West Virginia* [1]
500,001 to 1,250,000	Austin, Texas [1] Portland, Oregon [2] Sacramento, California [1]	*Louisville, Kentucky* [1]	*Buffalo, New York* [2]
Over 1,250,000	*Phoenix, Arizona* [1] *North San Diego, California* [1/3]	Chicago, Illinois [2] *Cleveland, Ohio* [2]	Pittsburgh, Pennsylvania [2] *Washington, DC* [2] *Prince George's County, Maryland* [1/3] *Montgomery County, Maryland* [1/3]

[1] Bus only
[2] Bus and Rail
[3] "Large Suburban" systems are part of a large metropolitan area, serving a particular suburban area.

Chapter 15

Macroeconomic Benefits of Highway Investment

Introduction

The economic benefits of transportation infrastructure investment have traditionally been measured at the project level, relying on concepts and measurement techniques drawn from benefit-cost analysis. In recent years, however, there has been growing interest in measuring the overall contribution of transportation investments in general to the economy, by measuring such effects at the macroeconomic level. Extensive research conducted during the past decade has attempted to identify and measure the relationship between the amount of transportation infrastructure and aggregate economic activity.

While not addressed in this chapter, it is important to note that there are also external disbenefits of infrastructure investments that should be considered in any comprehensive benefit cost analysis. The impacts of highway and transit investments on air quality are discussed in Chapter 19.

Sources of Macroeconomic Benefits

Traditional benefit-cost analysis tools such as the Highway Economic Requirements System (HERS) used in this report focus on reductions in vehicle operating costs, the economic value of savings in travel time experienced by facility users, and benefits from the increased use of highways that are induced by these facility improvements. (See Chapter 7 and Appendix A.) User benefits include time and cost savings in both personal and business travel, as well as savings that result from faster and less costly movement of freight by trucks. Conventional benefit measures also include reductions in costs to public agencies for road maintenance and the economic value of reductions in property damages and injury costs resulting from less frequent accidents. More recent tools such as HERS may also include any changes in the economic costs of environmental impacts (such as air pollution or noise) caused by highway vehicles in their analysis.

The effects of highway investments on aggregate economic activity arise from the complex workings of a market economy. Economic players translate the increased supply of highway capital (and the resulting reductions in transportation costs) into reductions in firms' cost of production and distribution. Firms may also respond to the resulting increase in the level of service the highway system provides by changing their use of other inputs or altering their production processes in ways that further reduce their production and distribution costs. Furthermore, producer cost savings may be reflected in lower market prices and higher output levels for the wide range of products and services that depend on transportation infrastructure.

Macroeconomic measures of highway investment benefits for the production sector capture the total savings in firms' production and distribution costs that result directly from an increased supply of highway capital. One major advantage of measuring highway investment benefits from an economy-wide perspective is that it may be possible to capture the total benefits from a continuing program of highway investments by all levels of government, without requiring detailed evaluation of individual projects. Carefully conducted macroeconomic benefit studies offer a useful approach for estimating the aggregate value of an overall program of highway investments, thus providing an important source of evidence on the total economic return these investments generate.

Investments in highway capital may also generate important macroeconomic benefits in addition to direct savings in transportation cost. Increases in the highway capital stock may also improve the productivity of labor or increase the return on private capital investment, thus increasing the amount of goods and services that can be produced using the resources that are available to the economy. By increasing the productivity of labor and private capital, highway investment could allow overall economic activity to grow more rapidly than demographic and technological progress alone would allow. If increases in the value of the Nation's highway capital stock raise the productivity of private inputs, the aggregate or macroeconomic returns to investments in highways may exceed those that would be captured using conventional measures of highway user and related benefits, perhaps by a significant margin.

Macroeconomic and User Benefit Measures

Despite similar objectives, macroeconomic measures of investment benefits are likely to differ somewhat from the highway user benefit measures that are the focus of benefit-cost evaluations (such as HERS). One of the key differences between the two approaches is that macroeconomic measures reflect market outcomes at the regional or national level, while microeconomic approaches may include valuations of benefits that do not result from market activity. For example, project-level economic evaluation recognizes certain highway user benefits that will not be captured by measures based on national income or output measures, since national income accounting does not include the value of time spent in unpaid household activities. Thus, the economic value of time savings in personal travel will be omitted from macroeconomic benefit measures, causing them to underestimate benefits from highway investments. The value of reducing highway fatalities, as reflected in the willingness to pay for reductions in life-threatening risk, is also omitted from such macroeconomic analyses.

On the other hand, macroeconomic approaches may capture some potentially significant benefits of highway investments that are omitted from the user benefit evaluation of highway improvements conducted by HERS. One of these is the improved reliability of transportation service that results when a highway investment reduces the variability of travel time for passenger trips or freight shipments between specific origins and destinations. Investments in highway infrastructure can reduce travel time variability by increasing the capacity of congested facilities, reducing the frequency of traffic accidents or other incidents that cause unexpected delays, or improving the "connectivity" of highway networks to provide alternative routes that allow travelers and freight vehicles to avoid delays. More reliable travel reduces the extra time that shippers must allow for to ensure that deliveries will be received on time even when delayed en route. Benefit measures that employ direct estimates of economy-wide savings in firms' logistics and distribution expenses may be able to capture the reorganization benefits that stem from both faster and more reliable shipment times.

Another category of returns from highway investments that may not be adequately reflected in typical user benefit estimates is the gain in economic welfare from increased competition in markets where suppliers of a product previously exercised monopoly power. By lowering transportation costs and reducing the delivered prices of products, investments in highway infrastructure can expand firms' geographic market areas, thus allowing them to introduce new sources of supply into more distant markets. The resulting savings in highway users' travel time and other transportation costs will indirectly capture the value of reductions in the prices of products delivered to these more distant markets, as well as of the resulting increase in demand for them. However, if local producers were previously able to charge higher prices for these products due to the absence of alternative sources of supply, any further reduction in prices caused by the increased competition that lower-cost transportation permits represents an additional benefit that may not be fully reflected in user benefits measures. Macroeconomic approaches may again offer the potential to capture this additional benefit, but the specific measures used must be carefully constructed in order to appropriately estimate it.

Research on Macroeconomic Benefits

Early studies of benefits resulting from transportation infrastructure investments used measures derived from national income and product accounts to estimate the aggregate benefits generated by investments in highways. While some of these studies estimated very large returns to highway investment, the specific economic mechanisms that might have produced these benefits often remained unclear. More recent research has attempted to identify the mechanisms through which highway investment can influence macroeconomic measures such as aggregate firm or industry production costs or economy-wide productivity growth, and to develop empirical estimates of the magnitude and economic value of these effects. Some recent research has estimated significant macroeconomic effects of highway spending, which in turn imply very high economic rates of return on historical investments in the Nation's highway infrastructure.

The Federal Highway Administration (FHWA) has been a major sponsor of recent research on macroeconomic approaches to measuring highway investment benefits. This research is intended to improve measures of economic returns from historical and prospective future investments in highway infrastructure, as well as to improve the transportation community's understanding of the specific mechanisms through which infrastructure investments affect the overall performance of the Nation's economy. Some of the most highly regarded studies of the magnitude of highway investment benefits and the economic mechanisms that generate these macroeconomic benefits have been produced through this effort.

A 1996 study conducted by Nadiri and Mamuneas under FHWA sponsorship developed a sophisticated econometric model of the influence of highway capital investment on firms' productivity and costs, and applied this model at both the detailed industry and economy-wide levels to estimate significant economic returns from highway investment. A more recent (1999) FHWA-sponsored study by Nadiri expanded the previous model to include benefits from the reductions in product prices and increased consumption that result when lower production costs are passed through to consumers. Using this more comprehensive model of highway investment benefits, Nadiri concluded that economic returns to highway investment were very high (perhaps exceeding 50 percent) during the 1960s, but subsequently declined to approximately the average rate of return on private capital (16—17 percent) during the 1980s. Under FHWA sponsorship, Nadiri has also conducted a more recent analysis of benefits to the household sector of the economy from highway investments. A future project will attempt to link the analysis of the production and consumption sectors together in a general equilibrium framework.

The FHWA continues to support additional research on other macroeconomic or aggregate approaches to measuring benefits from highway investments, and to adapt its microeconomic analysis tools to incorporate non-traditional benefit concepts. For example, the addition of incident delay (valued at a premium over routine travel time) in the benefit calculations in HERS is an attempt to address some of the benefits of improvements in highway system reliability. (See Appendix A.) Another major research effort under FHWA sponsorship is attempting to develop a conceptually sound and empirically practical approach to estimating highway investment benefits by measuring savings in firms' logistics costs that result from additions to highway infrastructure. Finally, attempts may be made to link HERS outputs to models of regional economic development that use measures of highway conditions and performance as an input.

Chapter 16

Pricing

Introduction

As discussed in Chapter 4, congestion on America's highways has been increasing in recent years as the growth in demand for highway usage has exceeded increases in road capacity. One approach to addressing the imbalance between supply and demand is to increase supply through highway system expansion. In recent years, however, there has been increased focus on factors influencing travel demand, particularly on the prices that highway users pay.

As discussed in Chapter 6, highways are funded primarily through a combination of fuel taxes, registration fees, tolls, and other taxes. Highway users also face other costs, such as vehicle operating costs and time costs, when using the roads. If the costs paid by drivers for making a trip are too low relative to the actual costs to society of that trip, however, then highways may be subject to overuse. This "underpricing" of highway use may occur for several different reasons:

- Drivers may not take into account the costs that their highway use imposes on others, such as environmental damage caused by using their vehicles. Also, highway users may only consider their own travel time in their trip-making decision, and not the additional delays that their use of a congested highway imposes on others.

- Highways generally have excess capacity in off-peak periods. The cost of providing the extra capacity needed for peak periods of heavy use can be substantial, however. For example, a 1992 study found that average construction costs for adding lanes in built-up urban areas amount to over 30 cents (in today's dollars) per mile driven on the added lanes during the peak periods that the lanes are most needed. However, variable user charges for highway use in the form of fuel taxes (which do not vary much based on when and where the motorist drives) average only 2 cents per mile.

- Some costs, such as auto insurance, may be paid for in fixed lump sums that do not correspond to actual use of the vehicle. As a result, the incremental cost of additional travel may be very low, thus encouraging overuse of the vehicle.

Road pricing involves adopting market principles to bring transportation supply and demand into balance. It typically entails fees or tolls for road use that vary with the level of congestion, which may be assessed electronically to eliminate delays associated with manual toll collection. It can shift some trips to off-peak times, less-congested routes, or alternative modes, or cause some lower-valued trips to be combined with other trips or be eliminated altogether. This concept of assessing relatively higher prices for travel during peak periods is the same as that used in many other sectors of the economy to respond to peak-use demands. For example, airlines offer off-peak discounts and hotels charge more during peak tourist seasons.

The promise of more rational pricing of transportation facilities is that it will lead to improved service for transportation users, more productive use of existing transportation capacity, and reduced need for future capacity expansion. A shift in a relatively small proportion of peak-period trips can lead to substantial reductions in overall congestion. And while congestion charges create incentives for more efficient use of existing capacity, they also provide improved indicators of the potential need for future capacity expansion. In addition, while pricing can create incentives for more efficient and productive use of highway capacity, it can generate revenues that can be used to further enhance urban mobility. Pricing can also bring about a more equitable distribution of the costs of highway capacity and usage among drivers and taxpayers.

Through pricing, highway officials manage the transportation system more effectively by improving its efficiency. In this regard, pricing may be considered a "demand side" counterpart to some of the highway operations strategies discussed in Chapter 21.

While this chapter focuses primarily on the technical aspects of pricing projects, the public acceptability of such projects is also a key consideration. This topic is covered in a separate biennial report to Congress, the "Report on the Value Pricing Pilot Program", required by Section 1012 of the Intermodal Surface Transportation Efficiency Act of 1991.

Types of Pricing Projects

There are many kinds of pricing projects. Most of these involve the introduction of variable tolls on existing toll facilities, added highway lanes, or existing free roads. Others include the conversion of high occupancy vehicle (HOV) lanes to high occupancy/toll (HOT) lanes, fast and intertwined regular (FAIR) lanes, and mileage-based pricing. Many of these projects have been implemented in recent years while others are being considered by State and local governments and other highway authorities.

Variable Tolls on Existing Toll Facilities

On existing toll facilities, the tolls paid by drivers have typically varied by vehicle type and by trip length. Under pricing, however, these tolls may be varied by the time of day as well, to account for higher levels of congestion in peak periods. Recent examples of this approach include:

- Midpoint and Cape Coral bridges in Ft. Myers, Florida
- New Jersey Turnpike and Garden State Parkway, New Jersey
- Port Authority of New York and New Jersey bridges and tunnels
- San Joaquin Hills Toll Road in Orange County, California

The New Jersey Turnpike Authority and the Port Authority of New York and New Jersey launched variable tolling strategies in 2000-2001. The Turnpike program provides for tolls about seven percent lower during off-peak hours than during peak periods for users of the electronic toll collection system, while the Port Authority charges off-peak tolls 20 percent less than peak period tolls on its bridges and tunnels.

Early results from these two projects indicated that variable tolling has had an impact on travel behavior. In New Jersey, recent traffic increases on the Turnpike have been smaller in the morning and evening rush hours than in off peak periods. In New York, traffic has been reduced in the morning and afternoon peak, and has especially increased in the "shoulder period" just prior to 6:00 AM when the tolls are increased.

Variable Tolls on Added Highway Lanes

Pricing may be especially appropriate on new lanes added during a highway capacity expansion. The prime example of this strategy is SR 91 in Orange County, California. The SR 91 Express Lanes opened in December 1995 as a four-lane toll facility in the median of a 10-mile section of one of the most heavily congested highways in the U.S. Tolls on the Express Lanes vary by direction, time of day, and day of the week. The tolls are set to reflect the level of congestion delay avoided in the adjacent free lanes, and to maintain free-flow traffic conditions on the toll lanes. Tolls are collected electronically, and vehicles with three or more occupants pay a reduced toll.

Conversion of HOV Lanes to HOT Lanes

Another pricing strategy is to establish high occupancy toll (HOT) lanes on existing underutilized high occupancy vehicle (HOV) lanes. Under this approach, peak period tolls are charged to drivers of vehicles who choose to use the HOV lanes but do not meet the occupancy requirements. Examples include the HOT lanes on I-15 in San Diego, California, and I-10 and U.S. 290 in Houston, Texas.

Under San Diego's I-15 pricing program, customers in single-occupant vehicles pay a fee each time they use the I-15 HOV lanes. Tolls are collected electronically. A unique feature of this pilot project is that tolls vary dynamically with the level of congestion on the HOV lanes, with fees varying in 25 cent increments as often as every six minutes to help maintain free-flow traffic conditions on the HOV lanes. Toll revenues support express bus service in the corridor. The pricing policy has been effective in spreading traffic over the peak period and in shifting some traffic out of the peak into the off-peak periods.

Another advantage of the pricing schemes on SR 91 and I-15 is that they provide an option for premium service that a motorist can use when needing to be on time for a business or personal appointment, or when a parent needs to avoid day care late fees. Studies have found that such users of the two toll facilities include significant numbers of low- and medium-income drivers, and that there is broad support among all highway users in the corridors for the toll policies.

FAIR Lanes

A new pricing concept called Fast and Intertwined Regular (FAIR) lanes was developed by FHWA to overcome equity concerns that sometimes surround efforts to implement variable tolls on previously untolled highway capacity. FAIR lanes involve separating congested freeway lanes into two sections, fast lanes and regular lanes. The separation may be done with methods as simple as using plastic pylons and lane striping. The fast lanes would be electronically tolled, with tolls set in real time to ensure that traffic moves at the maximum allowable free-flow speed. Users of the regular lanes would still face congested conditions, but would be eligible to receive credits if their vehicles had electronic toll tags. The credits would be a form of compensation for giving up the right to use the lanes that had been converted to fast lanes. The credits could be used as toll payments on days when a traveler chooses to use the fast lanes, or as payments for transit or paratransit services, which would be subsidized using toll revenues from the fast lanes.

Other Pricing Concepts

In addition to road-use charges, there are other pricing concepts which rely on market principles to reduce peak period driving. For example, **mileage-based pricing** involves varying normally fixed vehicle use costs by extent of usage. Such strategies provide an incentive to motorists to save money by reducing their use of private vehicles. Examples of this type of pricing concept are "pay-as-you-drive" automobile insurance and car sharing (which involves substituting car ownership for variably-priced car usage). "Pay-as-you-drive" automobile insurance has been implemented on a pilot basis in Houston. Car sharing has been implemented in Boston; Seattle; Portland, OR; Washington, DC; and San Francisco. Other pricing concepts include parking policies, such as **parking "cash-out."** Parking cash-out involves providing employees who use free or subsidized parking at their worksites an option to receive from their employers the value of the parking benefit in cash if they choose not to drive to work. Parking cash-out has been implemented in Los Angeles and other metropolitan areas in California.

The Value Pricing Pilot Program

TEA-21 authorized the Value Pricing Pilot Program (VPPP), a successor of the Congestion Pricing Pilot Program (CPPP) authorized under ISTEA. As an experimental program, its objective is to learn the potential of different pricing approaches for reducing congestion. The grant program supports efforts by State and local governments or other public authorities to establish, monitor, and evaluate pricing projects, and to report on their effects.

Two important findings resulting from the operation of the early pilot projects are that drivers do alter their behavior in response to variable pricing, and highway users are receptive to pricing if it can be shown to provide them with improved transportation services. Direct impacts on highway system operations experienced as a result of operational pricing projects include:

- Improved utilization of available HOV lane capacity, thus allowing more people to be moved through the travel corridor
- Generation of revenues to support express bus service
- Shifting of trips out of the peak-congestion period into the shoulders of the peak, leading to more efficient use of available capacity
- Improved service for users by maintaining free-flow traffic conditions through the use of value priced priority lanes

There may often be political controversy associated with efforts to establish a new way of charging for highway use. This means that special emphasis must be placed on educational efforts before pricing projects are introduced. If a pricing project is to be successfully implemented, its benefits must be clearly defined to users, either directly in the form of reduced travel delay and enhanced travel options, or indirectly through targeted uses of toll revenues.

Introduction of pricing will need to be gradual, through pilot tests involving pricing on single lanes—such as converting underutilized HOV lanes into HOT lanes, or on single highway bridges or other facilities—before more comprehensive pricing initiatives can be launched. Also, pricing may need to be combined with some form of compensation provided to those who pay pricing fees or who give up the right to use facilities that formerly were provided without charge. Such compensation can take a number of forms, including highway capital improvements that benefit users of the corridor where pricing is occurring, provision of alternative transportation services such as transit, "life line" toll credits similar to credits provided to low income public utility customers, or toll credits provided to those who choose not to use value priced lanes.

The Benefits and Costs of Pricing

As the SR 91 example suggests, pricing can be politically acceptable in the U.S. when combined with highway capacity expansion. A recent study evaluated three future pricing scenarios involving the introduction of pricing in combination with adding a lane to a severely congested urban freeway:

- *Scenario A:* Higher tolls in peak periods on existing toll facilities and new tolls in peak periods on *all* lanes of existing toll-free highways when they are expanded. New tolls of 10 cents per mile would be charged. This is estimated to be equal to the incremental capital and operating cost per mile driven on *all lanes* during the peak periods;

- *Scenario B:* Peak period tolls on added lanes only, with tolls set high enough to ensure free flow of traffic in the added lanes; and
- *Scenario C:* FAIR lanes involving peak period tolls on two lanes only (i.e., one added and one existing lane) with tolls set high enough to ensure free flow of traffic in the fast lanes, and with toll credits provided to users of the remaining regular lanes.

A prototypical example involving the addition of a lane in each direction of a severely congested 10 mile long, six-lane urban freeway facility was used in the analysis. Benefits include the value of time savings from reduced traffic delays and reductions in other social costs. Exhibit 16-1 provides estimates of the annualized costs and benefits for each strategy for the 10-mile prototypical example. Costs include annualized capital costs for tolling infrastructure and annual toll operation costs. The results of the study indicate that substantial net benefits may be gained from implementing pricing in conjunction with highway capacity improvements.

Exhibit 16-1

Annual Net Benefits of Alternative Pricing Strategies in Conjunction with Expansion of a Prototypical Highway (Millions of Dollars)

SCENARIO	DESCRIPTION	COSTS	BENEFITS*	NET BENEFITS
A	Peak Period Tolls on Entire Facility (10 cents/mi)	$2.00	$16.40	$14.40
B	Tolling of Added Lanes	$1.00	$11.90	$10.90
C	FAIR Lanes	$2.00	$21.20	$19.20

* Benefits are estimated relative to a base case involving adding a lane in each direction with no value pricing.

Chapter 17

Transportation Asset Management

Introduction

Parts I and II of this report focus on current system condition and performance and future capital investment requirements to achieve specified system performance levels. The report also provides an assessment of the relationship between investment requirements and current spending. The analysis in Parts I and II implicitly assume that transportation investment will be allocated in an effective manner, but does not include an explicit discussion of potential options appropriate for responding to anticipated system conditions and requirements. This Chapter describes transportation asset management (TAM) and provides an overview of recent advances which, when implemented, have the potential to reduce the Nation's highway investment gap.

A new initiative in the transportation community, TAM, provides a framework for the optimal allocation of resources by transportation agencies. When implemented, it will dramatically change the fundamentals of investment decisions. The breakthrough of TAM arises from the fact that the expenditure of funds will (1) be based on trade-off analyses where alternatives are considered across functions, asset classes, and modes; (2) be driven by customer requirements as reflected in performance goals; (3) include economic and engineering considerations; (4) incorporate an extended-time horizon; and (5) be systematic and fact-based.

TAM will lead to the highest possible total return on investment, eventually reducing the gap between what the Nation needs to spend on its transportation assets and what it actually spends. When fully implemented, TAM has the potential to reduce the total life-cycle costs of providing transportation services and improve safety, system reliability, pavement smoothness, and financial performance. The investment requirements presented in this report are consistent with many of the fundamental concepts and principles of TAM.

This chapter is the second in a series of updates on initiatives to advance TAM. Appendix D in the ***1999 C&P Report*** included an assessment of current transportation decision-making processes, identified ways in which asset management principles could be utilized to improve the process, and identified ongoing initiatives by the Association of State Highway and Transportation Officials (AASHTO) and the FHWA related to the implementation of asset management approaches. This chapter looks more narrowly on the FHWA's accomplishments in this area during 2000 and 2001.

Transportation Asset Management: Background

TAM is a strategic approach to managing and investing in transportation infrastructure. It includes all aspects of transportation decision-making, covering operations, maintenance, construction, finance, etc. What differentiates TAM from the traditional approach to managing assets is the decision-making framework. This section expands on the TAM concept.

What is TAM?

TAM is not a specific product or service, but rather a way of doing business that will apply differently from organization to organization. It provides a framework for making decisions in order to use resources efficiently. Assets can take various forms—they can be people, money, information, and physical infrastructure. FHWA is currently focusing on physical assets such as pavements, structures, tunnels, and hardware. Over time, this focus will be expanded to include the full range of transportation assets.

The TAM framework, in broad terms, consists of these elements:

- The establishment of performance expectations consistent with goals, available budgets, and organizational policies. These expectations guide the analytical and decision-making processes.

- The collection of inventory and performance information to determine future system requirements.

- The use of analytical tools and reproducible procedures to provide cost-effective strategies for allocating budgets to satisfy agency needs and customer requirements.

- The presentation of alternative investment options, which are evaluated for consistency with long-range plans, policies, and goals.

- The periodic re-evaluation of the entire process through performance monitoring.

Why TAM?

State and local transportation agencies entered this century facing a series of new and different challenges. The responsibilities of these agencies have shifted in focus from major highway construction projects—primarily the designing and building of the Interstate Highway System—to maintaining, preserving, and improving the effective utilization of the existing system. This shift presents a complex range of challenges as user expectations for the system continue to increase and demand continues to grow. Highways are more congested than ever in many parts of the country. Increasing demand and normal wear and tear subject the system to ongoing deterioration.

Layered on top of these challenges is the impact of reductions in staff that are occurring at the Federal and State levels as a result of government downsizing initiatives and the general aging of the highway workforce. A robust economy during the 1990s also made it difficult for transportation agencies to compete for and retain capable personnel. As transportation agencies lose experienced staff, they are finding that it makes sense to use more systematic approaches that capture corporate memory and expertise and aid in the decision-making process.

Additionally, in States throughout the country, transportation budgets are competing with other budget demands. Furthermore, legislative initiatives are directing transportation funds to activities outside traditional transportation projects.

Despite these changes, the public still expects governmental agencies to preserve and protect the transportation system on which they rely. In fact, public expectations have risen. Today, transportation agencies are expected to communicate and explain their management approaches and results to elected officials and the general public. In addition, they must be fully accountable.

Clearly, a new way of doing business is required to respond effectively to this mix of strong, competing demands. The major shift that is occurring requires and demands a systematic and thorough process. State Departments of Transportation (DOT) and other transportation agencies are moving from constructing new assets to using TAM principles in their business practices to better manage the entire infrastructure.

What are the Key Elements of the TAM Framework?

For a TAM approach to be applied effectively to a transportation system, the following elements are essential:

- A logical decision-making framework that incorporates principles from the disciplines of engineering, economics, and business. The results will reflect a systematic, organized, logical, and reproducible approach.

- Engineering, economic, performance, and behavioral models and associated data inputs that provide the means to identify optimal investment strategies.

- An effective means for transmitting the information required by stakeholders (ranging from legislators to front-line practitioners) vertically throughout the organization. Information must also flow horizontally across functions, asset classes, and modes.

- Known customer expectations along with the organizational structures, practices, policies, and budgets unique to each agency and legislative environment. Performance goals provide a way for transportation agencies to respond to the public's interest in how well their assets are being managed.

- The ability to conduct "What if?" analyses. This provides the means of weighing and articulating the agency and user impacts of choosing one alternative over another.

- Fact-based dialogue among all interested parties, where relevant, objective, and credible information is available to all parties in the decision-making process.

Appendix D in the ***1999 C&P report***, referenced earlier, contains a more complete description of the elements of the TAM framework, and presents an example of a generic asset management system.

Transportation Asset Management: 2000-2001 Accomplishments

This document focuses on activities undertaken by FHWA's Office of Asset Management, many of which are executed in partnership with other organizations. Cooperative arrangements with organizations such as the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), industry associations, and academic organizations are a top priority of the Office. In fact, "partnership" is a guiding theme in the work the Office undertakes. The mission of the Office of Asset Management, established in 1999, is to provide leadership and expertise in the development and application of TAM. Products are delivered through technical assistance and training services. The Office's services are available to all State and local transportation agencies.

The mission of Office of Asset Management consists of three major areas. The first is to develop, refine and promote management systems for pavements, bridges, and other highway assets. The second is to develop, recommend, and advance engineering economic analysis and evaluation tools, data integration and management approaches, and other TAM techniques for use by State DOTs. The third is to develop and promote programs to reduce the deterioration and improve the overall quality and performance of the highway system.

During 2000 and 2001, a variety of research, development, training, technology deployment, technical support, and outreach initiatives have been undertaken and completed by the office. We have identified four overarching themes: (1) ensuring the availability of necessary data and information; (2) developing innovative analytical tools and techniques, and business processes and practices; (3) teaching, training, and bringing awareness to the people that will influence final investment decisions, and (4) providing assistance in deploying the tools, techniques, and processes. Deployment activities will be forthcoming as the tools, techniques, and business processes become available.

Details of individual projects and initiatives undertaken by the Office are given below:

Data and Information

- Developed an implementation strategy for new standards to measure pavement roughness, rutting, and faulting. These pavement distress standards were approved by AASHTO during FY 2000 and were presented at several workshops throughout the country.

- Initiated a contract that will demonstrate and document how a State can use its pavement management system to monitor the real-life performance of its pavement network. The project is designed to track the performance of critical pavement parameters and to demonstrate the importance and the advantages of linking all databases with pavement information electronically.

Analytical Tools and Techniques and Business Processes and Practices

- Developed a prototype and conducted a pilot evaluation of the Highway Economic Requirements System-State Level (HERS-ST), a variation of the HERS model used to produce the highway investment requirements in this report. (See Chapter 7 and Appendix A). State representatives participating in the pilot project explored the appropriateness of using the HERS application in program development, trade-off analysis, "needs" estimation, and for addressing new standards issued by the Governmental Accounting Standard Board (GASB). Based on positive input from the HERS-ST pilot participants, the FHWA has initiated development of HERS-ST Version 2.0 which will be significantly more user-friendly and will accept a broader array of State-supplied data. The software, with training, will be distributed to State officials in late 2002.

- Participated in the design, development, and testing of PONTIS 4.0. This new version of the bridge management software is now available and being deployed to States and other agencies. The NBIAS model used to produce the bridge investment requirement estimates in this report is a derivative of PONTIS. (See Chapter 7 and Appendix B).

- Developed Life-Cycle Cost Analysis instructional software designed to support evaluation of alternative pavement design decisions based on total agency and user life-cycle costs. This model will account for uncertainty in cost and performance, and provide outputs for the use of risk-analysis in decision-making.

- Initiated a contract to develop a first-generation guide and management system for highway and transit tunnels. The project is currently underway and will (1) establish an inventory of highway and transit tunnels in the United States, (2) develop detailed guidance for inspecting and rating the condition of tunnel components, (3) establish preservation and rehabilitation strategies, (4) develop a prototype database system, and (5) establish procedures for integrating tunnel management systems with bridge management systems and TAM decision-making frameworks.

- Investigated, with AASHTO, the feasibility of developing a management system for roadway hardware including guardrails, signs, crash cushions, signals, and similar items on and adjacent to highways.

Training, Education, and Awareness

- Developed a Web site called "Communities of Practice for Asset Management" in partnership with AASHTO. This interactive Web site consists of eight areas addressing specific aspects of TAM.

- Conducted a peer-exchange workshop in cooperation with AASHTO on GASB's *Statement 34, Basic Financial Statements—and Management's Discussion and Analysis—for State and Local Government.* GASB-34 calls for State, local, and municipal governments to report the original cost of infrastructure constructed or improved since 1980, and, for each reporting year, the cost of using the assets.

- Organized jointly with the AASHTO Task Force on Asset Management a Data Integration Forum and Peer Exchange intended for information management practitioners in transportation agencies.

- Developed new National Highway Institute (NHI) training courses on "Engineering Applications for Pavement Management Systems", "Use of Critical Path Methods for Estimating Scheduling and Timely Completion", Pavement Preservation: The Preventative Maintenance Concept", and "Pavement Preservation: Selecting Pavements for Preventative Maintenance". Initiated a contract to develop a new NHI course on TAM. This course will be a companion to the upcoming *AASHTO Guide to Transportation Asset Management.* Initiated development of an executive-level Engineering Economic Analysis course for transportation managers.

- Published the *Asset Management Primer*, the *GASB 34 Primer*, the *Data Integration Primer* and the *Data Integration Glossary for Asset Management.* Published and distributed state-of-the practice CD-ROMs, videotapes, and other materials on pavement preservation techniques.

- With the National Partnership for Highway Quality, identified and promoted concepts, activities, and technologies to improve the quality of planning, design, construction, and maintenance of the Nation's highways.

- Provided leadership and technical support to the Transportation Curriculum Coordination Council (TCCC), which consists of representatives from various regional technician training and certification groups, the private sector, FHWA, and NHI.

- Participated in pooled-fund studies and provided technical support on the safety and mobility of the highway system during construction and maintenance, including control of hazardous wastes and application of innovative technologies for work zone traffic control and safety; accelerated construction; and use of new materials, practices, and methods.

The initiatives described above underscore the progress that FHWA's Office of Asset Management has made between 2000–2001 in providing products, information, tools, training, and technical support. These products and programs are valuable to State DOTs as well as our other transportation partners.

Related Activities

As indicated earlier, partnerships are crucial for TAM concepts and practices to gain widespread acceptance. Working with partners minimizes the potential of duplicating efforts and allows the leveraging of limited funds. Key partnerships with the Office of Asset Management have been formed with AASHTO, TRB, the National

Partnership for Highway Quality, the Foundation for Pavement Preservation, and other industry associations. The Office of Asset Management also participates in the National Research and Technology, (R&T), Partnership Forum, which was established by FHWA, AASHTO, and TRB to coordinate research and technology activities.

The Office works jointly with AASHTO committees to include the Committees/Subcommittees on Highways, Bridges and Structures, Maintenance, Construction Quality, Transportation Finance, and the Transportation Asset Management Task Force. The Office assisted the AASHTO Task Force on TAM in revising their 1998 TAM Strategic Plan. The plan now includes five key goals:

- Develop partnerships with public and private entities having an interest in and commitment to TAM.
- Develop and document an understanding of TAM and how it can be used by member States.
- Promote the development of TAM tools, analysis methods, and research topics.
- Communicate with and inform the leadership and member States on the use of TAM.
- Assist member States as they assess and implement TAM within their State.

Under the auspices of the National Cooperative Highway Research Program, an applied research program managed by TRB that focuses on the research requirements of State DOTs, the Office of Asset Management has been working with AASHTO since early 2000 to develop a *Guide to Asset Management*. The guide will provide States with assistance, guidance, and tools for comprehensive TAM.

The Office participates with the Asset Management subgroup of the National Research and Technology, (R&T), Partnership Forum, which was established by FHWA, AASHTO, and TRB to coordinate research and technology activities. In FY 2001, the Office contributed to the Forum by identifying major research theme areas, reviewing existing R&T programs related to TAM, comparing current activities to future requirements to determine gaps and duplications of effort, prioritizing research gaps and identifying high priority areas, and establishing opportunities for partnering on current and future research.

The Office is actively involved with the TRB Task Force on Asset Management, which sponsored four sessions on Asset Management at the January 2001 TRB Annual Meeting and held two meetings to develop a research agenda for future TRB and Asset Management efforts. The Task Force recommended establishing a permanent TRB Committee on TAM to take part in activities in the following areas:

1. Defining TAM and its benefits.
2. Technical aspects of TAM.
3. Coordinating with other organizations.
4. Sustaining TAM and demonstrating effectiveness.

The Task Force plans to produce a document describing the state-of-the-practice in TAM.
In addition, future plans include research into the possibilities of applying TAM to other areas of the transportation field such as transit.

Chapter 18

Travel Model Improvement Program

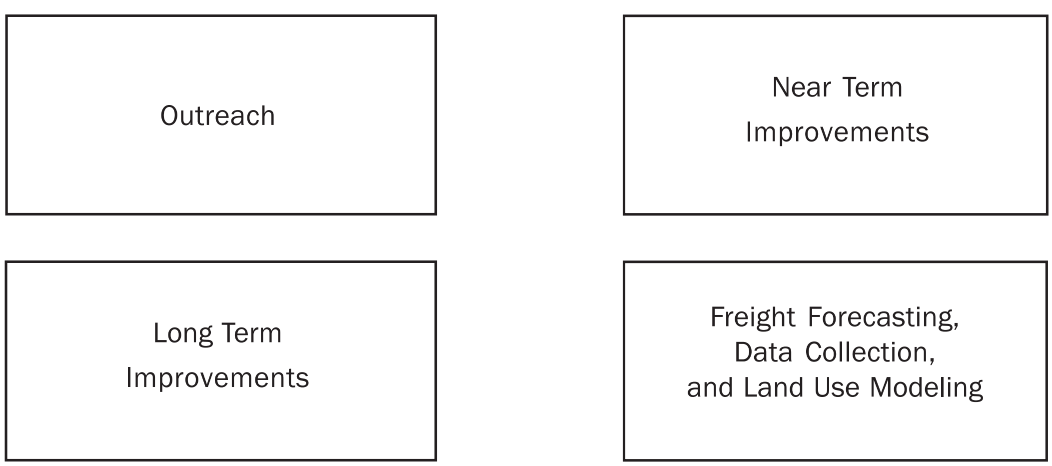
Introduction

As discussed in Chapter 17, the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) have a strong interest in helping State and local governments develop tools to support local transportation policy and program analysis. Among the most important such analyses are estimates of future highway and transit travel growth made by State and metropolitan transportation planning agencies. These travel estimates are critical in developing transportation plans, transportation air quality conformity analyses, and emissions forecasts. They are also an important input into the highway and transit investment needs models.

Current transportation modeling procedures are based on paradigms developed more than 35 years ago. Since then, many changes have occurred in transportation policy, transportation technology, and travel behavior, all of which have placed additional demands on the modeling process. Policy changes include the requirement for models to support air quality analysis, traffic operations improvements, analysis of freight movements, and telecommuting. Technological changes include the use of Intelligent Transportation Systems (such as signal optimization and traffic operations improvements) to better manage traffic flows. Behavioral changes include an increased reliance on trip chaining and the shift in travel from peak to off-peak times. Taken together, these changes have made it necessary to significantly upgrade travel forecasting procedures and to support local areas in their improvement of travel forecasting methods.

Responding to this need, FHWA, in cooperation with FTA, the Office of the Assistant Secretary for Transportation Policy, and the Environmental Protection Agency (EPA), established the Travel Model Improvement Program (TMIP). TMIP seeks to advance the state of the art and state of the practice in travel forecasting methods. TMIP has four primary components: 1) outreach, to support local areas in the deployment of travel models; 2) near term improvements, to update existing forecasting methods; 3) long term improvements, to develop an entirely new methodology for travel forecasting; and 4) freight forecasting, data collection, and land use modeling to improve the quality of the input to the travel forecasting process.

The Travel Model Improvement Program



Outreach

The outreach effort supports advancing the state of the practice in travel forecasting. Outreach assists local areas in improving existing techniques as well as the implementation of newly developed techniques. Outreach includes training, direct technical assistance, and building a community of practice among modelers to facilitate mutual support in the modeling process. Through the National Highway Institute, TMIP provides training on basic methodologies in travel forecasting. Courses have addressed basic and advanced methods of forecasting, data collection, and mobile source emissions. Technical assistance includes direct one-to-one technical support and the distribution of reports on TMIP products. To facilitate interaction among modelers, TMIP sponsors an Internet listserv, an Internet Web site, and periodic conferences and seminars on topics of current interest.

Outreach is a two-way street, disseminating information and ensuring that TMIP focuses on user needs. To ensure that TMIP meets customer needs, a review panel composed of travel model users provides periodic comment to TMIP on the direction and scope of the program. Members of the panel include representatives from State departments of transportation, Metropolitan Planning Organizations, transit operators, State air quality agencies, environmental groups, the real estate development community, and the academic community.

Near Term Improvements — Updating Existing Forecasting Methods

The TMIP has established an extensive program to improve the capabilities of existing travel forecasting procedures. This program includes improvements to models of trip generation and trip distribution mode choice and assignment procedures. Examples of completed projects include methods to provide feedback among the components of the travel forecasting process, modeling based on trip chaining rather than individual trips, and modeling time of day of travel. TMIP also deploys the ITS Deployment Analysis System, which provides easily usable analytic tools to evaluate proposed ITS investments. The effects of such investments on the highway system are covered further in Chapter 21.

The technical procedures developed as part of TMIP's Near Term improvements have been used in Air Quality Conformity Analysis, studies required by the National Environmental Policy Act, FTA's New Starts analyses, and the Metropolitan Transportation Planning Process.

Long Term Improvements — Developing a New Methodology

While TMIP has improved existing forecasting methods, TMIP also recognizes the need for a basic redesign of the travel forecasting process. The Transportation Analysis and Simulation System (TRANSIMS) meets this need. TRANSIMS uses state-of-the-art microsimulation technology to simulate both the movements of individuals and vehicles and the activities of households. TRANSIMS can trace the activities in an urban area throughout a 24-hour time period, simulating people, vehicles, and households on a second-by-second basis. Within TRANSIMS, every trip starts as a walk trip and then shifts to other modes such as auto and transit, thus explicitly accounting for the non-motorized component of every trip.

TRANSIMS has the capability to address issues that current models have found difficult to model, such as emissions analysis based on vehicle operating mode, environmental justice, and global climate change. TRANSIMS simulates the activity of individual vehicles, and vehicle activities, such as acceleration and deceleration, are input to the TRANSIMS emissions model. TRANSIMS can thus provide a better estimate of vehicle emissions than the current techniques generally used. Since TRANSIMS can identify individuals by demographic group and trace their activities through the day, it can be used as a tool to analyze environmental justice issues. TRANSIMS can also estimate the greenhouse gas emissions resulting from metropolitan travel.

While not anticipated in the development process, TRANSIMS can play a major role in planning for defense against terrorist attacks. For example, in planning for biological terrorism, it is possible to use TRANSIMS to model the spread of disease, locate field hospitals, and identify optimal sites for the placement of sensors for the detection of disease. TRANSIMS can also assist in planning for emergency evacuations and modifying the transportation system to respond to or recover from terrorist attacks. The use of TRANSIMS for such purposes is also discussed in Chapter 12.

TRANSIMS was developed by the Los Alamos National Laboratory, and a more user-friendly version is being developed for commercial use. TRANSIMS is now undergoing field testing in Portland, Oregon.

Freight Forecasting, Data Collection, and Land Use Modeling

Freight movement is probably the least understood part of the transportation system. TMIP has produced the Quick Response freight manual, designed to assist metropolitan areas in making short-term improvements to their freight forecasting processes. TMIP is also developing a more comprehensive freight forecasting procedure that will address all aspects of the freight planning process. Chapter 22 includes more information on FHWA activities relating to freight operations.

High quality input data provides a critical basis for the development of travel models. TMIP has several products designed to assist local agencies in improved data collection. In particular, TMIP recently published a travel survey manual to assist local areas in gathering survey information. This manual has been of immediate use, since many urban areas are currently updating surveys. Use of this manual can allow for accurate, cost effective updates to outdated surveys.

With the rise of concerns about induced travel, smart growth, preservation of open space, and continuing urban sprawl, understanding land use and the role location and land use patterns play in the demand for travel has become a critical issue. TMIP has developed methods to estimate the impact of transportation on regional land use patterns. TMIP has also addressed the impact of small-scale urban design on travel, enabling local agencies to develop plans that decrease the need for additional transportation infrastructure while meeting the need for mobility. TMIP has documented methods used by localities to forecast land use, and FHWA has published a case study of these methods.

Future Directions

For the future, TMIP will continue to respond to user needs in the development of new techniques and address the analytic needs of local planning agencies. In addition, as part of the outreach effort, TMIP will develop materials and techniques to educate decision makers about the capabilities and applications of travel models. Through such efforts, TMIP will not only support the quality of the modeling process but also encourage the use of models to improve decision-making based on modeling.

The transportation community is now faced with the challenge of preparing for responses to a range of situations not previously considered. TMIP will support the development and deployment of tools to meet these new requirements. TMIP has begun this process and has had discussions with the Department of Defense concerning the use of TRANSIMS in planning for chemical and biological attacks. TMIP will continue to meet the analytical needs of the transportation planning community and change as these needs evolve.

Chapter 19

Air Quality

Introduction

Air quality effects need to be considered when evaluating the impacts of future transportation investments. That is why two of the investment models in this report—HERS and TERM—include emissions costs. This chapter describes the general relationship between air quality and transportation.

While the Clean Air Act (CAA) has controlled pollutant emissions from all air pollution sources, the greatest success can be found in the control of on-road mobile sources. Emissions reductions from motor vehicles have accounted for 84 percent of the total emissions reductions of the six criteria pollutants since 1970. The automotive, fuels, highway, and transit communities have managed to achieve this success in cleaning up the Nation's air, with the help of tight Environmental Protection Agency (EPA) emissions standards and fuel requirements, while at the same time meeting the increasing demands of improved mobility and safety.

This chapter begins by discussing the history of air quality legislation and the sources and types of air pollution that are primarily affected by transportation. It then discusses the past and expected trends of pollutant emissions, followed by a summary of highway and transit programs that are being used to reduce motor vehicle emissions.

The Clean Air Act and Air Quality

Air pollution has been a problem for a long time. However, until the 1950s there were few laws that addressed this issue. One event that first captivated public attention occurred in October of 1948, when 20 people were killed and over 7,000 became ill because of severe air pollution over Donora, Pennsylvania. The Donora incident resulted from factory emissions and meteorological conditions that trapped those emissions, and it led to State and Federal air quality controls. Air pollution has been identified as a cause of several health and environmental problems, including respiratory illnesses and other diseases, crop damage, decreased visibility, and structural deterioration.

Although air quality legislation was enacted during the 1950s and 1960s, the 1970 Clean Air Act (CAA) marked the first time that air pollution was seriously addressed on a national scale. The Clean Air Act was amended in 1977 and most recently in 1990. The Clean Air Act, as amended, provides the principal framework for Federal, State, and local efforts to protect air quality from all pollution sources. Air pollution comes from many different sources: stationary (point) sources such as factories and power plants; smaller area sources such as dry cleaners and painting operations; on-road mobile sources such as cars, buses, and trucks; non-road mobile sources such as construction equipment, airplanes, boats, and trains; and naturally occurring sources such as windblown dust and volcanic eruptions.

Under the CAA, Federal controls and emissions standards have been established to reduce emissions. States must also develop State implementation plans (SIPs) that they enforce to clean up polluted areas and protect and maintain air quality. Motor vehicle controls are only one part of the picture, but they have played a significant role.

EPA has established increasingly tight national standards requiring cleaner motor vehicles and fuels. Also, where CAA goals were not being met, State and local transportation officials have been challenged to find ways to reduce vehicle emissions by reducing the number of single-occupant vehicles and making alternative modes of transportation (such as transit and bicycles) an increasingly important part of the transportation network.

National Ambient Air Quality Standards

The National Ambient Air Quality Standards (NAAQS, also referred to as "air quality standards") are Federal standards, established through extensive scientific review, that set allowable concentrations and exposure limits for certain pollutants. The standards are intended to protect public health and welfare. Air quality standards have been established for six pollutants for which EPA has published criteria documents: ozone (or smog), carbon monoxide, particulate matter, nitrogen dioxide, lead, and sulfur dioxide. On-road mobile sources primarily contribute to four of these criteria pollutants: ozone, carbon monoxide, particulate matter, and nitrogen dioxide.

In 1997, EPA developed updated air quality standards for ozone (known as the "8-hour" standard) and for fine particulate matter (known as the "$PM_{2.5}$" standard). However, these standards were challenged in court, and litigation has persisted until recently, blocking their implementation. The Supreme Court has now upheld the standards, and a lower court has dismissed further challenges. EPA is in the process of developing a plan for implementing these standards, and it is expected that nonattainment areas will be designated and be required to develop SIPs in the upcoming years to meet them.

It is anticipated that these updated standards will affect a much larger number of areas than are currently in nonattainment. It may be substantially more difficult for areas to identify strategies and measures that will allow them to meet the standards. In addition, the contribution of transportation to $PM_{2.5}$ emissions is unclear, and additional research will be necessary to determine how transportation strategies can be utilized to control $PM_{2.5}$ emissions.

Hazardous Air Pollutants

An emerging issue in air quality and transportation is hazardous air pollutants, also known as air toxics. These pollutants are known or are suspected to cause cancer or other serious health or environmental effects. They include pollutants like benzene, perchloroethylene, methylene chloride, heavy metals like mercury and lead, polychlorinated biphenyls (PCBs), and dioxins. Not all air toxics are emitted from transportation sources. While the harmful effects of air toxics are of particular concern in areas closest to where they are emitted, they can also be transported and affect the health and welfare of populations in other geographic areas. Some can persist for considerable time in the environment and/or accumulate in the food chain.

To address concerns about the potentially serious impacts of hazardous air pollutants on public health and the environment, the CAA includes a number of provisions that have required EPA to characterize, prioritize, and control these emissions as appropriate. On the mobile source side, many of the emission control programs put in place to control criteria pollutants reduce air toxic emissions as well. These programs have reduced and will continue to reduce on-highway emissions of air toxics significantly.

In March of 2001, EPA designated 21 compounds as mobile source air toxics (MSATs), recognizing that motor vehicles are significant emitters of these compounds. Although EPA has established this list of MSATs, it has not established that all emissions of these compounds are health risks, nor has it established any standard or measure of what concentration of these compounds might be harmful. EPA's final rule specifically states "that inclusion on the list" of MSATs "is not itself a determination by EPA that emissions of the compound in fact present a risk to public health or welfare, or that it is appropriate to adopt controls to limit the emissions of such a compound from motor vehicles or their fuels." Further evaluation is necessary to determine the need for and appropriateness of additional mobile source air toxics controls for on-highway and non-road sources and their fuels.

Cleaner Air

The Nation has experienced considerable success under the Clean Air Act. National levels of all criteria pollutants are down over the last 20 years. Ozone levels nationally have improved considerably, and although some areas have shown increases, ozone levels in urban areas where problems have historically been the most severe have shown marked improvement in response to stringent controls. Nationally, carbon monoxide levels are the lowest recorded in the last 20 years and this air quality improvement is consistent across all regions of the country. The most recent 10-year period (1990-1999) shows that the National average of annual mean PM_{10} concentrations decreased 18 percent. This is described by Exhibit 19-1.

Exhibit 19-1

Percent Decrease in Concentration of Criteria Pollutants, 1992-2002[1]

POLLUTANT	1980-1999	1990-1999
Carbon Monoxide (CO)	57	36
Lead (Pb)	94	60
Nitrogen Dioxide (NO_2)	25	10
Ozone (O3)[2]	20	4
Particulate Matter (PM_{10})	N/A	18
Sulfur Dioxide (SO_2)	50	36

[1]This ozone concentration is based on the 1-hour ozone NAAQS. In 1997, EPA promulgated a new 8-hour ozone NAAQS. However, due to legal challenges, this 8-hour standard has not yet been implemented.
[2]Concentration measurements of PM10 for 1980 are not available.

Source: National Air Quality and Emissions Trends Report, 1999, EPA OAQPS, Research Triangle Park, NC, March 2001.

To determine which areas have air pollution problems, monitoring networks have been established to measure the concentration of the pollutants in the outside air. Monitors are inspected regularly and their data analyzed to determine if areas meet the standards. If monitored levels of any pollutant violate the NAAQS, then EPA in cooperation with the State designates the contributing area as "nonattainment." Once the area has again met the standards and has healthy air, and the area has a plan in place to maintain the standards, EPA may redesignate that area back to "attainment." Such areas are also known as "maintenance" areas. Since 1992, the number of nonattainment areas has decreased by 46 percent. This is described by Exhibit 19-2.

Exhibit 19-2

Number of Areas Designated Nonattainment, 1992-2002[1]

POLLUTANT	1992	2002
Carbon Monoxide	78	24
Lead	13	3
Nitrogen Dioxide	1	0
Ozone	134	74
Particulate Matter (PM_{10})	84	68
Sulfur Dioxide	53	26
All Pollutants	363	195

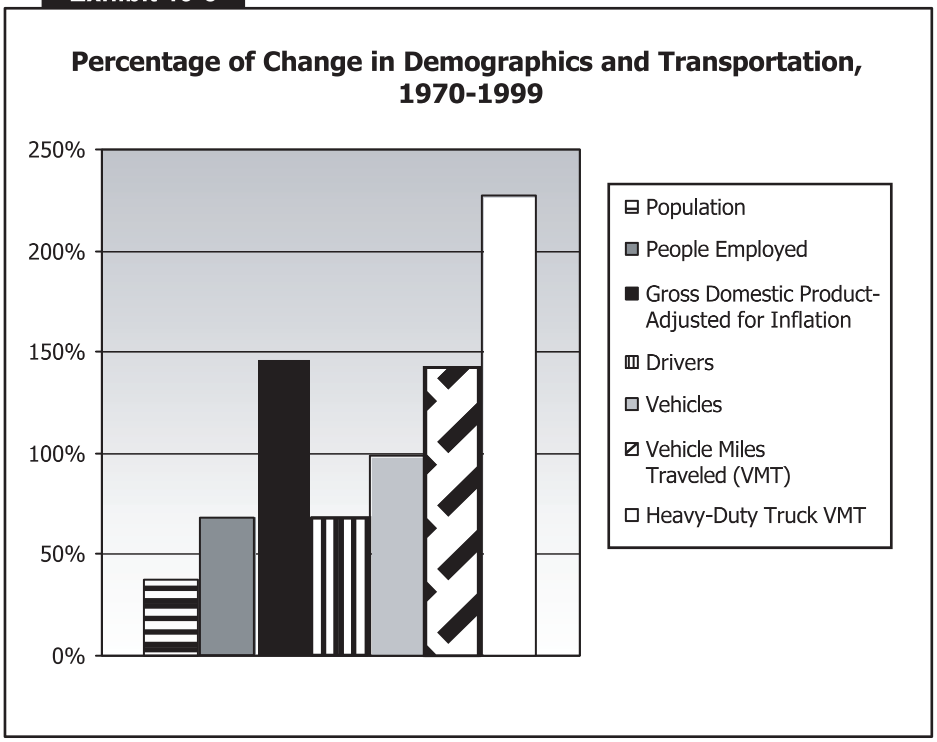
[1] EPA Green Book website, *Nonattainment Status for Each County by Year*, as of January 15, 2001, www.epa.gov/oar/oaqps/greenbk/anay.html.

However, just looking at the number of nonattainment areas does not necessarily tell the whole story. Many areas are still considered nonattainment for procedural reasons, when actual monitoring data shows that their air quality is meeting the standards. For example, the most recently available data for 1998-2000 showed that only 34 areas violated the 1-hour ozone standard (down from 98 areas that were originally designated and classified in 1991), and that for 1999-2000 only 3 areas violated the carbon monoxide standard.

There are a number of reasons why an area may still be designated nonattainment, even if the area is not violating the standards. An area may need additional time needed to resolve technical issues associated with demonstrating that the standards will be maintained. There are often coordination issues among transportation and air agencies, and the public over which projects should be given funding priority in maintaining the standards or how future emissions should be allocated among stationary, area, and mobile sources. Also, actions may be required by State and local legislative bodies to demonstrate that control measures have adequate commitments and are enforceable.

The above referenced improvements in air quality have been achieved even with dramatic increases in population, and personal and freight travel. Since 1970, population has increased 38 percent; the number of people employed has increased 68 percent; the Gross Domestic Product, adjusted for inflation, has increased 147 percent; the number of drivers has increased 68 percent; total vehicle miles traveled (VMT) per year have increased 142 percent; and heavy-duty truck travel has increased 227 percent. **At the same time, total on-road motor vehicle emissions have *decreased* 77 percent.** Exhibit 19-3 describes these trends.

Exhibit 19-3

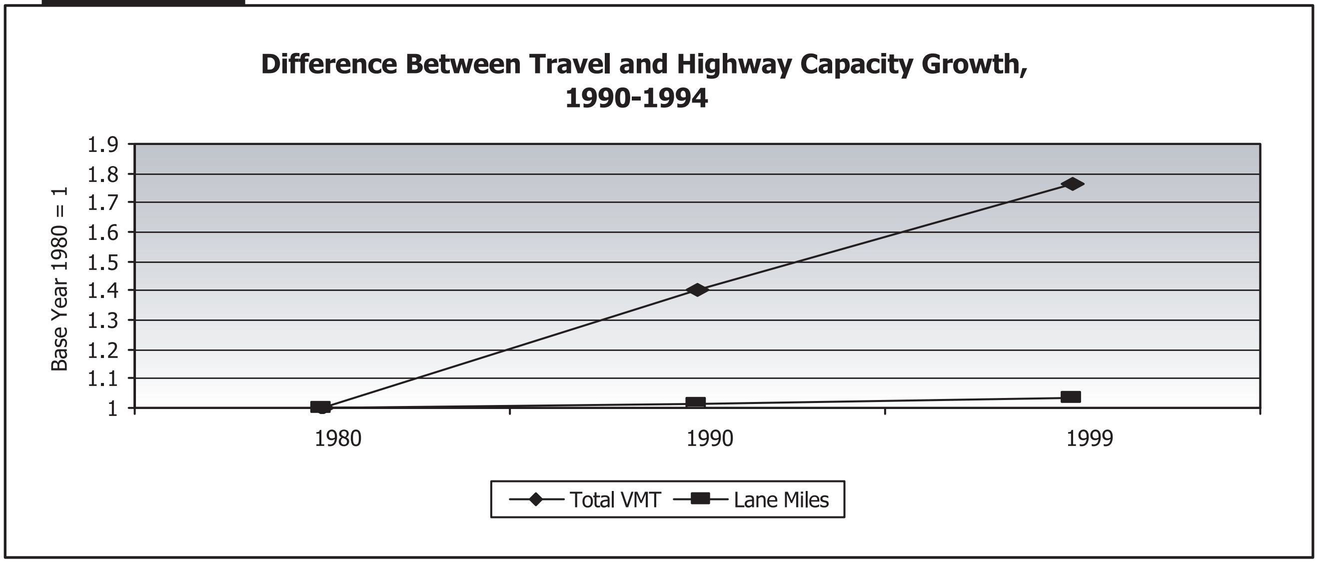


Sources: U.S. Census Bureau, Population and Housing Counts website, Population 1790-1990; U.S. Census Bureau, Census 2000 Results website, Resident Population; U.S. Census Bureau, Statistical Abstract of the United States, 2000; Federal Highway Administration, Highway Statistics Summary to 1995 and Highway Statistics 1999.

As seen below, transportation planners have been faced with huge increases in personal and freight travel. They have also faced other challenges toward accommodating this growth. For example, actual construction of new and expanded lanes on the Nation's highway system over the last 20 years has only increased the system by 3 percent. Exhibit 19-4 describes this phenomenon in terms of the difference between expansion and traffic volume. Not surprisingly, congestion—a major source of air pollution—has grown steadily over the last two decades in urban areas of every size. Severe congestion, which greatly impacts air quality, lasts a longer period of time and affects more of the transportation network in 1999 than in 1982. The average annual delay per person climbed from 11 hours in 1982 to 36 hours in 1999 percent.

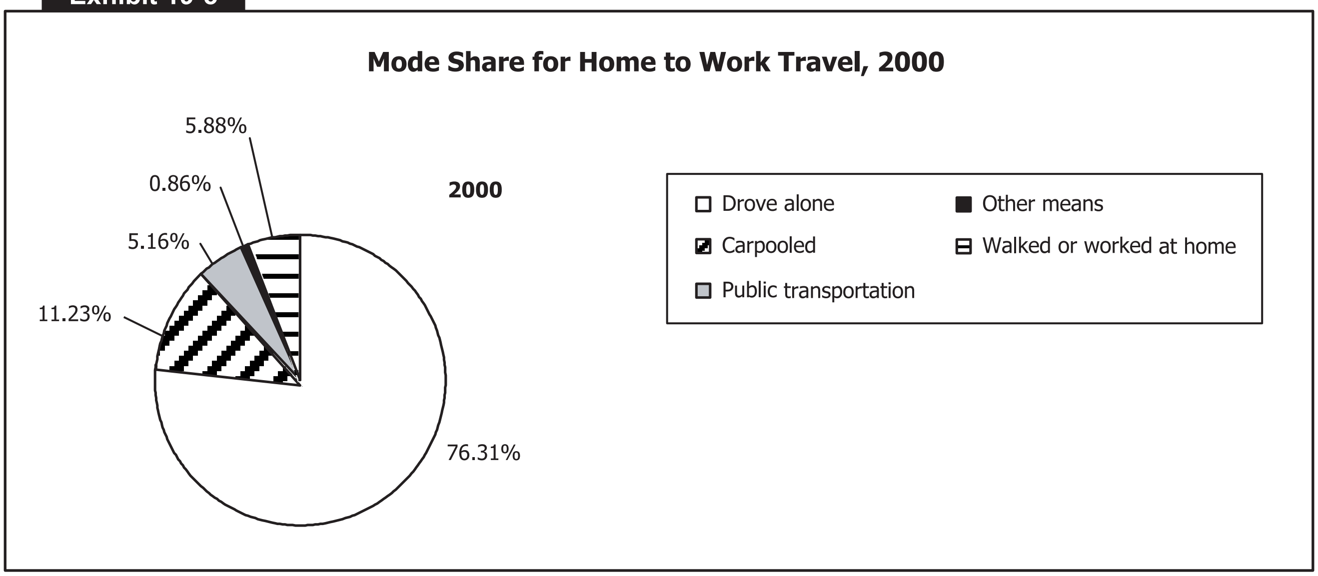
Another challenge has been trying to decrease the amount of people who travel by single-occupant vehicles, and encourage travel by other modes, as well as decreasing the number of trips people take. As can be seen in Exhibit 19-5, the majority of people in the United States rely on single-occupant vehicles to travel between home and work.

Exhibit 19-4



Sources: Highway Statistics 1999 and Highway Statistics Summary to 1995.

Exhibit 19-5



Source: Census 2000 Supplementary Survey.

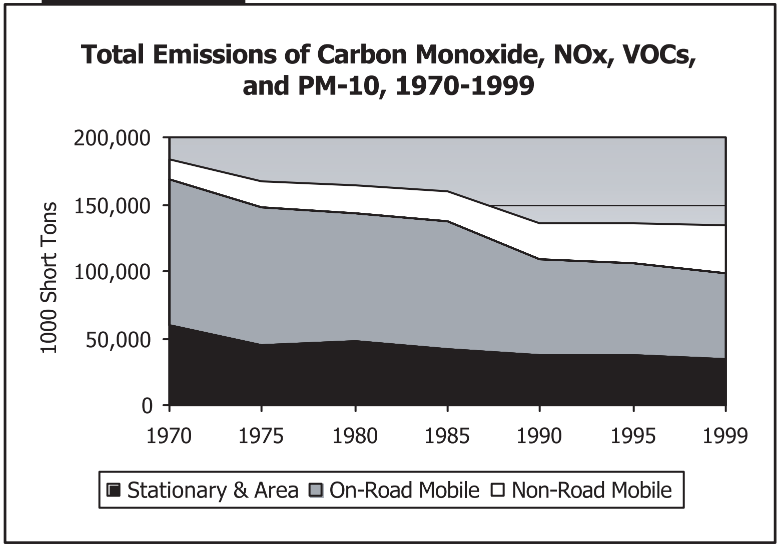
Emissions Trends in Transportation

In spite of the challenges, national emissions trends of on-road mobile sources have declined over the last 30 years. As shown in Exhibit 19-6, despite large increases in population, personal travel and freight transportation, and in spite of very limited highway expansion and public mode choice, total on-road motor vehicle emissions of carbon monoxide (CO), volatile organic compounds (VOCs), oxides of nitrogen (NOx), particulate matter (PM-10), lead (Pb), and sulfur dioxide (SO2) have declined 77 percent since 1970. The Environmental Protection Agency (EPA) expects this downward trend to continue well into the future.

In addition to the reduction in emission levels, on-road motor vehicle emissions have become a smaller percentage of total emissions. In fact, in 1970 motor vehicles contributed 59 percent of total emissions of carbon monoxide, oxides of nitrogen (NOx), volatile organic compounds (VOCs), and particulate matter

(PM-10) when compared to stationary, area, and non-road mobile sources. However, by 1999, the motor vehicle portion of emissions of these pollutants dropped to 48 percent. This is described in Exhibit 19-6.

Exhibit 19-6



Source: National Air Quality and Emissions Trends Report, 1999, EPA OAQPS, Research Triangle Park, NC, March 2001.

The majority of the emissions reductions have resulted from stricter emissions standards, improved engine technology, and cleaner fuels, and engines and fuel are to become even cleaner under recent EPA-issued emissions standards and cleaner fuel requirements. Between 2004 and 2007, more protective tailpipe emissions standards will be phased in for all passenger vehicles, including sport utility vehicles (SUVs), minivans, vans and pick-up trucks. This regulation marks the first time that larger SUVs and other light-duty trucks are subject to the same national pollution standards as cars. In addition, EPA lowered standards for sulfur in gasoline, which will ensure the effectiveness of low emission-control technologies in vehicles and reduce harmful air pollution. When the new tailpipe and sulfur standards are implemented, Americans will benefit from the clean-air equivalent of removing 164 million cars from the road. These new standards require passenger vehicles to be 77 to 95 percent cleaner than those on the road today and the reduction of the sulfur content of gasoline by up to 90 percent.

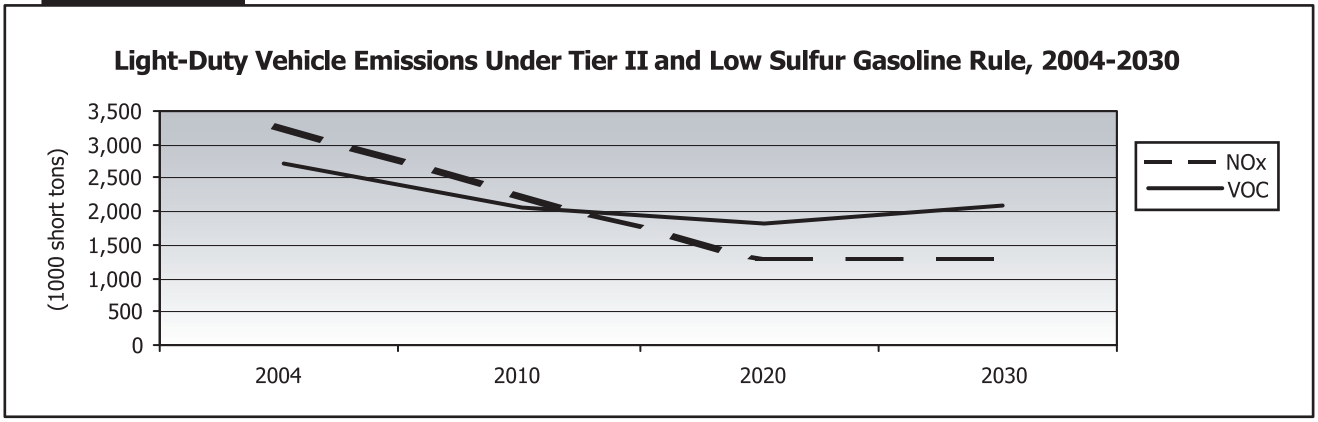
EPA has also recently issued new emission standards that will begin to take effect in model year 2007 applying to heavy-duty highway engines and vehicles. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. Because these devices are damaged by sulfur, EPA is also reducing the level of sulfur in highway diesel fuel by 97 percent by mid-2006. As a result, each new truck and bus will be more than 90 percent cleaner than current models. The clean air impact of this program is expected to be dramatic when fully implemented. This program will provide annual emission reductions equivalent to removing the pollution from more than 90 percent of today's trucks and buses, or about 13 million trucks and buses. Exhibits 19-7 and 19-8 describe this graphically, where NMHC refers to non-methane hydro-carbons, a chemical compound emitted in vehicle exhaust and evaporative emissions.

ISTEA and TEA-21

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) revamped the Federal highway and transit programs to give State and local officials added tools to improve air quality, including a strengthened planning process and programs specifically directed to air quality improvement and transit. ISTEA gave State and local officials flexibility in choosing among highway, transit, and other transportation alternatives, allowing for the best mix of projects to address air quality.

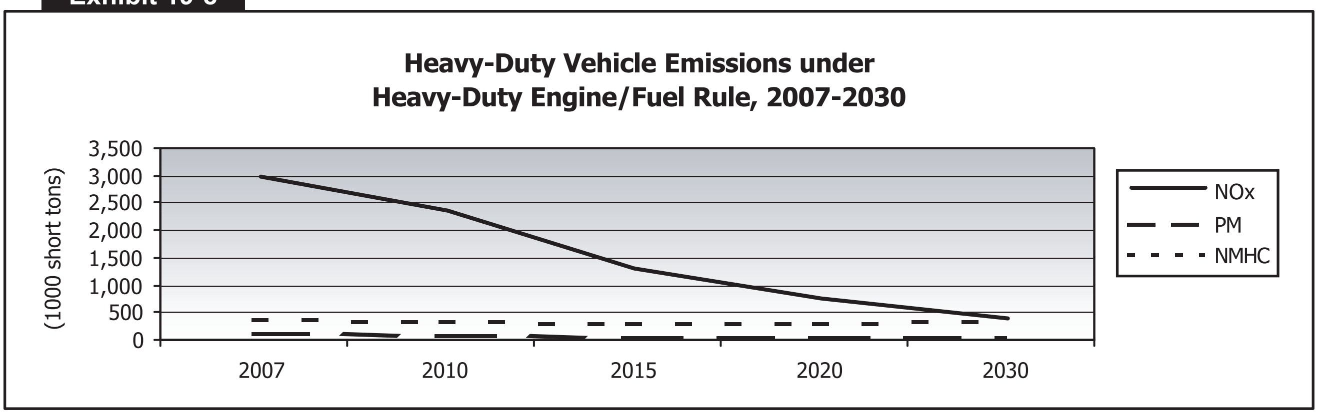
ISTEA also required States and metropolitan planning organizations (MPOs) to carry out a comprehensive transportation planning process in order to better coordinate the best mix of transportation projects which will improve air quality. ISTEA also included a major new program to deal with transportation-related emissions.

Exhibit 19-7



Source: Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements, EPA 420-R-99-023, December 22, 1999.

Exhibit 19-8



Source: Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, EPA420-R-00-026, December 2000.

The Congestion Mitigation and Air Quality Improvement Program (CMAQ) directs funding to projects and programs to reduce emissions in nonattainment and maintenance areas.

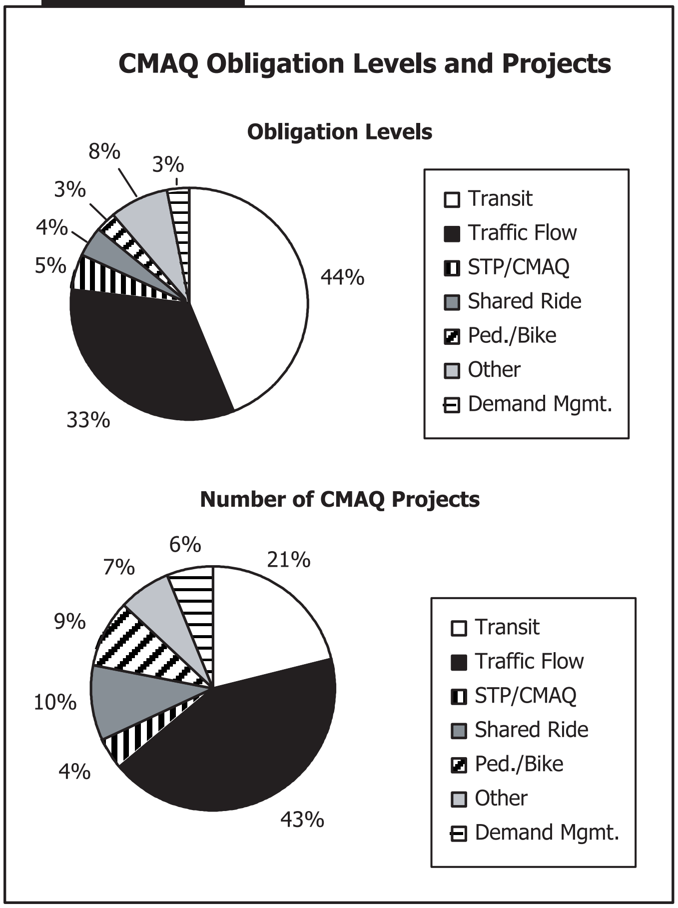
In 1998, the Transportation Equity Act for the 21st Century (TEA-21) continued the provisions of ISTEA, and significantly increased funding levels to provide for an expanded source of funding which can be used for transportation programs and projects that reduce motor vehicle emissions.

Congestion Mitigation Air Quality Improvement Program

The CMAQ Program provides funds for transportation related projects that will reduce pollutant emissions in areas not meeting air quality standards for ozone, carbon monoxide and particulate matter. Over $8.1 billion has been authorized over the six-year program period of TEA-21 extending from 1998 through 2003. While reducing congestion is a goal of CMAQ, the primary focus of the program has been on improving air quality. Generally, the money is used for projects like transportation control measures (TCMs) that are described further in this section and have the intended purpose of reducing emissions from vehicles.

The amount of funds available for CMAQ projects for any given State is dependent on the severity of its air pollution and on the size of the population exposed to that pollution. Funds apportioned to States are based

Exhibit 19-9



Source: Annual CMAQ Reports, FHWA.

on nonattainment and maintenance areas, and must be used in those areas. However, States are guaranteed a minimum apportionment of CMAQ funds. Projects that are typically funded include transit projects, traffic flow improvements, development of park-and-ride lots to encourage transit or carpooling/vanpooling, the development of employer-based programs, emissions inspection and maintenance programs, and other projects designed to reduce vehicle use and the resulting vehicle emissions. One of the key components of the CMAQ program is its flexibility, that allows State and local officials to fund the projects and programs that will work best in their communities to reduce emissions and address congestion.

An evaluation of the success of the CMAQ Program was conducted by the National Academy of Sciences and completed in April 2002. The purpose of this study was to determine if the CMAQ program had been able to demonstrate that it was an effective program in reducing emissions from transportation sources, reducing congestion, and improving quality of life. The study found widespread support for the program although it noted that quantifying the success of the program was difficult because of the many different types of projects funded under the program for which there is no standard method for evaluating emission reductions. The report noted that CMAQ provided a "…valuable laboratory for learning how well different types of projects perform in improving air quality…" It also noted that some projects have been more successful than others in providing emission reductions. The report recommended that the CMAQ program be continued and offered some suggestions to improve the ability to quantitatively estimate the benefits of the projects.

Funds provided by the CMAQ program only constitute a small percentage of the total funds used for transportation projects, and as such, affect only a small portion of the existing transportation network in a metropolitan area or nationally. Therefore, the gain from these projects will have obvious limits. Nonetheless, the CMAQ program serves a very important function in providing developmental funds for projects an area believes would help in reducing emissions. The air quality benefits for a project are determined and documented before that project can be considered eligible as a CMAQ project.

Transportation Control Measures

Transportation control measures are specific measures that are included in an area's air quality State implementation plan to reduce the use of single occupancy vehicles or to improve the efficiency of the transportation system. Exhibit 19-10 describes these types of measures. As with projects funded under the CMAQ program, it is believed that by encouraging the use of alternate forms of transportation or transportation patterns through these projects, reductions in emissions can be achieved, which will help areas meet air quality standards. Many of these projects and programs are targeted at changing behavioral patterns and therefore their effectiveness is a function of the value drivers place on their time, convenience and financial resources. Their effectiveness will be further limited by the relative size of the projects as discussed above. Transportation control measures are only part of the picture for reducing emissions and encompass a wide variety of alternatives including transit development, improvement or expansions programs, and behavioral programs promoting changes in personal transportation use patterns.

Exhibit 19-10

Transportation Control Measures CAA §108(f)(1)(A), 42 U.S.C. §7408(f)(1)
(i) programs for improved public transit;
(ii) restriction of certain roads or lanes to, or construction of such roads or lanes for use by, passenger buses or high-occupancy vehicles (HOV);
(iii) employer-based transportation management plans, including incentives;
(iv) trip-reduction ordinances;
(v) traffic flow improvement programs that achieve emissions reductions;
(vi) fringe and transportation corridor parking facilities serving multiple-occupancy vehicle programs or transit service;
(vii) programs to limit or restrict vehicle use in downtown areas or other areas of emissions concentration particularly during periods of peak use;
(viii) programs for the provision of all forms of high-occupancy, shared-ride services;
(ix) programs to limit portions of road surfaces or certain sections of the metropolitan area to the use of non-motorized vehicles or pedestrian use, both as to time and place;
(x) programs for secure bicycle storage facilities and other facilities, including bicycle lanes, for the convenience and protection of bicyclists, in both public and private areas;
(xi) programs to control extended idling of vehicles;
(xii) reducing emissions from extreme cold-start conditions;
(xiii) employer-sponsored programs to permit flexible work schedules;
(xiv) programs and ordinances to facilitate non-automobile travel, provision and utilization of mass transit, and to generally reduce the need for single-occupant vehicle travel, as part of transportation planning and development efforts of a locality, including programs and ordinances applicable to new shopping centers, special events, and other centers of vehicle activity;
(xv) programs for new construction and major reconstruction of paths, tracks, or areas solely for use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest. For purposes of this clause, the Administrator shall also consult with the Secretary of the Interior; and
(xvi) programs to encourage removal of pre-1980 vehicles.*

*Note: Excluded from CMAQ Funding under TEA-21

Source: Clean Air Act Section 108(f)(1)(A), 42 USC 7408(f)(1).

Inspection and Maintenance Programs and Other Control Measures

Other control measures are as important in reducing emissions. For example, Inspection and Maintenance Programs are required in certain areas. These programs are intended to insure that vehicles are maintained properly so that the emissions from the vehicle are minimized. These programs provided significant emission reduction benefits since vehicles built prior to the 1990s emitted large quantities of some pollutants. The relative effectiveness of I&M programs has decreased in importance over the years as newer vehicles are emitting far less emissions than vehicles one decade ago and the deterioration of the vehicle emission control systems have been greatly reduced, resulting in cleaner vehicles operating for longer periods.

Other measures to reduce emissions include accelerated vehicle retirement programs to encourage owners of older, higher polluting vehicles to turn in their vehicles and receive funds that can be used for the purchase of a lower polluting vehicle. Episodic emission control programs are designed to educate the public about individual activities that impact local air quality and can include messages encouraging people to use mass transit on days when air quality is anticipated to be poor. Other programs addressing land-use control and congestion pricing exist. The cumulative effect of all these programs has been a substantial impact on reducing emissions associated with motor vehicles.

Public Education

The causes of air pollution are not always intuitive and as a result, individuals, organizations and companies have different views on its solutions. Efforts to reduce emissions require a public education campaign to raise awareness on pollution's causes and cures. "It All Adds Up to Cleaner Air" is a program designed to educate the public on methods for reducing emissions. Its focus is to work with State and local agencies to increase public awareness of the connection between travel choices and congestion. The program is led by the Federal Highway Administration and has the support and endorsement of the Environmental Protection Agency and the Federal Transit Administration. These federal partners are working collaboratively with State and metropolitan officials to educate the public on causes of transportation related air pollution. Three core messages are the foundation of this program, including maintaining vehicles in top running condition, encouraging trip-chaining or combining several trips into one trip, and choosing alternative modes of transportation when possible. Public education is helping to reduce emissions from transportation activities by developing support for individual and community solutions.

Q. What is the difference between the amount of air pollution produced by public transportation vehicles and privately-owned vehicles?

A. According to a recent report by researchers affiliated with the American Enterprise Institute, Applied Mathematics, and the Brookings Institution, and published by the American Public Transportation Association, public transportation produces "about 90 percent less volatile organic compounds, more than 95 percent less carbon monoxide, and almost 50 percent less nitrogen oxides and carbon dioxide than private vehicles would" to transport the same number of people.

Transportation Planning and Conformity

As stated earlier, ISTEA strengthened the transportation planning process. One way it did this was by requiring States and MPOs to carry out a comprehensive planning process to better develop transportation plans that could help improve air quality. The requirements of ISTEA were matched with provisions in the 1990 amendments to the Clean Air Act limiting Federal transportation activities in nonattainment and maintenance areas under certain circumstances. This provision in the CAA is intended to integrate the transportation and air quality planning processes and is known as transportation conformity. It is seen as a way to ensure that Federal funding and approval goes to those transportation activities that are consistent with air quality goals. A conformity determination demonstrates that the total emissions projected for a transportation plan and program are within the emissions limits ("budgets") established by the SIP, and that transportation control measures are implemented in a timely fashion.

In 2001, a very high percentage (94-100 percent) of nonattainment and maintenance areas had developed transportation plans that met emissions reduction goals. This is described in Exhibit 19-11.

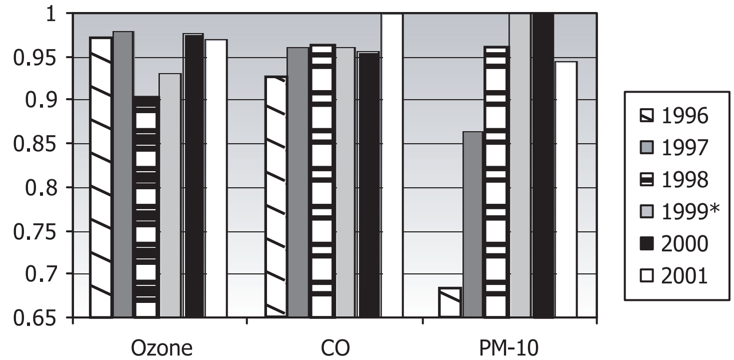
Transit and Clean Air

Transit vehicles represent only a very small share of total on-road transportation vehicles. In 1998, for example, on-road transit vehicles represented only 0.06 percent of the total on-road vehicles in the United States. Of the total number of diesel heavy trucks and buses on the road in 1998, transit-specific buses represented less than one percent. In terms of transit's contribution to air emissions, the 1998 total emissions of hydrocarbon, carbon monoxide, and nitrogen oxide from transit buses were less than 2,000 kilograms per vehicle-mile as compared to more than 5,000,000 kilograms per vehicle-mile for all U.S. automobiles and light trucks. Exhibit 19-12 compares emissions from the bus fleet with emissions from diesel trucks, automobiles, and light trucks.

In addition to improvements in automobile emissions control, technological improvements have reduced emissions from transit vehicles. Fuel and engine design improvements, such as the use of alternative fuels and the use of cleaner-burning diesel engines, have led to a more efficient transit fleet. Many of these developments have been made possible through the funding increases realized under ISTEA, TEA-21, and flexible funding programs like the CMAQ program.

Exhibit 19-11

Areas Meeting On-Road Mobile Source Emissions Goals
Fiscal Years, 1996-2001



* Data is incomplete for 1999; only 40 States provided information.

Fiscal Year Percent of Nonattainment & Maintenance Areas Meeting Emissions Goals

	Ozone	CO	PM-10
1996	96.70%	92.60%	68.20%
1997	98.00%	96.20%	86.40%
1998	90.30%	96.40%	96.00%
1999*	93.00%	96.20%	100.00%
2000	97.80%	95.70%	100.00%
2001	97.00%	100.00%	94.44%

Sources: Annual Performance Reports, FHWA.

Buses represent the single largest mode of transit travel in the United States. In 1999, more than 43 percent of passenger miles traveled on transit services were on buses. Transit buses consume a large volume of fuel (on average, nearly 10,000 gallons of fuel per vehicle per year). Buses represent the largest consumer of diesel fuel in the transit industry. Because of the large consumption of fossil fuel by buses and the impact that fossil fuels may have on air quality, this section focuses on specifically on transit bus fleet emissions and developments in cleaner bus technologies.

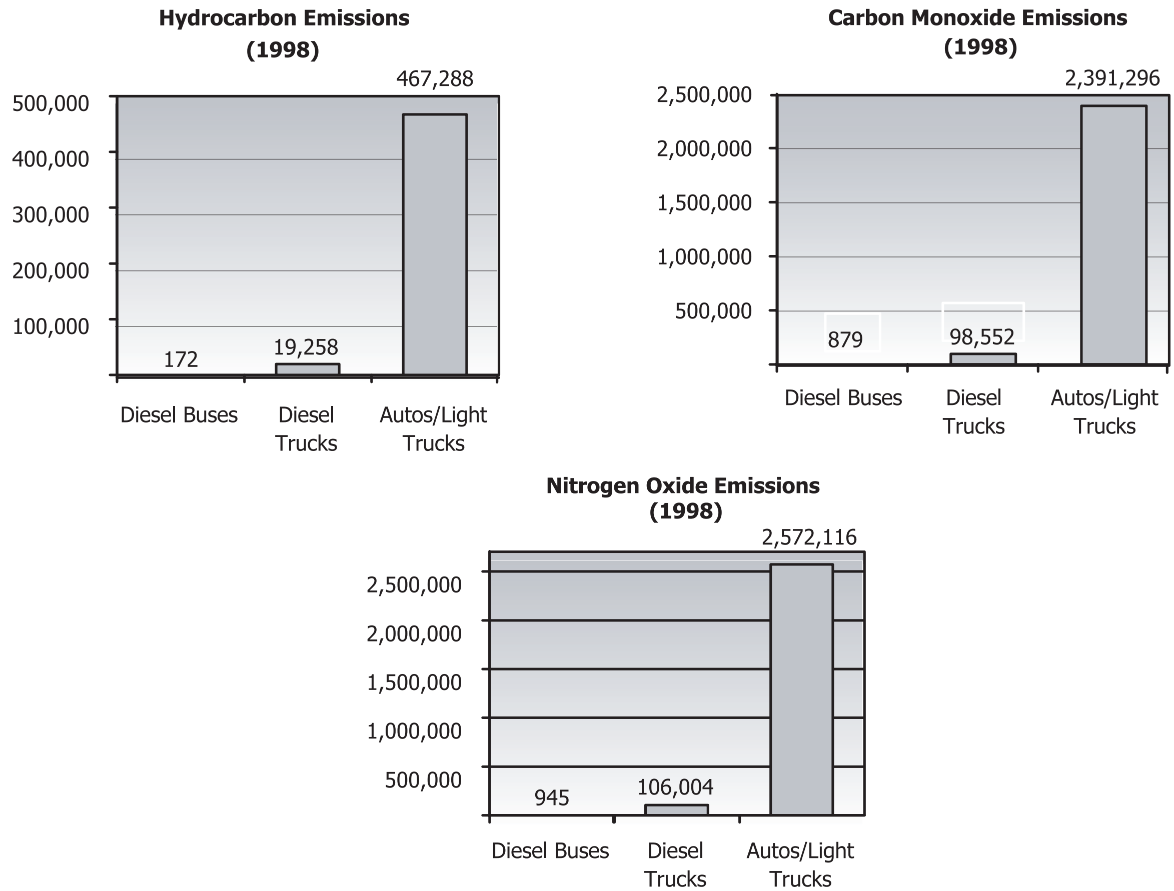
Diesel engines remain the overwhelming majority of bus engine types purchased by U.S. transit agencies. According to the American Public Transportation Association, diesel engines represented more than 75 percent of new bus purchases in 1998 and 1999. This is described in Exhibit 19-13. The second largest group of purchases in those years was for buses powered by compressed natural gas (CNG), representing more than 16 percent of all bus purchases during this period. Other bus types, including liquid natural gas, liquid petroleum gas, hydrogen fuel cell, biodiesel, and gasoline, represented less than 8 percent of new bus purchases. (See Exhibit 19-14.)

Diesel engines provide relatively high fuel economy and reliability. Historically, diesel engines have emitted high levels of particulate emissions, sulfur dioxide, and nitrogen oxides. Today's diesel engines, however, are already substantially cleaner than those purchased only ten years ago. Through improved engine controls, cleaner fuel, and the use of advanced catalysts, conventional diesel engines are generating significantly lower levels of particulate and sulfur emissions.

Another fuel source is natural gas. Unlike conventional diesel fuel, which contains sulfur particulates and often impurities, natural gas contains essentially no sulfur and is relatively clean-burning. It is also abundant in the

Exhibit 19-12

Comparison of Emissions by Vehicle Type, 1998 (Kilograms per Vehicle Mile)



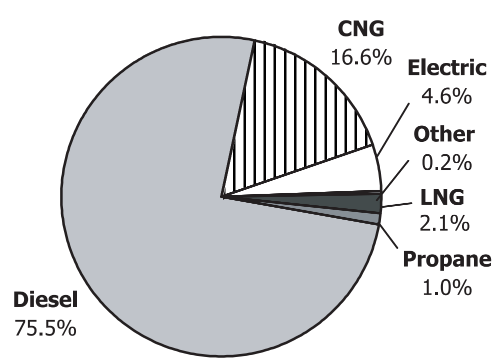
Source: Bureau of Transportation Statistics.

United States. Because of the gaseous nature of this fuel, it must be stored onboard a vehicle in either a compressed gaseous state (CNG) or in a liquefied state (LNG). (See Exhibit 19-15.)

CNG buses are becoming the largest segment of alternative fuel transit buses; in 1998 and 1999, for example, they constituted over 16 percent of new bus purchases. They require specialized vehicle fuel storage as well as fueling facility infrastructure. Specifically, the fuel tank on the bus must be able to handle pressurized fuel storage and the fueling infrastructure must install pressurizing natural gas pumps. The on-board gas cylinders are often quite large and can significantly affect the weight (and therefore fuel economy) of the vehicle.

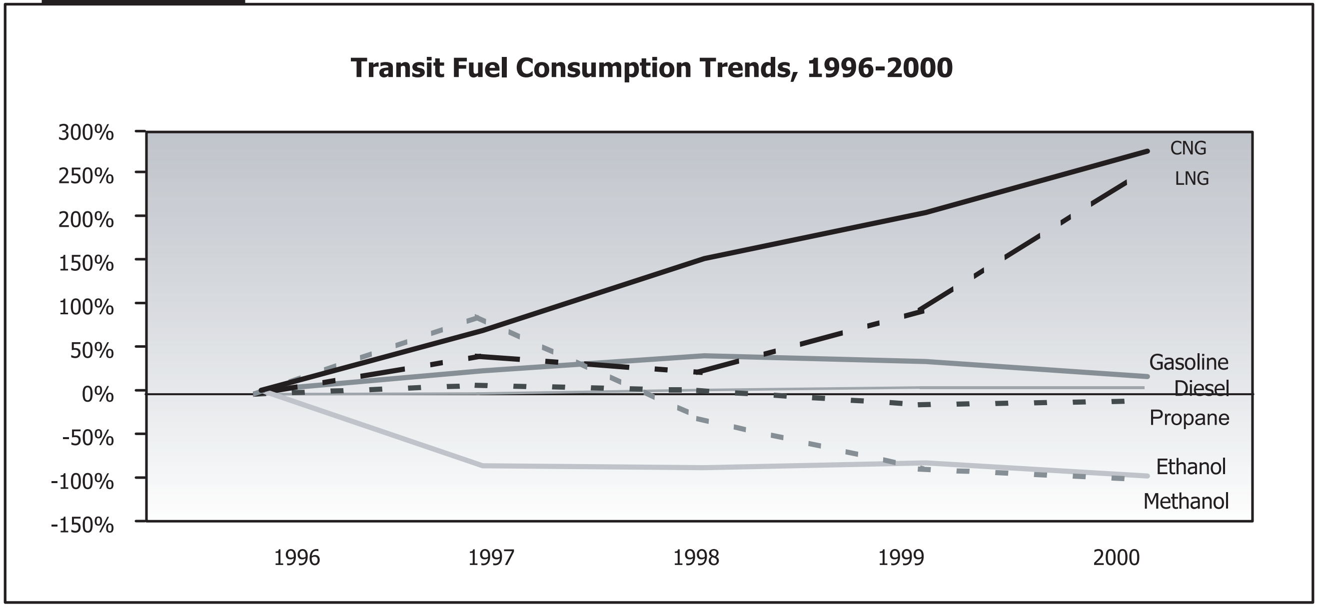
Exhibit 19-13

Total Bus Purchases, 1998-1999



Sources: National Transit Database

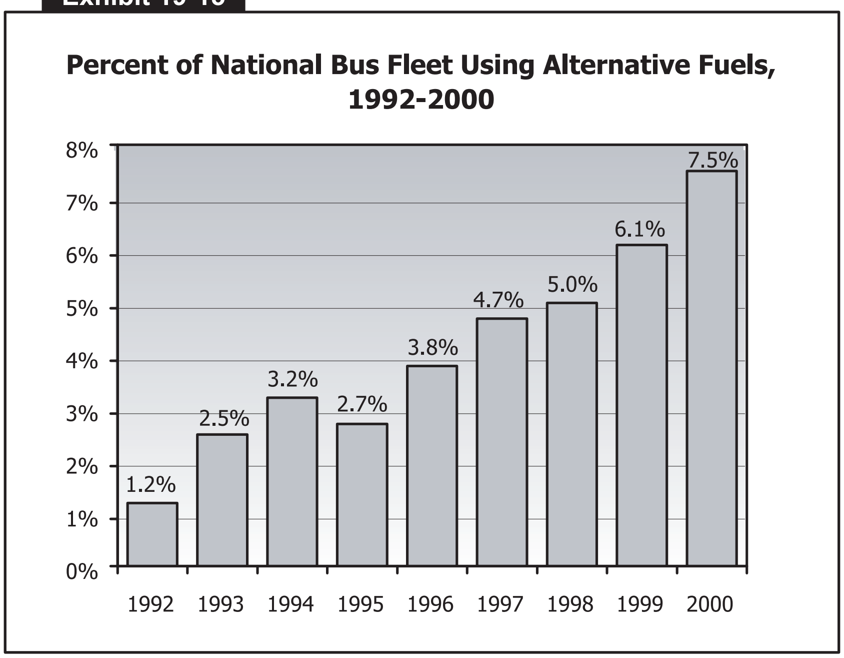
Exhibit 19-14



Source: National Transit Database

Liquefied natural gas (LNG) requires similar pressurized storage to CNG. LNG is almost pure methane and, because it is a liquid, has an energy storage density much closer to gasoline than CNG. The requirements of keeping the liquid very cold, along with its volatility, make its applications more limited for transportation purposes. LNG requires on-board fuel storage that can keep the fuel at a cold temperature. In 1998 and 1999, LNG buses represented about 2.1 percent of new bus purchases in the United States. (See Exhibit 19-16)

Exhibit 19-15



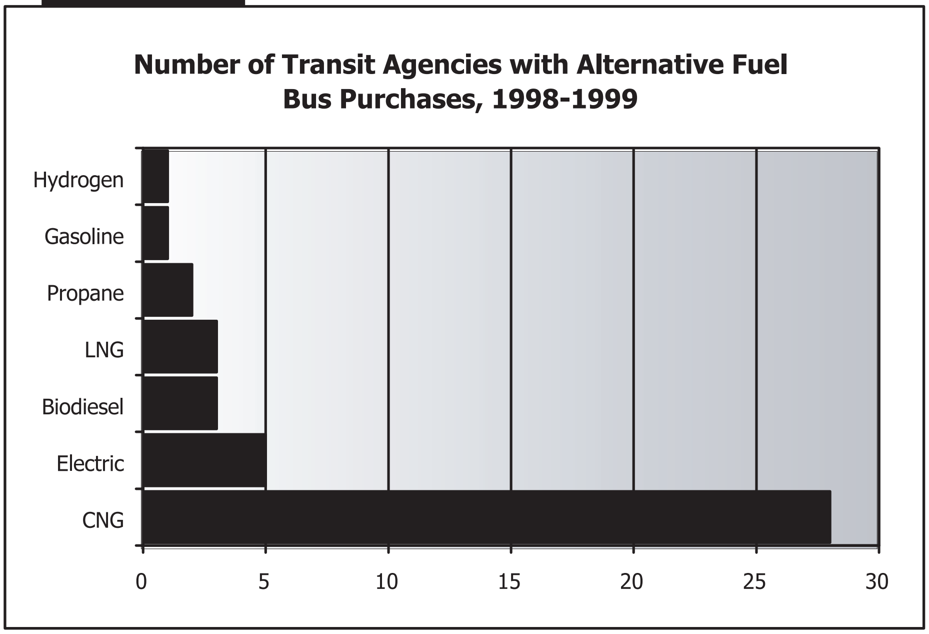
Source: 2000 National Transit Summaries and Trends

A new interesting fuel source is biodiesel, a synthetically manufactured diesel fuel made from biomass products such as soybeans, canola oils, animal fats, waste vegetable oils, and microalgae oils. Once these oils are combined with alcohol to create biodiesel fuel, it can be used solely or blended with conventional diesel for use in vehicles. Pure biodiesel is considered to be essentially free of sulfur, non-toxic, and can be used in conventional diesel engines with no major modifications. In addition, under emissions testing conducted for the Clean Air Act, biodiesel may produce significantly less carbon monoxide and particulate emissions than conventional diesel. As a renewable fuel, it may also have benefits towards reducing greenhouse gases. In

1998 and 1999, three transit agencies purchased these experimental vehicles for use in their transit bus fleets. (See Exhibit 19-17.)

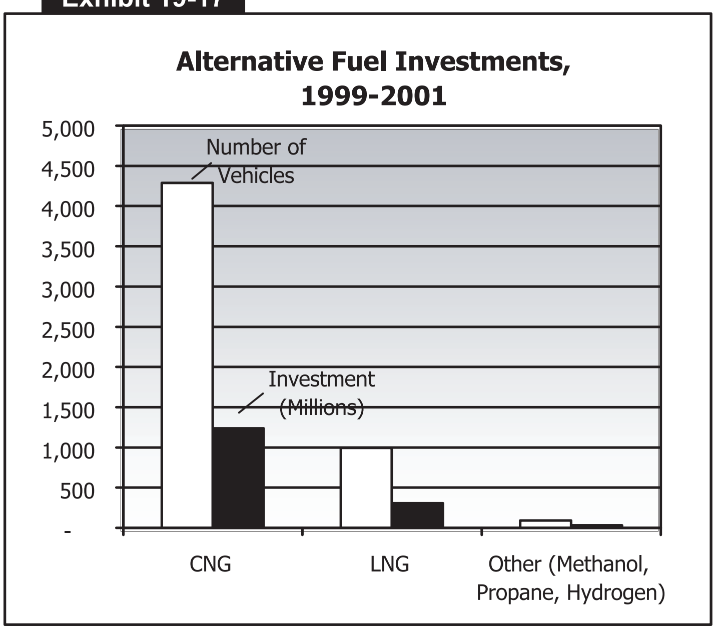
Improvements are also being made to the actual design of buses. From 1999 to 2001, more than 300 transit agencies invested $1.57 billion in alternative fuel buses for their fleets. This funded the purchase of more than 5,300 vehicles. These investments included the purchase of new vehicles, retrofitting of existing vehicles, and infrastructure development or rehabilitation.

Exhibit 19-16



Source: Transportation Electronic Award and Management System.

Exhibit 19-17



Source: Environmental Protection Agency, National Air Quality and Emissions Trends Report, 1999, March 2001.

According to the Energy Information Administration, alternative fuel transit buses currently operate in 39 States. Thirty-seven percent are operated in California and 15 percent in Texas. Other States with alternative-fuel transit bus fleets that number more than 100 vehicles include Arizona, Georgia, Nevada, New Mexico, New York, Ohio, and Washington. Of this current fleet of alternative fuel vehicles, 70 percent were designated CNG, 15 percent LNG, 6 percent propane, and 4 percent all other alternative fuel types.

While transit's contribution to air pollution is very low, transit agencies are still doing their part to reduce emissions from bus fleets. Since 1996, there is a clear indication that clean burning, more fuel-efficient buses are playing a larger role in transit. With the regulatory standards for reducing emissions, the financial incentives of TEA-21 and other legislation, and the availability of alternatives to traditional diesel engines, there is little reason to doubt that the amount of emissions generated by transit bus fleets will dramatically decline in both the near and the long term.

Conclusion

It is true on a National level that air quality is getting better, but it is also true on at the local level in almost all metropolitan areas around the country. From 1990 to1999, only 9 percent of metropolitan areas had an upward trend of ozone concentrations; only one percent of metropolitan areas had an upward trend of PM-10 concentrations; and no metropolitan areas had an upward trend of carbon monoxide concentrations. Reducing pollutant emissions from motor vehicles has been the major factor to this trend in cleaner air, while enhancing the community and social benefits of transportation. Technological innovations, cleaner fuels, and the detailed highway and transit programs described in this chapter have reduced emissions significantly over the past 30 years, and this trend is projected to continue well into the future.

Chapter 20

Federal Safety Initiatives

Introduction

On September 20, 2001, Secretary of Transportation Norman Mineta addressed the Senate Committee on Commerce, Science, and Transportation, assuring the public of a transportation system that is safe, secure, and stable. Safety is a fundamental societal goal and a longtime priority for the U.S. Department of Transportation. The Department is commited to safety for all transportation modes; this chapter describes the programs used by the Department and its partners to improve safety on highway and transit systems specifically. Safety data is examined in Chapter 5.

Highway Safety Programs

Over the past four decades, the U.S. Department of Transportation has used a variety of tools to reduce highway fatalities and injuries. The Department has worked to improve safety through regulation; for example, Federal laws are implementing penalties on States that do not enforce intoxicated driving standards. The Department has also made grants to States to promote responsible driving and partnered with industry and public interest groups on public education campaigns. The Department also supports engineering and technological research so that State and local agencies can construct and maintain safer transportation systems.

The Department's highway safety program is comprehensive and extensive. Rather than adopting a single policy to improve safety, the Department uses many initiatives and interacts with both the public and private sectors.

Safety Restraint Systems

The public's acceptance of safety restraint systems represents one of the great public policy success stories of the past two decades. This resulted because of a two-pronged effort involving education and enforcement. Prompted by an intense public service campaign, public acceptance of safety devices steadily increased during the 1980s and 1990s. By 2000, about 71 percent of American motorists used shoulder belts, compared with 58 percent in 1994. Additionally, 49 States and the District of Columbia had mandatory safety belt laws by 2002, and 17 States and the District of Columbia had primary enforcement laws that allow police to stop a vehicle when they observe a safety belt violation.

Safety belts were the earliest type of automobile restraint system. Air bags were installed later in motor vehicles to provide additional safety for passengers. An estimated 106 million passenger vehicles in 2000 were equipped with air bags. This number will increase as aging cars are retired, since all passenger vehicles sold in the 1998 model year and thereafter have been required to have driver and passenger air bags. A third safety mechanism, child restraint systems, are also increasingly used by parents to reduce the likelihood of harm to young passengers.

Exhibit 20-1 shows the number of lives estimated to have been saved by restraint systems between 1994 and 2000. Safety belts saved an estimated 11,889 lives in 2000; air bags saved 1,584 lives; and child restraints saved 316 lives that year. Safety belts alone are estimate to have prevented 135,102 deaths between 1994 and 2000.

The U.S. Department of Transportation is engaged in several initiatives to increase passenger safety. Section 1403 of TEA-21, for example, contains a safety incentive grant program to encourage States to enforce **seat belt** use. Under this program, funds are allocated each Fiscal Year from 1999 until 2003 to States that exceed the national average for **seat belt** use or that improve their State's **seat belt** use rate. The authorized level for this program increased from $82 million in FY 1999 to $112 million in FY 2003.

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.

Exhibit 20-1

Estimated Number of Lives Saved by Restraint Systems, 1994-2000

	1994	1995	1996	1997	1998	1999	2000	ANNUAL RATE OF CHANGE 2000/1994
Restraint Type								
Seat Belts	9,206	9,790	10,414	10,750	11,018	11,197	11,889	3.7%
Air Bags	276	470	686	842	1,043	1,263	1,584	29.9%
Child Restraints	308	279	365	312	299	307	316	1.2%

Source: Fatality Analysis Reporting System.

Section 2003 of TEA-21 established a new program of incentive grants to encourage States to implement child passenger protection programs. This program was authorized at $7.5 million in FY 2000 and FY 2001. Section 2003 also established a new program of incentive grants to reduce highway deaths and injuries resulting from individuals who ride 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 U.S. Department of Transportation has worked with industry partners, States, and local governments to improve driver behavior. During the 1980s and 1990s, for instance, an aggressive public relations campaign helped educate millions of Americans about the dangers of impaired driving, which led to a sharp decline in highway fatalities and injuries.

There are numerous Departmental initiatives to promote responsible driving. Section 1404 of TEA-21, for example, established a new program of incentive grants 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 .08 BAC the national standard for impaired driving. States that did not adopt .08 BAC laws by FY 2004 would have certain highway construction funds withheld.

Q. How can public awareness campaigns improve highway safety?

A. Public awareness campaigns have helped reduce the number of alcohol-related crashes. Similar campaigns have educated the public about the importance of safety restraint systems and helmets. Recently, there has been interest in using public awareness campaigns to spotlight “cutting edge” issues such as the dangers of fatigued and distracted driving and the importance of rural emergency management services. Speeding is also a perpetual problem; in 2000, speeding was a contributing factor in 30 percent of all fatal crashes.

Operations Strategies

Chapter 21 describes how operations strategies can improve the performance of the highway system. Operations strategies include actions taken by public agencies to maintain capacity and highway safety by controlling traffic, responding to incidents, clearing snow and other obstructions, and providing information to users on highway conditions and alternatives. Operations strategies can also, however, improve the safety of the driving public.

Intelligent Transportation System (ITS) infrastructure, for example, has substantially affected highway safety. This has been accomplished by smoothing traffic flow, warning drivers of hazardous conditions, and providing technology for better incident response and enforcement.

Ramp metering technology has helped reduce crashes. The Minneapolis-St. Paul area has implemented ramp metering on its freeway onramps since 1969. In late 2000, the entire system of more than 400 ramp meters was turned off for several weeks to collect baseline data on system performance without metering. The evaluation report estimates that the ramp metering system helps prevent approximately 1,041 vehicle crashes per year.

Another ITS initiative is video surveillance. Over the last 5 years, video surveillance has become a common feature on freeways in many urban areas. These video systems help identify and verify incidents. It is much easier to clear the roadway if the right emergency services can be dispatched quickly. This minimizes traffic back-ups and associated secondary crashes. A Minnesota study found that 13 percent of all peak period crashes were the direct result of a previous incident. A separate field test in San Antonio determined that surveillance in that area resulted in a 15 percent reduction in injury-related crash rates.

ITS technology can also provide drivers with specific information to help them avoid crashes. The Dynamic Downhill Truck Speed Warning System in Denver's Eisenhower Tunnel measures truck weight, speed, and axle configuration. The system then computes a recommended safe speed for each truck, which is displayed on a variable message sign. Since deployment of this system, truck-related crashes have declined on steep downhill grade sections (even though truck traffic volume has increased by an average of 5 percent per year).

Operations managers are also trying to improve safety by making drivers better aware of weather conditions. Washington State posts mountain pass conditions on its road weather information World Wide Web site to help travelers avoid delays and dangerous conditions. During the 1997–1998 winter season, this site was visited 10 million times. Based on this response, State officials are integrating into the Web site observations from 400 weather sensor sites around the State. Utah, Alabama, California, Georgia, South Carolina, and Tennessee are also experimenting with fog detection and warning systems on roads or bridges. Tennessee, for example, installed a system of fog detection devices, variable message signs, and variable speed limit signs on a section of Interstate-75 that was the site of more than 200 fog-related vehicle crashes between 1973 and 1993. There were no fog-related crashes in the six years after the system was implemented.

Another innovative operations strategy is the increasing use of service patrols. Service patrols in Illinois, Indiana, and Georgia have been well-received by the traveling public. Hoosier Helper patrols in Indiana, for instance, provide assistance to drivers on 16 miles of Interstate-80 and Interstate-94 and eight miles of Interstate-65 near Gary. Patrols provide support for the State Police during incidents and assist drivers free of charge by changing flat tires, supplying fuel, and calling tow trucks. A recent study of the effectiveness of this program showed that daytime operations yielded a 4.7-to-1 benefit-to-cost ratio, and that 24-hour operations yielded a 13.3-to-1 benefit-to-cost ratio.

Motor Carrier Safety

The Federal Motor Carrier Safety Administration (FMCSA) has primary authority within the U.S. Department of Transportation for regulating motor carrier safety. FMCSA is involved in numerous safety initiatives, only some of which are described below.

FMCSA implements the cross-border truck and bus provisions of the North America 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 United States-Mexico border.

FMCSA has invested heavily in infrastructure and personnel along the United States-Mexico border. For example, the agency provided special funding above allocated Motor Carrier Safety Assistance Program (MCSAP) grant levels to increase commercial motor vehicle inspections and other enforcement activities along the border. Between 1995 and 2001, the agency provided over $23 million for border related enforcement and compliance activities, and State and Federal inspectors conducted nearly 225,000 inspections of Mexican trucks. By 2002, FMCSA had deployed 60 full-time Federal inspectors to inspect inbound motor carriers from Mexico at the border.

FMCSA also implements the Performance and Registration Information Systems Management Program (PRISM). The goal of PRISM is to improve motor carrier safety through a comprehensive system of identification, education, awareness, safety monitoring and treatment. The PRISM initiative has two major elements. The Commercial Vehicle Registration Process establishes a system of accountability by insuring that no vehicle is registered without identifying the carrier 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 a Federal "unfit" or "imminent hazard" designation and the possible suspension of vehicle registration by the State.

Q. What results did the PRISM pilot program produce?

A. The PRISM pilot program produced significant results. First, it increased accountability since better identification allowed safety incidents to be traced to a specific motor carrier. PRISM also led to improved productivity. It increased efficiency by developing a more accurate process to target high-risk motor carriers and efficiently allocate scarce enforcement resources. Warning letters proved to be an effective and inexpensive alternative to a compliance review for carriers with less severe safety performance problems. Third, the program improved data quality; for example, it led to a procedure for obtaining operational data on motor carriers as part of a State's annual vehicle registration renewal process. Finally, the program improved customer service. Under the PRISM initiative, a State could issue truck identification numbers. This is more customer-friendly because it reduces the number of government agencies that a motor carrier must deal with to get on the road.

Infrastructure Enhancement

There are numerous research initiatives underway to determine how physical infrastructure improvements can improve safety. The Federal

Highway Administration (FHWA) has identified four focus areas: run-off-the-road crashes, speeding-related crashes, crashes at intersections, and pedestrian and bicyclist crashes. Infrastructure improvements can lower these types of crashes in different ways. Typically, the number of fatalities prevented from infrastructure improvements on a rural highway can be higher than the number of fatalities prevented on an urban highway, and the number of injuries prevented is higher for an urban road than a rural road.

There were 15,905 single vehicle run off the road crashes in 2000 (about 38 percent of all fatal crashes). These crashes could be reduced through engineering techniques: better geometric design, more durable pavement markings, more visible roadside signs, and increased skid- resistant roadway surfaces. One of the measures to help prevent run off the road crashes is the installation of rumble strips that create a noise effect when a driver drifts off the road onto the shoulder.

Q. **How effective are rumble strips in reducing run off the road crashes?**

A. Maryland installed continuous shoulder rumble strips along 195 miles of its highways in 1999. An evaluation was conducted using 2000 crash data to determine if the installation of rumble strips reduced fixed-object crashes and crashes in the opposite direction, both of which are very severe and likely to result in injuries or fatalities. The results were very positive. The number of fixed-object crashes declined by 104, and there were 4 fewer opposite direction crashes. The study concluded that the installation of rumble strips resulted in an estimated safety benefit of $182 for every dollar spent.

A separate study in New York concluded that run-off-the-road crashes declined by 65 percent between 1993 and 1998, after rumble strips were installed on that State's highways. This has resulted in a savings of $18 million a year from reduced fatalities alone.

Rumble strips are funded through FHWA's Hazard Elimination Program. This program is designed to improve safety at dangerous highway locations. Typical projects include intersection improvements, new or upgraded traffic signals, highway lighting, pavement and shoulder widening. Additionally, FHWA provides assistance to States to improve the safety of rail crossings. The Highway-Rail Grade Crossings Program is designed to reduce the number and severity of train collisions with vehicles and pedestrians. All public crossing safety improvements are eligible for Federal funding. Typical projects include the installation of signs and markings, upgrades to active warning devices, sight distance improvements, grade separations, and the elimination of crossings.

Since these programs began, they have produced benefits for communities across the United States. These benefits include an overall reduction in the number and severity of crashes or reductions in specific types of crashes. For example, a hazard elimination project was implemented at an intersection in Lawrence, Kansas. A study of this intersection indicated a pattern of left turn and rear end collisions. Local officials added left-turn lanes and upgraded the traffic signals and, within a year of the improvements, minor crashes had declined from 28 to 12; injury crashes dropped from 12 to 3; and left turn crashes declined from 14 to 4. Rear end crashes remained the same, but the number of injuries resulting from these crashes declined from 7 to 2.

Uniform Traffic Standards

FHWA works with NHTSA, FMCSA, and the National Committee on Uniform Traffic Laws and Ordinances to develop uniform traffic laws and regulations. Traffic laws must clearly and accurately define the responsibilities of drivers and pedestrians; if not, traffic signs, markings, and signals will fail in their purpose. Laws must also state who has authority to provide and enforce the observance of traffic control devices. FHWA recently published a new version of the Manual on Uniform Traffic Control Devices, which defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways.

Data Collection

Data collection is an important part of the Department's safety efforts, allowing problem areas to be identified and guiding the allocation of resources to address those problems. Numerous agencies are involved in collecting data about fatalities and injuries. For example, FHWA's Safety Core Business Unit represents the Department of Transportation at the International Traffic Records Forum, an annual meeting that addresses worldwide crash data collection efforts. FHWA's Safety Core Business Unit has also supported the National Model, a software package that helps local law enforcement agencies collect accurate crash information.

FHWA, FMCSA, and the National Highway Traffic Safety Administration (NHTSA) are collaborating on study to determine the causes of large truck crashes that result in a fatality or serious injury. The Large Truck Crash Causation Study involves studies at 24 sites nationwide. Data collection will end once statistics have been collected on at least 1,000 crashes, probably by mid-2003.

Data collection is often problematic, since statistics must be gleaned from crashes that occur at the local level. FMCSA maintains a Motor Carrier Management Information System Crash File that is designed to be a census of all large commercial truck and bus crashes. However, many States do not return reports to FMCSA that meet the crash criteria. Additionally, many reports that are received are incomplete or inaccurate. FMCSA and NHTSA are now working jointly to improve this system.

Section 2005 of TEA-21 established a new program of incentive grants to encourage States to collect safety data in a more timely, comprehensive manner. The authorized level for this program increased from $5 million in FY 1999 to $10 million in FY 2002.   Accurate crash information is needed to determine the extent of safety problems, but data must first be reported by State and local authorities.

Transit Safety Programs

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 Education; (4) Substance Abuse; (5) Security and (6) Data Collection and Analysis. Additionally, FTA works to improve safety through the Department's Intelligent Vehicle Initiative.

Modal Safety Program

The Modal Safety Program has three key components:

- Rail Fixed Guideway
- Railroad
- Bus

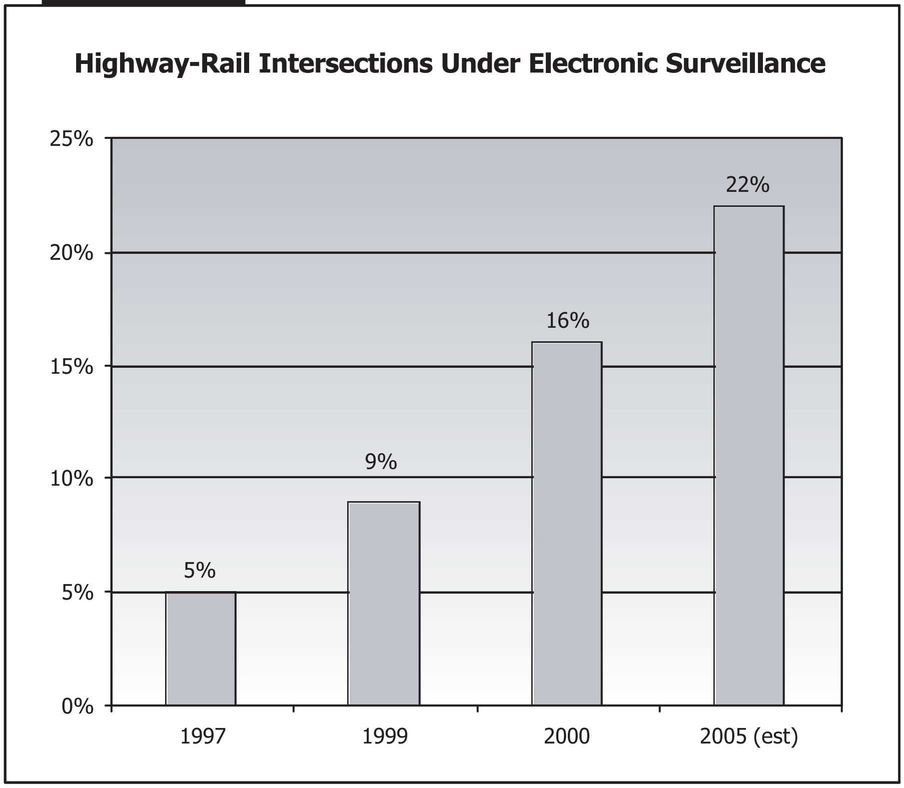
The Rail Fixed Guideway component of the Modal Safety Program was implemented in 1995; when FTA published a final rule requiring States with fixed guideway systems to designate an independent oversight agency to oversee the safety of rail systems not regulated by the Federal Railroad Administration (FRA). Currently 22 States and 36 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. 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. 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 and Materials Safety; and (3) Train Control Centers Safety.

Under the Railroad Grade Crossing Safety subprogram, FTA demonstrates, evaluates, and deploys innovative grade crossings 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. As shown in Exhibit 20-2, the percentage of highway-rail intersections under electronic surveillance increased from 5 percent in 1997 to 16 percent in 2000, and is expected to continue to climb.

Under the Rail Vehicles 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. 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.

Exhibit 20-2



Source: US Department of Transportation, ITS Tracking, Survey Results.

Under the Train Control Centers 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. 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.

The Bus component of FTA's modal safety program is comprised two parts. The Bus Testing Program ensures that 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, PA, 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. These core program elements are 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

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 website describing ongoing programs and new initiatives; and technical assistance, guidelines, and newsletters on safety issues.

Training and Education

FTA provides safety and security training to the transit industry through the Transportation Safety Institute, the National Transit Institute 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; Transit Rail Accident Investigation; Transit Rail System Safety; Fundamentals of Bus Accident Investigation and Substance Abuse Management. Through the Transit Safety Institute, FTA has provided training to over 70,000 transit industry employees since 1971, including more than 23,000 since 1998. Through the National Transit Institute, FTA has conducted three Workplace Safety and Security train-the-trainer courses in FY 2002 and has four additional courses planned in FY 2002, as well as three FY 2003 sessions. In FY 2002, through the Volpe Center, FTA conducted 13 drug and alcohol seminars, drawing over 1,100 people.

Substance Abuse Program

The Omnibus Transportation Employee Act of 1991 authorized the U.S. Department of Transportation 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. FTA is responsible for implementing these regulations and auditing the compliance of transit operators with these rules. As of July 29, 2002, FTA has conducted 126 audits since the inception of the drug and alcohol audit program in 1997. Thirty-eight audits are scheduled for FY 2002.

Security Review Program

Between February 1997 and July 2002, FTA conducted 59 Security Reviews and 20 follow-up Security Reviews of transit agencies. Security reviews are independent security and emergency management reviews of transit agencies plans, procedures, and training to ensure the highest level of transit system security against major crimes and acts of terrorism, and to assess the ability to quickly and effectively respond to the consequences of a critical emergency incident. Specifically, the reviews have included an evaluation of the:

- Transit agency system security program, including plan and procedures
- Threat and vulnerability assessment (TVA) process used
- Emergency management plan and response procedures
- Countermeasures to transit crimes and terrorism
- Training of transit personnel in security and emergency response procedures
- Training of emergency response personnel in transit operations and procedures
- Coordination of emergency response agencies with the transit agency during an emergency incident

Based on the review, FTA makes recommendations to the transit agency to mitigate vulnerabilities and improve emergency response capabilities.

FTA security programs are discussed in more detail in Chapter 12.

Data Collection and Analysis Program

All transit agencies must submit safety and security data into the FTA National Transit Database Safety and Security Module. This data on transit safety and security is 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. FTA has extended its efforts by collecting transit vehicle accident and incident causal data through the State Safety Oversight Annual Reporting requirement 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

FTA is also working to improve safety through the DOT's Intelligent Vehicle Initiative (IVI). 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 efficiently.

Chapter 21

Operations Strategies

Introduction

This chapter explores the advantages of implementing operations strategies to improve the efficiency and effectiveness of the Nation's highway system. Operations strategies include actions taken by public agencies to maintain capacity and safety of highways by controlling traffic, responding to incidents, clearing snow and other obstructions, and providing information to users on highway conditions and alternatives.

The Need for Operations Strategies

Historically, highway agencies have focused most of their attention on building and maintaining road infrastructure. Much less attention has been paid to operating the road system to provide the highest level of service possible. Effective and efficient operation of highways was largely left to motorists and carriers. With increasing road congestion, the expense and difficulty of building new facilities, and the need for safe and secure highways, this view has begun to change. Many highway officials now recognize that operational strategies, including traffic control and enforcement, incident and emergency management, ice and snow removal, and the deployment of Intelligent Transportation Systems (ITS) technologies, can make a major difference in how the highway system performs.

Operations strategies are needed to mitigate congestion in its many forms. Highway congestion is not just a problem of recurring "rush hour" delay in the largest U.S. cities. Over half of the 4.5 billion hours of vehicle delay every year, measured by the Texas Transportation Institute in 68 cities, is due to incidents such as breakdowns and crashes. Oak Ridge National Laboratory estimates that, throughout the Nation, delay caused by freeway work zones, poorly timed traffic signals, and by snow, ice, and fog is greater than delay from breakdowns and crashes. Several sources of non-recurring delay were not considered in these estimates, including special events, rain, rail-highway grade crossings, toll booths, and work zones on arterials other than freeways. The estimates also do not include recurring delay in rural areas on local roads with concentrations of recreational travel and on heavily traveled intercity highways.

As summarized in Exhibit 21-1, operations strategies can influence the reliability, timeliness, safety, and security of highway use while responding to recurring delay and temporary capacity loss. The relationships of operations strategies to these conditions are described in the following sections, as well as in Chapter 12 (national security) and Chapter 20 (safety).

Operations and Reliability

As discussed in chapter 13, reliable, predictable travel times are especially important in a society where travelers put a high value on their own time and where many goods are relatively expensive and are needed in tightly scheduled manufacturing and distribution systems. Late arrivals can have significant economic costs for workers reporting at the beginning of their day or picking up children from day care at the end of the day, for factories waiting for parts to assemble, and for carriers who are missing guaranteed delivery times. Even when the transportation system breaks down, travelers are less disturbed if they can predict with some certainty how long they will be caught in traffic and adapt their plans.

Of the many factors that get in the way of reliability, some can be anticipated well in advance, others have shorter times for adapting, and some happen with little or no advanced warning. For example,

Exhibit 21-1

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?	WHAT DO TRAFFIC MANAGERS NEED TO KNOW TO ACT MORE EFFECTIVELY AND EFFICIENTLY?
Reliability (reliable, predictable travel time)	Special events; Work zones; Bad weather; Vehicle crashes and breakdowns	Reroute traffic or adjust lanes and traffic control; Snow and ice removal; Incident response vehicles; Emergency medical services	Type and location of delay; Amount of traffic being disrupted; Alternative routes, modes, schedules; Type and location of resources to respond to incidents, crashes, and weather
Timeliness	All of the above plus: Daily and seasonal peaks of heavy traffic; Bottlenecks; Poorly coordinated traffic control	All of the above plus: Adaptive signal control; Ramp meters; Reversible lanes; Adjustments to carrier schedules	All of the above plus: Diurnal variations in traffic flow by day of week, week of month, month of year
Safety	Vehicle crashes and breakdowns, work zones, and bad weather; Driver behavior; Poor facility design and traffic control; Poor physical condition of facilities	Detect and respond to crashes; Traveler information on location of crashes and problem areas and on alternative routes; Driver education; Better signage and markings; Identify and correct unsafe conditions	Type and location of incident; Frequency of incident by type and location; Facility condition; Type and location of resources to respond to incidents
Security	Property theft; Personal assaults; Military logistics; Terrorism; Regional disasters	Visible monitoring as a deterrent; Reroute traffic or adjust lanes and traffic control; Detect and respond to threats and incidents; Identify and correct unsafe conditions; Threat assessments and disaster response plans; Traveler information on location of threats and incidents and on alternative routes	Type and location of threat or incident; Frequency of incident by type and location; Facility condition and vulnerability; Amount of traffic being disrupted; Alternate routes, modes, schedules; Type and location of resources to respond to threats and incidents

special events, from sporting contests to symphony concerts, frequently concentrate large quantities of traffic on limited portions of highway and transit systems. Other events such as parades and races close parts of the street network. There are about 2,000 events each year requiring analysis by a traffic engineer just in the City of Los Angeles. Special events are not limited to densely settled urban areas, as illustrated by the Winter Olympics and the original Woodstock music festival. With adequate notice and preparation, transportation managers can adapt traffic controls and transit schedules to handle the crowds, participants can find the least congested routes or plan for the delays, and other travelers can avoid the traffic by rerouting or rescheduling their trips.

Major reconstruction projects or overnight patching of potholes can significantly reduce highway capacity and cause congestion in urban and rural areas at all hours of the day and night. Like special events, most work zones can be anticipated and effective adjustments made by managers and users if information on the location and timing of the work is provided in advance.

Snow and ice close highways over thousands of square miles for days and block some mountain passes for months. Fog and rain bring traffic to a crawl in both warm and cold climates. Wind blocks trucks and campers from routes in deserts and mountains. Hurricanes force thousands of residents to flee coastal areas as rain and wind make local roads difficult to navigate. While bad weather is notoriously difficult to predict days in advance, technology is providing much better warnings hours in advance and better understanding of how much transportation facilities are likely to be affected (such as whether road surfaces are too cold for de-icing methods to work). Effective weather information helps users make route and schedule decisions, and helps traffic managers know when to reduce speed limits or close facilities, dispatch snow and ice removal equipment, or redirect traffic.

Vehicle crashes and breakdowns are the least predictable events. The most severe crashes often happen at night or on rural roads with little effect on traffic flow, but some crashes (particularly involving large trucks) during rush hours in congested cities can affect the urban area's entire freeway network. More important than traffic disruption is the potential for loss of life, as discussed in Chapters 5 and 20. When transportation managers become aware of a crash or breakdown, they can advise emergency response units and attempt to divert traffic from the site until the disruption has been cleared. When the geographic and temporal pattern of crashes is identified, crashes become more predictable and countermeasures can be deployed more effectively.

Operations and Timeliness

A reliable transportation system is inadequate if it does not get travelers to their destinations within a reasonable time. Traveler needs and economic efficiency are not served if highways slow consistently to a crawl. In addition to the temporary sources of capacity loss and delay, recurring congestion and poor traffic control increase travel time, adding significantly to the cost of travel and goods movement.

Streets in major cities are clogged by commuters during weekday rush hours and by shoppers on weekends. Seasonal throngs of visitors clog routes to recreational areas in rural areas. Intercity corridors and passenger terminals are strained around holidays, most notably on the Sunday following Thanksgiving. If the geographic and temporal patterns of traffic are adequately measured and understood, traffic management strategies such as reversible lanes and ramp meters can be implemented to increase capacity during the peak periods.

Even the most effective operations strategies cannot handle the continuing growth in vehicle travel on a static facility. The size of the population, the number and lengths of trips being taken by each person, and the quantity of goods being moved continue to increase. Congestion is most acute at major interchanges and locations where expressways narrow or transition into surface streets. Border crossings, highway-railroad grade crossings, and local streets that connect terminals with intercity arterials cause additional bottlenecks. Bottlenecks can be identified by their impact on traffic flow and by network analysis methods. Bottleneck removal usually involves significant construction and has the potential to negatively effect the local environment and community.

Motorists are often frustrated by idle time sitting at traffic signals, whether they are caught behind a line of vehicles or stopped at a red light with no other vehicles are in sight. Traffic signals can be set to move large volumes of traffic during rush hour or handle the occasional vehicle late at night, but a vast number of signals are not tied to necessary traffic sensing and control systems, or are not adequately coordinated or calibrated to move traffic efficiently.

Operations and Safety and Security

The relationship of operations and ITS technology to security and safety is discussed in Chapters 12 and 20, respectively. Aspects of these relationships not covered in those chapters are summarized here.

Safety is affected by many conditions beyond the control of traffic managers, such as driver behavior, vehicle design, and condition of highway infrastructure, as well as by traffic control and signage in the traffic manager's domain. Traffic managers can work with public safety officials to respond to bad weather, vehicle crashes, breakdowns, work zones, and other intrusions into the normal flow of traffic that create unexpected situations for drivers, often causing additional crashes. Traveler advisories can also divert motorists from dangerous situations caused by weather, work zones, and other vehicle crashes. A variety of ITS technologies, described in Chapter 20, are available to improve safety.

In addition to the concerns listed in Chapter 12, security involves:

- Property theft and personal assaults. Freight carriers and shippers of high-value goods must constantly deal with property theft. Travelers become concerned, sometimes to the point of changing travel plans, when they hear of incidents involving personal assaults against stranded motorists, taxicab operators or their passengers, or public transit patrons. These incidents are similar to crashes, requiring detection and quick response to minimize damage and identification of geographic and temporal patterns to help guide countermeasures. Detection systems can also be a deterrent if equipment such as video cameras is visible to potential transgressors and can provide evidence to find and prosecute wrongdoers.

- Regional disasters. Emergency responses and evacuations are not limited to acts of terrorism. Transportation managers have coped with evacuations and loss of capacity on the transportation network from hurricanes, earthquakes, floods, extensive fires in Florida and the West, and toxic releases from freight train derailments in both cities and rural areas. Often, some warning is given before a natural disaster strikes, and evacuations can be completed. Manmade disasters usually require more immediate action. In either case, transportation managers and public safety officials must know the threat to roads and travelers and any changes in the condition of the transportation network in order to guide responses for victims and support the logistics of reconstruction.

Implementation of Operations Strategies

A combination of improved operations, capital investments, and behavioral adjustments is needed to maintain flows of people and goods, respond to emergencies, correct unsafe conditions, reduce security threats, and preserve highway assets. Federal and State transportation programs stressed the importance of capital investments throughout the 20th Century, and added an emphasis on the

Q. **What types of operations technologies are being developed?**

A. Two of the more promising technologies involve Road Weather Information Systems and Traveler Information Systems.

Detailed weather information provided to travelers and road management agencies promises to lessen the effects of poor weather on safety and mobility and to reduce weather-related expenses. Much weather data are already collected by the National Weather Service (NWS), but this information is usually not detailed enough for specific roadways. To overcome this, many state and local governments are implementing Road Weather Information Systems (RWIS). RWIS includes all weather-information sources used in road operation and maintenance. In this discussion, RWIS refers only to the fixed roadside sensor suites for pavement condition and surface weather observations.

A network of information stations is needed to measure and forecast weather conditions at the level needed for road management. A weather station consists of a pavement temperature sensor, subsurface temperature sensor, precipitation sensor, wind sensor, air temperature and humidity sensors, visibility sensors, and remote processing unit. Spacing for this network is estimated to be approximately 15 miles to 30 miles based on climatic conditions (particularly snowfall). Additional information and closer spacing of information collection points is often required based on several factors. These may include local weather problems such as high snowfall, high rainfall, icing, fog, and high winds, places where the terrain makes weather problems more difficult to cope with, and the level of snow maintenance activities.

Traveler information systems provide assistance to the individual surface transportation traveler and allow transportation agencies in urban and rural environments to manage service disruptions and congestion. Information provided by a traveler information system usually includes road closure and restriction information due to construction, maintenance, special events, and HOV rules; current traffic conditions including recurring and non-recurring congestion; current road conditions due to the weather; and major service disruptions, changes, or additions.

Over the next 20 years, an $8 billion investment would be needed to maintain existing traffic signal controls in metropolitan areas that had 50,000 or more residents in 2000 and to maintain remaining technologies in the 78 largest areas. An additional $5 billion would be needed to expand this technology following existing trends. A more aggressive deployment to cover metropolitan areas of significant need would require $29 billion over 20 years in addition to the $8 billion to maintain existing operational improvements.

The major components of a traveler information system include data collection, data processing, and data dissemination. Costs here are based on estimates and include funding needed for data collection and data processing but not data dissemination. Data collection equipment is typically deployed on freeways and major arterials and includes various roadside detection technologies (loops, video image, and microwave radar), CCTV video surveillance cameras, telecommunications infrastructure, and an Internet-based road condition reporting system for traffic and traveler information.

preservation of physical assets in the 1980s. Attention is now turning to improved operations, particularly to the data and institutions needed to support enhanced operations.

Traffic managers, public safety officials, and public works agencies cannot respond effectively to traffic disruptions or life-threatening situations unless they know what is happening on the transportation system on a continuous, comprehensive, and up-to-the-minute basis. Their responses are often hampered by the piecemeal nature of efforts to monitor traffic disruptions and life-threatening situations, gaps in the areas covered by monitoring equipment, monitoring equipment that is not kept in working order, and the failure to share key information among all potential responders.

Effective responses are also hampered by the lack of available personnel and equipment, often attributable to jurisdictional and agency barriers to sharing resources. Accountability for responding to incidents and fixing recurring operational problems with highway facilities is often diffused and hard to establish. Because national and local priorities emphasize the construction and physical preservation of facilities, traffic monitoring and control devices are often out of service due to lack of maintenance.

Data have long been recognized as essential for planning and constructing highways, but data are no less important for operating and preserving highway assets safely and efficiently. Comprehensive, accurate, up-to-the-minute data are essential for highway managers who anticipate problems and are proactive in resolving those problems, making effective tradeoffs among a wide range of resources and consequences. Without adequate data, highway managers have become accustomed to reacting to emergency calls and complaints with whatever resources are immediately at hand. Data collection and integration are given low priority because managers are not experienced with the greater efficiencies and effectiveness of being anticipatory, proactive, and systematic.

Without public visibility and accountability for managing highway facilities, governments will not provide adequate resources for monitoring, and the culture of highway management will remain reactive rather than proactive. An external stimulus is needed to break this cycle and establish a data-driven, anticipatory, proactive culture among highway managers.

Infostructure

The Federal Highway Administration sponsored a National Summit on Operations in October 2001 that brought together more than 200 transportation professionals interested in operations strategies. The National Summit on Operations discussed the development of regional operations collaborations and coordination, continued deployment of ITS technology, and national implementation of an information infrastructure, also known as "Infostructure." At the national level, the Infostructure would include three main elements: (1) statewide reporting; (2) monitoring in large metropolitan areas; and (3) surveillance of key infrastructure facilities.

Statewide reporting would provide a system in place to report on capacity-restricting events, such as accidents, incidents, and weather obstructions. One example is the Condition Acquisition and Reporting System (CARS) implemented in the states of Iowa, Minnesota, Missouri, and Washington to assist various agencies in the acquisition and reporting of incident data by reducing communication difficulties, redundancies, and inaccuracies. Another example of a statewide reporting system is the Highway Closure and Restriction System (HCRS) developed initially by Arizona, but which has been expanded to include Nevada, Utah, and New Mexico. This web-based system reports such information as incidents/accidents, road closures, road maintenance, traffic congestion, weather conditions, etc. These systems are flexible enough to permit states to exchange information with adjoining States and information service providers, and disseminate information to the public via a Web site. This would provide important information about the closing or severe capacity reductions of key highways. This has obvious implications for security as well as normal operations. If transportation and public safety officials cannot obtain such information in near real time, proper response is impossible.

The second national element would involve monitoring metropolitan areas with more than one million residents. This roughly corresponds to the 60 largest cities in the United States. For congestion-management as well as security reasons, it is prudent to have real-time monitoring of volume, speed, and weather covering freeways and principal arterials as well as major rail and bus transit systems in these urban areas. Currently, less than 25 percent of the freeways and virtually none of the other arterials have real-time monitoring. There are a number of different ways that this information could be provided, such as through traditional traffic sensors like loop detectors, technologies that could provide the same information but are not located on the highway right-of-way, or through vehicle-based systems. The private sector will likely play a key role as data provider to State and local governments. While such information is important for any metropolitan area, it is imperative from a security point of view to ensure our largest metropolitan areas are able to monitor their key transportation facilities for both emergencies and other operational needs.

The third national element would involve surveillance of key facilities. There is now increased recognition of the need to more closely monitor key transportation assets for both protection and response. Work to identify critical infrastructure is underway and will likely include bridges, tunnels, key evacuation routes, and certain military routes needed for rapid deployment of military/security assets. Some combination of volume, speed, and weather monitoring along with video surveillance may be needed to ensure the safety and availability of these facilities. Traditionally, most government agencies have addressed security issues in a reactive mode rather that a proactive mode. Protecting our key infrastructure facilities should include a well-balanced plan that takes into account both proactive and reactive measures.

At the local level, there are information needs beyond these national elements that are necessary for local operations. These needs will vary from jurisdiction to jurisdiction and most will be determined at the local level. This information is needed to support such functions as security, traffic and transit management systems, commercial vehicle operations, incident and emergency management, regional traveler information, hurricane evacuation route monitoring, statewide weather and road condition monitoring, and construction management.

Regional Collaborations

Regional operations collaborations and coordination can be considered a “table” at which regional operations policies, protocols, activities, and projects are defined, discussed, debated, and coordinated by transportation system operators, including State and local transportation and public works agencies, public safety personnel, and transit system operators. Representatives at the “table” would be those responsible for day-to-day management and operations activities. These officials would:

- Develop, maintain, and monitor the effective implementation of a regional concept of operations;
- Set performance targets; identify, collect, and store regional data for performance measurement, trend analysis, and monitoring; report to the public on system performance;
- Coordinate region wide operational improvements to enhance highway safety;
- Carry out regional collaboration for security and emergency transportation operations on key evacuation and military routes and the protection of critical NHS and STRAHNET infrastructure and provide for continued operations during an emergency;

- Prepare a Regional Operations Action Agenda; use performance data to identify operational problems, evaluate potential solutions and facilitate their accomplishment;

- Ensure the coordinated delivery of timely traveler and user information on transportation system operations to the full range of system users; and

- Provide substantive input to the Statewide and/or regional transportation planning process on necessary investments to improve system performance.

As long as all appropriate system operators are involved, performance of these functions could be led by an existing regional agency, other existing agencies such as State departments of transportation or large city or county governments, or an organization formed for the specific purpose of focusing on regional operations. In larger States, with several major metropolitan areas, these functions might be carried out in a different fashion in various parts of the State. Agencies serving rural regions could also collaborate together to perform these functions to improve operations. Rural regional operations, for example, may focus on weather, emergency response, and work zone issues.

Conclusion

Operations will become more anticipatory, proactive, and systematic as public visibility and accountability for managing highway facilities improves, particularly as attention is focused on development of timely and comprehensive information, effective traffic management tools, adequate financial resources, and institutional authority and accountability to enable users to make the best use of the transportation system.

Without greater attention to operations, Americans will continue to waste many hours in delay from 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; and Americans will remain vulnerable to natural and manmade disasters. Unless the problems of reliability, timeliness, safety, and security are managed through more effective operations, the Nation will continue to incur economic costs in foregone productivity and wasted fuel, as well as human costs in terms of public health and a reduced quality of life.

Chapter 22

Freight

Introduction

This chapter examines the importance of freight transportation to the Nation, the effects of highways on freight transportation, and the different demands placed by freight on the surface transportation system. Freight transportation is a critical enabler of economic activity, and trucking is a key element of freight transportation.

The condition and performance of the highway system is crucial to the efficiency and effectiveness of trucking, and the growth of truck traffic is placing greater burdens of the condition and performance of the highway system. This web of relationships becomes the basis for representing freight transportation more robustly in the HERS model and in supplemental investment analyses. This chapter describes special freight needs not fully explored earlier in Chapter 7.

This chapter covers investment analyses not included earlier in Chapter 7 on general investment requirements or in Chapter 12 on national security implications. Special analyses of investment requirements of National Highway System (NHS) connectors and rail-highway grade crossings are covered in Chapters 25 and 26, respectively.

Freight Transportation and the Economy

Nearly seven million businesses rely on the U.S. transportation network to conduct local business, engage in interstate commerce, and carry out international trade. At the same time, more than 100 million households rely on freight transportation to provide access to goods and services produced by businesses both here and abroad. The extensive U.S. transportation network allows Americans to buy fresh fruits, vegetables, send packages overnight, and purchase merchandise that is manufactured and assembled in different plants all over the world.

The benefits of freight transportation to the economy are enormous. From a macroeconomic perspective, transportation is a significant share of the U.S. gross domestic product (GDP). In 1999, purchases of transportation-related goods and services accounted for 10.6 percent ($980 billion) of GDP. The diverse and extensive list of purchases includes the services of for-hire freight carriers, vehicles, parts, maintenance, and fuel. Only housing, health care, and food account for a greater share of GDP.

For-hire transportation services, which include warehousing, contributed $303 billion or 3.3 percent to GDP in 1999. Nonetheless, many industries and businesses depend on their own transportation operations (primarily trucking) to move goods. The agriculture, forestry, and fisheries industries, for example, rely more heavily on in-house transportation than on for-hire services to support their production. In 1996 (the latest year for which data are available), in-house transportation contributed $142 billion to the economy.

Freight transportation also contributes to the economy by providing jobs to millions of people. In 2000, more than 10 million people were employed in transportation-related industries, including for-hire services, vehicle manufacturing, service stations, and parts suppliers. Of that total, for-hire transportation (including warehousing) employed more than 4.4 million workers, a majority of whom worked in freight transportation-related jobs.

Another 5.5 million people worked in transportation occupations in nontransportation industries, such as truck drivers for grocery stores. Truck drivers, alone, accounted for nearly 70 percent of the total number of transportation occupational workers. When this number is added to transportation-related industry employment figures, about 1 out of 8 U.S. civilian jobs are related to transportation.

Improvements in freight transportation productivity contribute to the economy by helping the United States remain competitive in international trade. (In the freight sector, output is usually measured by quality-adjusted ton-miles, and input is measured by the number of employees or employee-hours). The Bureau of Labor Statistics reports that productivity for the intercity trucking, railroad, air, and petroleum pipeline industries has improved over the last 20 years. The railroad industry has posted the most impressive gains, followed by the pipeline and air modes. Improvements in railroad productivity came, in large part, from deregulation, divestiture of uneconomic lines, reduction in the labor force, and technological and logistical changes.

Finally, freight transportation infrastructure is a significant and integral part of the nation's wealth and productive capacity. With the exception of railroads and pipelines, transportation infrastructure relies, to a large extent, on public investment and joint partnerships between the public and private sectors.

The Effects of Highways on Freight Transportation

Highways are a critical component of the freight transportation system. In 1997, trucks carried 72 percent of the value and 69 percent of the tons of everything shipped by manufacturers, wholesalers, and selected other industries in the United States. 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 carried over 1 trillion ton-miles of commodities in 1997.

The performance of the highway system has a direct bearing on the effectiveness and efficiency of truck transportation. As noted in Chapter 21, reliable travel times are critical to truckers who serve just-in-time manufacturing and distribution systems and carry time-sensitive cargo. The effects of recurring and nonrecurring delay discussed in Chapter 21 are thus greatly magnified on the costs of trucking, and therefore on the role trucking plays in the economy.

FHWA has undertaken a number of efforts to measure the performance of trucking, which reflects how the highway system affects freight transportation and which in turn affects the economy. They include measuring commercial vehicle cost per mile and commercial vehicle travel time and delay.

Estimates of Commercial Vehicle Cost

In an effort to evaluate national highway freight transportation performance and efficiency, FHWA reviewed a sample of motor carriers' expenses associated with the physical movement of cargo. Based on this review, FHWA found that the annual average of actual expenses per mile for all types of for-hire trucking (less-than-truckload, truckload, specialized carriers) had risen slightly from $1.76 in 1990 to $1.78 in 2000. Specific costs that had pushed up average motor carrier expenses were increasing diesel fuel prices and insurance fees. During the decade, average costs per mile were about $1.60. When these expenditures were adjusted for inflation, average cost per mile in constant dollars actually declined during the 10-year period. Overall, freight rates were found to be relatively stable during the last decade.

By 2005, motor carrier expenses per mile are predicted to average 5 to 6 cents per mile higher than today. However, motor carrier rates should continue to fall in constant dollars by 2 to 3 cents-per-mile by 2005. This assumes no substantial shock in motor carrier operational costs, such as those resulting from a significant jump in diesel fuel prices. Potential upward pressures could stem from labor cost increases, higher employee benefits, and escalating truck insurance premiums. Despite these influences, the continuing competition for freight shipments and the strong bargaining position of shippers will likely stifle excessive rate increases.

Delays at International Border Crossings

The FY 2003 FHWA Performance Plan aims to improve the economic efficiency of the U.S. transportation system, thereby enhancing the Nation's position in the global economy. One way to promote improvement is to ensure the continuing mobility and efficiency of cargo shipments as they move along the surface transportation system. An objective of this goal, therefore, is to reduce the hours of delay for commercial motor vehicles entering and leaving the United States at its northern and southern ports-of-entry with Canada and Mexico. The border crossing process is one of the few elements in logistical planning and execution that is almost completely beyond the control of both motor carrier and the shipper. Predicting with certainty the time needed to cross a border crossing is difficult.

In 2001, coordinated, on-site reviews were made at seven ports of entry that handle 60 percent of U.S. truck trade among the three NAFTA nations. Linked with research now underway to model border crossings activity, these site reviews will enable the FHWA to make informed recommendations about crossing improvements. The results will also help the agency to engage with other Federal, State and local jurisdictions in constructive dialogue about how, together, they can improve the performance, security, and mobility of commerce at these important international locations. Exhibit 22-1 summarizes the results.

The seven ports of entry reviewed in 2001 were: Otay Mesa, California; El Paso, Texas; Laredo, Texas; Blaine, Washington; the Ambassador Bridge (Detroit), Michigan; Blue Water Bridge (Port Huron), Michigan; and Peace Bridge (Buffalo), New York. The measurement chosen to monitor commercial vehicle activity on-site was "travel delay per truck trip." This encompasses the time taken by the individual commercial vehicle from the initial queuing point in the exporting country, *through* the exporting country's final checkpoint, and up to and through the first inspection point in the importing country. Travel in both directions was assessed (i.e., truck travel into and out of the United States.)

The on-site reviews found that the time needed for processing commercial vehicles entering the United States (inbound clearances) was confirmed to be significantly longer than that for departing (outbound clearances) at almost every location. The controlled substance incursion and illegal immigration inspections performed by U.S. inspection agencies on the Southern Border required reviews of incoming cargoes and their operators that led to unavoidable time delays.

The actual extent of delays encountered in *both* directions, and the reasons for them, however, tended to vary by individual port-of-entry. There is no single trend across sites beyond the noted tendency (1) for inbound clearances to take longer than outbound, and (2) for Southern border delay times to exceed Northern border delay times.

The results of the 2001 reviews revealed site-specific findings that may not readily lend themselves to a "one size fits all" corrective action initiative. Nevertheless, procedural changes, application of advanced technologies, and facility design modifications at selected ports-of-entry—some already underway—offer the possibility of greater productivity in the processing of commercial vehicles and reduced travel delay.

Increased traffic volume did not necessarily correlate with significantly increased delay. For example, commercial vehicle activity sampled at the Otay Mesa, California crossing found significant variations in peak periods of delay from one day to the next. Increases in traffic *volume*, however, did not necessarily result in greater processing time at this location, apparently because administrative actions were taken in response to the growing back-up that met the volume challenge. By contrast, at the Peace Bridge, New York crossing, increases in vehicle volume tended to be a precursor for increased average delay times, with an increase in one leading directly to an increase in the other.

Exhibit 22-1

Comparison of Outbound and Inbound Times Obtained (in minutes)

CROSSING	BASELINE TIME	AVERAGE TIME	95th PERCENTILE TIME	BUFFER TIME	BUFFER INDEX (%)
All Outbound Crossings	N/A	14.2	37.4	23.3	164.1%
All Inbound Crossings	N/A	26.8	70.1	43.3	161.6%
All Northern Outbound Crossings	N/A	12.6	34.3	21.7	172.2%
All Northern Inbound Crossings	N/A	24.1	70.3	46.2	191.7%
All Southern Outbound Crossings	N/A	17.2	45.2	28.1	163.4%
All Southern Inbound Crossings	N/A	33.8	64.9	31.1	92.0%
Ambassador Bridge Outbound	5.7	8.8	13.7	4.9	55.7%
Ambassador Bridge Inbound	12.9	20.4	33.9	13.4	65.7%
Blaine Outbound	4.8	21.5	35.3	14.3	66.5%
Blaine Inbound	8.1	17.3	35.6	18.3	105.8%
Blue Water Bridge Outbound	5	6.2	9.1	2.9	46.8%
Blue Water Bridge Inbound	11.1	34.2	80.3	46.1	134.8%
Peace Bridge Outbound	9	21.7	38	16.2	74.7%
Peace Bridge Inbound	8.3	23.3	83.4	61.9	265.7%
El Paso Outbound	9	13.2	34	24.7	187.1%
El Paso Inbound	7.6	37.2	77.4	40.2	108.1%
Laredo Outbound	1.8	17.2	45	27.8	161.6%
Laredo Inbound	12.2	31.2	54.9	23.7	76.0%
Otay Mesa Outbound	9.5	19.1	36.9	17.8	93.2%
Otay Mesa Inbound	6.4	35	64.3	29.3	83.7%

Source: FHWA Office of Freight Management and Operations.

In total, for *all* seven ports of entry, the average *inbound* delay time was 16.0 minutes, while the average *outbound* delay time was 8.1 minutes. For the four northern ports in the survey, the average *inbound* delay time was 12.5 minutes. The average *outbound* was 6.2 minutes. For the three southern ports, the average *inbound* delay time was 24.9 minutes. The average *outbound* delay time was 11.6 minutes.

A "buffer time" and "buffer index" for each port-of-entry also was also calculated. The buffer time represents the *difference* between the 95th percentile crossing time (i.e., the time within which 95 percent of all surveyed trucks passed through the survey checkpoints) and the average crossing time for all trucks. The buffer index is the buffer time expressed as a percentage of average time (i.e., the extra percentage of time that must be budgeted by shippers and motor carriers planning to cross the border at a particular location). As such, the buffer index eliminates differences among the actual, physical length of crossings. It provides a standardized measure among the 7 ports-of-entry of the significantly longer transit times that may befall a motor carrier crossing the border—often well above the average time calculated—depending upon the site being used.

The buffer time for all inbound crossings is almost twice that for outbound traffic. The average buffer time for all outbound crossings was 23.3 minutes, with an average buffer index of 164 percent. The average buffer time for all inbound crossings was 43.3 minutes, with an average buffer index of 162 percent. These aggregated times camouflage the wide variations in the buffer indices at the individual ports-of-entry, however. For example, at the Ambassador Bridge, the buffer index for inbound truck traffic was just over 65 percent, reflecting a 95th percentile time of 33.9 minutes during the average travel time of 20.4 minutes. This indicates that, even with its substantial volume of traffic, operators of the Ambassador Bridge sustained movement across the bridge without imposing lengthy increases in delay times. Contrasting markedly with this was the inbound buffer index at the Peace Bridge of 266 percent, where the 95th percentile time (83.4 minutes) far exceeded the calculated average crossing time (23.3 minutes).

The buffer index is only an indicator of potential crossing times that could be experienced. It does not reveal *why* the extended times occur at the various sites.

Gateway Infrastructure

Much of the increase in truck activity is related to international trade growth, which is concentrated at international gateways. Since the 1970s, international trade has emerged as a major component of the U.S. economy, as imports of consumer goods, and petroleum have increased significantly. At the same time, exports have also increased, led by shipments of raw materials, agricultural products, and manufactured goods. With the expected growth in traffic and increased attention to cargo security, a large number of gateway infrastructure projects are planned. The numbers presented here are drawn from numerous sources, including several port authorities, State departments of transportation, and other governmental bodies. These studies contain varying time frames and scopes. This summary of projects has been compiled using several guidelines.

First, projects needed to be closely tied to ports. General freight projects that were not directly connected to port access were excluded. Second, previously funded projects were excluded if possible. The reports analyzed did not always distinguish between projects that needed funding and those that do not. Third, both port of entry projects and ocean port projects were included.

Exhibit 22-2 presents a summary of the total spending required for port access projects by area. The list does not identify specific projects, but instead represents the best information available for a given State or port. Many of the sources used provided no more information than is available here, while others listed specific projects. More complete information would likely require interviewing representatives of port authorities and State departments of transportation.

Q. **What are some additional findings from the review of the seven ports of entry?**

A. The review reached several other conclusions. For example, the number of inspection and processing booths open at each port-of-entry at any given time has significantly influenced travel time and delay. At many ports, there appeared to be significant variability during the day with respect to the number of booths open at any given time. There is a definite relationship between the number of booths open, the travel demand, and the travel time through the crossing. Decisions on how many to open at any given time are apparently not made purely with mobility or crossing times in mind and are not always made by the transportation agencies.

Before the September 11, 2001 terrorist attacks, U.S.-Canadian ports-of-entry generally processed inbound trucks with less delay, and with less variability, than did U.S.-Mexican ports-of-entry. Southern crossings generally handled more traffic, but with generally more variability in the times required for crossing. (The exception to this pattern was the Blue Water Bridge port-of-entry at Port Huron, Michigan). As noted, concerns about drug traffic and illegal immigration apparently contribute to extended inspection times at the Southern border. However, other influences on travel time and delay are less self-evident and may need further consideration.

A study on urban mobility prepared by the Texas Transportation Institute indicates that delay times are more predictable and not as volatile in their swings across the sample day as those witnessed at the seven ports-of-entry in 2001. This confirms the earlier statement that international border crossings offer a considerable challenge for those parties planning commercial cargo movement departures, transit times, and arrivals than do most other links in the national transportation system.

Speed is an important factor in the movement of cargo, although the security of shipments is now of great concern. Crossing times at Detroit's Ambassador Bridge port-of-entry, as noted above, were markedly different from others in the sample. Despite the bridge's dramatically higher volume of traffic, generally shorter crossing times were achieved. While inbound crossing times exceeded outbound, as at the other six locations, the margin of difference was significantly narrower and more consistent across the sample period. Whether the reason for this difference in performance is a function of policy, bridge ownership, tactics, infrastructure, capacity, or facility design remains to be determined.

The Peace Bridge at Buffalo was found to have the greatest similarity between inbound and outbound average crossing times, registering relatively low among the 7 ports-of-entry in this regard. However, it also demonstrates the highest inbound buffer index (265.7 percent). Thus, while its average crossing times are similar in both directions, the *potential* exists for motor carriers to be significantly delayed when traveling from Canada into the United States at this location.

Three of the ports-of-entry included in the study (Otay Mesa, Blaine, and Laredo) have some form of "truck only" crossing, with the El Paso crossing (the Ysleta-Zaragoza bridge) being primarily trucks. In terms of the time required to transit the facilities and the volumes of traffic processed, however, "truck-only" crossings do not appear to perform significantly differently from those other crossings where automobile and truck traffic are intermingled. This finding was unexpected and deserves further evaluation.

How Freight Transportation Affects the Highway System

Trucks carry freight throughout the highway system. Although commercial vehicles account for less than 10 percent of all vehicle-miles of travel, truck traffic is growing faster than passenger vehicle traffic and 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 likely to grow substantially if the demand for freight

Exhibit 22-2

International Gateway Projects

SOURCE	AREA	$ (MILL)	DATE	NOTES
Texas Border Transportation Task Force	Texas	1,800	1999	land crossings; $600 million programmed, $1.2 billion recommended
Trade and Traffic Across Eastern US Canada Border	Maine	61	1997	near and long term projects
Trade and Traffic Across Eastern US Canada Border	Michigan	2,942	1997	near and long term projects; includes $1.3 billion of corridor needs
Trade and Traffic Across Eastern US Canada Border	New York	2,257	1997	land crossings; near and long term; includes $1.7 billion of corridor needs
Trade and Traffic Across Eastern US Canada Border	Vermont	123	1997	near and long term only; includes $123 million of corridor needs
Case studies for freight funding (Casgar)	California	13,400	2002	might include some non-port related investments; includes Ports of Los Angeles, Long Beach, Oakland, and Ports of Entry; at least $8 billion
Washington Freight Mobility Strategic Investment Board	Washington state	241	2001	only directly port relevant projects ($1.9 billion total freight projects)
Intermodal Connector Needs for OR highway plan	Oregon	163	1997	all intermodal projects (mostly water port related)
Arizona Trade Corridor Study (AZ-MEX commission)	Arizona	1,879	1999	land crossings; truck only, no numbers given for rail
Florida Landside Access Study	Florida	1,327	1997	highway and rail improvements planed, not funded
Port Authority of NY/NJ	Elizabeth seaport access	750	unknown	may or may not include $110 million for cross-harbor tunnel project
Hampton Roads MPO	Virginia Hampton Port	3,700	2001	Total relevant projects, but truck trips are only 10-15% of trips; improvements proposed are not freight specific

Source: FHWA Office of Freight Management and Operations.

transportation doubles over the next 20 years, as has been predicted.

To understand and forecast nationwide patterns of freight activity on both highway network and complementary modes, several databases have been integrated into a Freight Analysis Framework by FHWA's Office of Freight Management and Operations. The Framework estimates county-to-county flows of goods by truck, rail, water, and air at the four-digit level of the Standard Transportation Commodity Classification system, and assigns those flows to individual segments of the transportation network for 1998, 2010, and 2020. The future years are based on macroeconomic forecasts, described in Exhibit 22-3.

The total volume of freight and related truck traffic will grow with the economy. Expected future freight volumes are based on forecasts by WEFA, Inc. that expect GDP to grow at an average annual compound growth rate of 3.5 percent in constant dollars between 1998 and 2010. WEFA expects a slower average annual compound growth rate of 2.8 percent in constant dollars between 2010 and 2020. Overall, the U.S. GDP is expected to growth at an annual rate of 2.9 percent in constant dollars between 1998 and 2020. Based on these economic assumptions, the Freight Analysis Framework projects that freight volumes will nearly double, increasing from 9 billion tons to almost 17 billion tons over this period. This translates into an average annual compound growth rate of 3.4 percent from 1998 to 2010, and 2.4 percent from 2010 to 2020.

The WEFA forecast also included two alternative forecasts predicting high and low levels of economic growth. Under the high growth scenario, shipments are expected to grow an average of 3.7 percent annually from 1998 to 2010 and 2.7 percent annually from 2010 to 2020. Freight tonnage in 2020 would reach almost 19 billion tons, a doubling of 1998 levels. By comparison, freight shipments would grow an average of 3.1 percent annually between 1998 and 2010 and 2.0 percent annually between 2010 and 2020 under the low growth scenario. Even under the low growth scenario, freight volume still increases by 74 percent to almost 16 billion tons.

Q. What are the WEFA long-term baseline forecast assumptions?

A. Key assumptions are outlined in Exhibit 22-3.

Exhibit 22-3

The WEFA Long-Term Baseline Forecast Assumptions

Population and Labor Force	Population growth will slow from 1 percent to 0.8 percent annually, slowing civilian labor force growth.
Employment and Unemployment	Manufacturing employment will continue to decline as a share of total employment, while service sectors will generate an increasing share of employment growth.
Productivity and Aggregate Supply	Potential GDP growth will slow relative to historical rates due to slower growth in the labor force, while productivity growth will remain steady.
Government Policy	The government sector share of GDP will decline due to slower growth in defense spending and a reduction in the share of interest payments relative to the federal budget.
Monetary and Financial	The Federal Reserve Board will remain watchful of inflation while ensuring growth in output consistent with potential output.
Consumption	The share of real consumption devoted to services and durable goods will rise, while it falls for nondurable goods, such as energy.
Business Investment	The investment share of structures will decline, while equipment's share will rise. The fastest growing sector of the economy for investment will be producers' durable equipment.
International Trade	Real export growth will slow growth in the trade deficit due to a decline in the value of the dollar and a reduction in US real unit labor costs relative to the rest of the industrialized world.
Industrial Production	Manufacturing of durable goods, particularly non-electrical machinery such as computers, will grow faster than nondurable goods. Plastics and paper will lead nondurable goods production.

Source: WEFA, Inc.

The top ten commodities in 1998 are predicted to remain about the same in 2020, as shown in Exhibit 22-4. Secondary traffic—which includes products moving out of warehouses or other terminals—is expected to remain the largest commodity category in terms of weight, generating about 31 percent of total growth in U.S. freight tonnage between 1998 and 2020. With an average annual compound growth rate of 4.4 percent for secondary traffic over the period, this forecast supports the trend that smaller, and more frequent shipments will remain important to the U.S. economy. Shipments of the Clay, Concrete, Glass, and Stone commodity group and Food Products would become the second and third largest commodities carried by the year 2020, with both commodity groups enjoying average annual growth rates of 3.7 percent. Coal, the second largest commodity carried in 1998, would fall to fourth, largely from modest growth in coal shipments until 2020.

On a modal basis, the top three commodity groups are expected to move primarily by truck. Coal is projected to remain the largest single commodity moved by rail, followed by chemicals and farm products; petroleum products, coal, and scrap metals are expected to be the top three commodities moved by the waterborne mode in 2020.

Exhibit 22-4

Top Commodities in 1998 and 2020

1998 TOP COMMODITIES		2020 TOP COMMODITIES	
ALL MODES	**TRUCK**	**ALL MODES**	**TRUCK**
Non-metallic Minerals	Non-metallic Minerals	Non-metallic Minerals	Small Package
Small Package	Small Package	Small Package	Non-metallic Minerals
Coal	Clay/Concrete/Glass/ Stone	Clay/Concrete/Glass/ Stone	Clay/Concrete/Glass/ Stone
Clay/Concrete/Glass/ Stone	Food/Kindred	Food/Kindred	Food/Kindred
Food/Kindred	Lumber/Wood	Coal	Lumber/Wood
Petroleum/Coal	Petroleum/Coal	Lumber/Wood	Chemicals/Allied Products
Lumber/Wood	Chemicals/Allied Products	Petroleum/Coal	Petroleum/Coal
Chemicals/Allied Products	Primary Metal	Chemicals/Allied Products	Primary Metal
Primary Metal	Pulp/Paper/Allied	Primary Metal	Pulp/Paper/Allied
Farm	Coal	Farm	Fabricated Metal

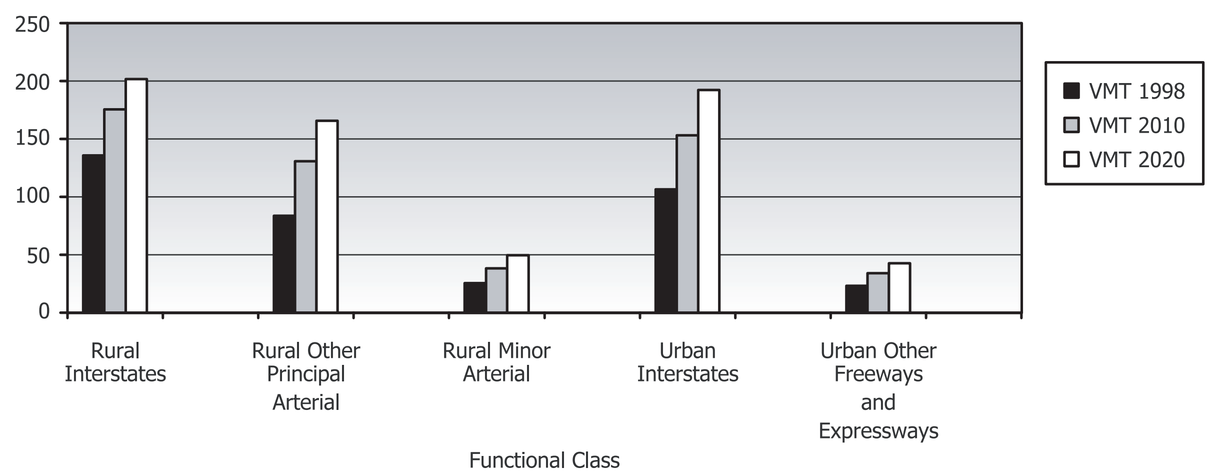
Source: FHWA Office of Freight Management and Operations.

These forecasts assume that transportation infrastructure capacity does not constrain demand for freight shipments, and that the shares carried by each mode of a given commodity do not change. Modal shares change only because the mix of commodities changes.

The result of these forecasts is a significant increase in truck traffic over the next two decades on all classes of highways. More than 25,000 miles of highway will carry more than 5,000 commodity-carrying trucks per day. Approximately one-fifth of that mileage will be significantly congested. [See Exhibit 22-5]

Exhibit 22-5

Comparison of Growth in Truck VMT, Millions of Miles per Day, 1998 to 2020



Source: FHWA Office of Freight Management and Operations.

Rest Areas

The deregulation of the U.S. trucking industry in the early 1980s led to significant changes in the way goods and products are moved. A proliferation of commercial carriers followed the relaxation of entry and operating requirements. Consequently, by 2000, approximately 500,000 interstate motor carriers were operating in the United States. That number continues to grow. During the same period, freight logistical systems have evolved to put more emphasis on reliable, "just-in-time" cargo deliveries and reduced, "zero-inventory" levels at shipper locations. Moreover, the need to access cargo terminals at specific hours, along with restrictions imposed by some urban areas, has compelled drivers to look for "staging" areas in which they may wait for terminal, loading dock, or port openings.

In addition, crash data generated by the Federal Motor Carrier Safety Administration estimates 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 factor in these incidents. Therefore, the probability that a 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 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 non-traditional 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 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, privately run facilities 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 innovative funding initiatives; cultivation and expansion of joint public-private initiatives to supply needed spaces; looking into greater use of non-traditional parking sites for truckers; use of emerging technologies to provide “real-time” information to drivers about parking availability; and improved signage along NHS rights-of-way to inform drivers about upcoming facilities.

FHWA and Freight Transportation

As demand for freight service grows, increasing pressure will be placed on a transportation system that is already strained in some locations. By the year 2020, freight tonnage is expected to nearly double, with even higher growth rates anticipated in and around key ports of entry, major corridors, and intermodal connectors and hubs. In order to better understand the challenges that come with increasing demand for freight transportation and improve efficiency, FHWA’s Office of Freight Management and Operations (HOFM) developed a Freight Productivity Program. The Freight Analysis Framework is an important part of this program.

Recognizing that freight can be moved more expeditiously and securely across our borders, HOFM is working with other government agencies and NAFTA partners to improve freight transportation productivity. For example, FHWA initiated the development of border simulation software to facilitate planning operations among U.S., Canadian, and Mexican transportation agencies and inspection services. The product of this joint effort is Border Wizard Pro, a dynamic simulation capability for land and water ports of entry. With Border Wizard Pro, NAFTA countries will be able to test alternative physical, operational, and staffing improvements to enhance efficiency, safety, and security. The Peace Arch, at I-5 in Washington/British Columbia will be the first crossing simulated in both directions.

HOFM also has launched a multiyear effort to collect and analyze border crossing travel time and delay data. This information will help identify trends in freight movement and needed changes in infrastructure and/or procedures at specific locations to reduce avoidable delays. At the same time, HOFM formed the North American Strategy Team (NAST) to address emerging issues and concerns at border crossings. The long-term objective of NAST is to develop a coherent strategy for the open, safe, and efficient movement of freight and passengers in North America.

As part of its efforts to improve freight transportation efficiency, HOFM evaluated the condition of NHS intermodal connectors, which provide vital links to ports and terminal facilities. Although intermodal freight connectors account for less than 1 percent of total NHS mileage, they are the “front door” to the freight community for a broad array of transportation services and options. They also support defense mobilization and national security goals. Because of the military’s increasing reliance on commercial transportation to move supplies and personnel, intermodal linkages to ports and airports has become an integral part of national defense planning. The findings of HOFM’s evaluation are reported in *NHS Intermodal Freight Connectors: Report to Congress.* This report noted that intermodal connectors are in relatively poor condition and do not get adequate attention in the planning and programming process. HOFM is now doing a follow-on study to identify deficiencies and needs. Information from this follow-on study is presented separately in Chapter 25.

Other HOFM initiatives hold promise in helping the Department of Transportation meet national security objectives, such as establishing an information system that will help those with the need to know what is in a container, or trailer at any time, anywhere. These activities are described in Chapter 12.

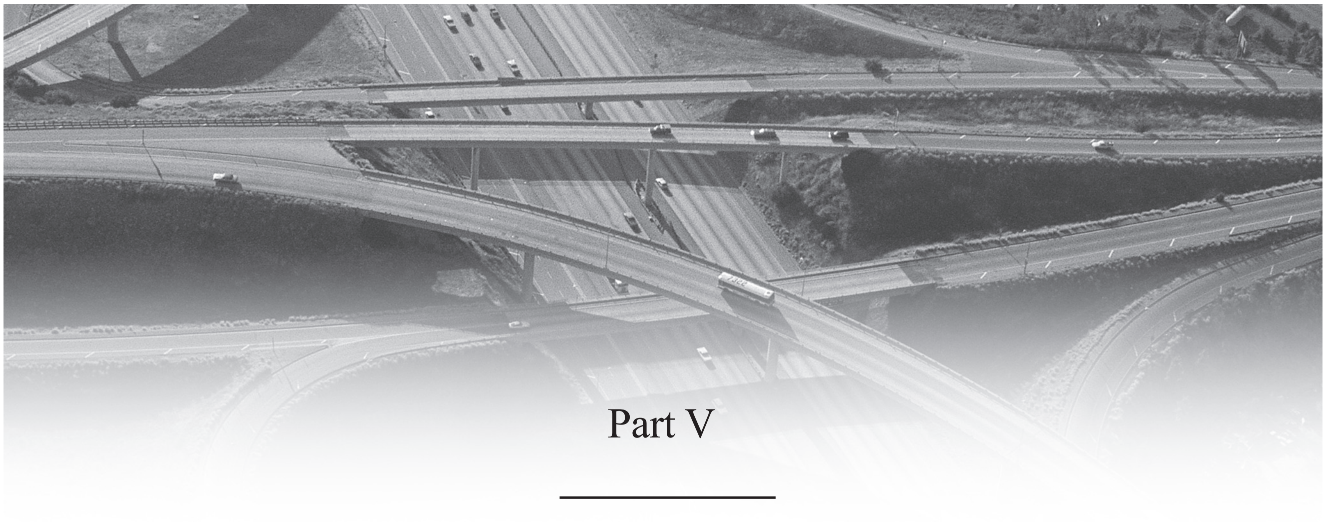
Finally, HOFM is leading a Department-wide policy initiative to address freight's unique challenges and to improve national productivity and competitiveness. This initiative involves the Maritime Administration, Federal Railroad Administration, Bureau of Transportation Statistics, Federal Motor Carrier Safety Administration, and the Office of Intermodalism. As part of this effort, HOFM has identified several key areas that merit further research and analysis. They are 1) the nature and geography of capacity needs, 2) systems operations and asset management, 3) planning and financing freight improvements, 4) multijursidictional approaches to improving freight flows, 5) professional capacity development, and 6) national security. Workshops and other outreach events were held throughout 2001 to examine current and emerging trends in these areas and to discuss policy options for improving productivity through TEA-21 reauthorization and other policy or legislative initiatives. The results of these efforts will be discussed in an upcoming HOFM publication on freight issues and challenges.

Investment Requirements

Most investment requirements related to truck movement are captured in the estimates presented in Chapter 7, which are largely derived from the HERS and 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. The impact of an increasing truck share in the future is also addressed in the sensitivity analyses presented in Chapter 10.

The HERS and NBIAS models, however, estimate only a portion of the investment requirements related to freight transportation. Additional investment requirements related to intermodal freight connectors to the NHS are covered in Chapter 25, and investment requirements related to rail-highway grade crossings are estimated in Chapter 26. Reconstruction of intersections to accommodate large trucks, deployment of information system to support commercial vehicle operations, and investments in alternative modes to carry freight around congested highway facilities warrant consideration as well, but are beyond the scope of this report.

One emerging area in freight transportation is the need to create effective, public-private partnerships to plan and implement freight-oriented investments. The Freight Analysis Framework provides a multimodal basis for identifying current and prospective problems for the freight transportation system. Planned enhancements to HERS and related analytical systems will identify more completely the investments in infrastructure and operations needed to support a vibrant economy.



Part V

Supplemental Analyses of System Components

Introduction

Chapters 23 through 27 delve more deeply into the analyses developed in Chapters 2 through 10 to focus on particular components of the Nation's highway and transit systems. Some of these analyses pull together material scattered in other locations through the report; others provide supplementary information not covered in the earlier chapters.

The five supplementary analysis chapters in this edition of the report are:

- Chapter 23, **Interstate System,** highlights the system characteristics, system conditions, operational performance, and financing of the Interstate system. The chapter also analyzes future investment requirements for the Interstate system. While the rural and urban Interstates are identified in the functional class tables in Chapters 2-10, this chapter provides additional details and brings all Interstate-related information into a single location.

- Chapter 24, **National Highway System**, is similar in scope and coverage to Chapter 23, 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 25, **NHS Freight Connectors**, includes an analysis of future investment requirements for these critical links. Many of the physical and operating deficiencies of NHS connectors are different in character than those of the mainline NHS; this special analysis is intended to identify items beyond the scope of the general NHS analysis contained in Chapter 24.

- Chapter 26, **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 27, **Transit on Federal Lands**, identifies the future investment that would be required to address growing demands for transit in these areas. This chapter is provided as a complement to the highway-oriented section on Federal Lands included in the 1999 C&P report.

Chapter 23

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 U.S. 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.

History of the Interstate System

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 $370 billion on Interstates through apportionments to the States.

The National Highway System Designation Act of 1995 included the Interstate System as the core of the NHS, described in Chapter 24.

System and Use Characteristics

Exhibit 23-1 describes the total public road length of the Interstate System (data for all roads can be found in Exhibit 2-8). In 2000, there were 46,675 route miles in the United States. About 71 percent of these miles were in rural communities, or 33,152 route miles. The remaining 29 percent of miles were in urban areas, or 13,523 route miles. By comparison, about 78 percent of all road miles in the United States were in rural areas, while 22 percent of miles were in urban communities.

Between 1993 and 2000, rural Interstate route miles increased by about 0.2 percent annually, while urban Interstate route miles increased by 0.6 percent annually. The 0.3 percent annual growth rate for Interstates was higher than the 0.1 percent growth rate for all roads during that time period.

Exhibit 23-1 describes the number of Interstate lane-miles between 1993 and 2000 (lane mileage data for all functional systems can be found in Exhibit 2-9). In 2000, there were 209,133 lane miles of Interstates in the United States. About 64.5 percent of lane miles were in rural communities, or 135,000 lane miles. About 35.5 percent of lane miles were in urban areas, or 74,133 lane miles. By comparison, about 76.6 percent of all highway lane miles in the United States were in rural areas, and 23.4 percent of lane miles were in urban areas.

Between 1993 and 2000, rural Interstate lane miles grew by 0.3 percent annually, while urban Interstate lane miles grew by 0.8 percent annually. The 0.5 percent annual growth rate for Interstates was more than double the 0.2 percent annual growth rate for all roads in the United States between 1993 and 2000. This growth has occurred due to both new construction and the reclassification of some arterials to Interstate status.

Exhibit 23-1

Interstate Route & Lane Miles, Selected Years 1993-2000

	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Route Miles						
Rural	32,795	32,703	32,919	33,077	33,152	0.2%
Urban	13,007	13,300	13,395	13,486	13,523	0.6%
Total	**45,802**	**46,003**	**46,314**	**46,563**	**46,675**	**0.3%**
Lane Miles						
Rural	132,559	132,346	133,573	134,611	135,000	0.3%
Urban	69,895	72,134	72,968	74,033	74,133	0.8%
Total	**202,454**	**204,480**	**206,541**	**208,644**	**209,133**	**0.5%**

Source: Highway Performance Monitoring System.

Exhibit 23-2 describes the number of Interstate bridges in 1996, 1998, and 2000 (data for all bridges can be found in Exhibit 2-10). Between 1996 and 2000, the number of rural Interstate bridges dropped from 28,638 to 27,797 bridges, while during the same period, the number of urban Interstate bridges increased from 26,596 to 27,882. 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 23-2

Number of Interstate Bridges, 1996, 1998, and 2000

	1996	1998	2000
Rural	28,638	27,530	27,797
Urban	26,596	27,480	27,882
Total	**55,234**	**55,010**	**55,679**

Source: National Bridge Inventory

Exhibit 23-3 describes vehicle miles traveled (VMT) on Interstate highways between 1993 and 2000. Use data for all roads can be found in Exhibits 2-13, 2-14, and 2-15. In 2000, Americans traveled 270 billion vehicle miles on rural Interstates and 397 billion vehicle miles on urban Interstates. Interstate travel represented the fastest growing portion of VMT between 1993 and 2000. Interstate VMT grew at an average annual rate of 3.4 percent between 1993 and 2000, while VMT on all roads grew by about 2.7 percent annually.

Exhibit 23-3

Interstate Vehicle Miles Traveled (VMT), 1993-2000, (Millions of VMT)

	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural	209,470	224,705	241,451	261,485	270,314	3.7%
Urban	319,621	344,640	364,769	386,874	397,291	3.2%
Total	**529,091**	**569,345**	**606,220**	**648,359**	**667,605**	**3.4%**

Source: Highway Performance Monitoring System.

Exhibit 23-4 describes Interstate highway travel by vehicle type between 1993 and 2000. In 2000, 80.3 percent of travel on rural Interstates was by passenger vehicles; 3.1 percent was by single-unit trucks; and 16.6 percent was by combination trucks. About

91.8 percent of urban Interstate travel was by passenger vehicles; 2.2 percent was by single-unit trucks; and 6 percent was by combination trucks. By contrast, passenger vehicle travel represented 92.5 percent of travel on all roads in 2000. Single-unit truck travel comprised 2.6 percent of travel, and combination truck travel represented 4.9 percent.

Exhibit 23-4

Interstate Miles Traveled by Vehicle Type, 1993-2000, Millions of VMT

	1993	1995	1997	1999	2000	ANNUAL RATE OF CHANGE 2000/1993
Rural						
PV	169,500	180,031	188,969	207,046	214,175	3.4%
SU	5,982	6,708	7,667	8,073	8,260	4.7%
Combo	32,826	36,644	41,642	42,976	44,377	4.4%
Urban						
PV	294,703	315,888	330,668	348,531	358,906	2.9%
SU	6,513	7,148	7,906	8,494	8,719	4.3%
Combo	16,183	18,492	20,641	23,792	23,472	5.5%

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 2001 HPMS.

Travel on rural and urban Interstates grew faster than on any other functional system. Between 1993 and 2000, for example, combination truck travel grew by 5.5 percent annually on urban Interstates and by 4.4 percent on rural Interstates. By comparison, combination truck travel on all roads increased by 3.9 percent annually between 1993 and 2000.

Physical Conditions

Chapter 3 describes the physical conditions of highways throughout the United States. There are numerous ways to examine physical conditions. This section looks at pavement condition; lane width; and alignment adequacy.

Pavement Condition

Exhibit 23-5 shows the percentage of total Interstate miles with "Acceptable" or better ride quality by population group for select years from 1993 to 2000. Also shown is the amount of Interstate pavement meeting a standard of "Good" ride quality. Since 1995, the number of Interstate miles rated as having "Good" ride quality has increased in all three population groups. (See Exhibit 23-6).

In 2000, 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, 68.5 percent of rural Interstate miles met standards required for classification as "Good" ride quality.

Exhibit 23-5

Percent of Interstate Miles with Acceptable Ride Quality for Selected Years

LOCATION OF INTERSTATES	1993	1995	1997	1999	2000
Rural Areas	93.5%	94.5%	95.9%	97.6%	97.8%
Small Urban Areas	93.5%	94.4%	95.8%	95.4%	95.8%
Urbanized Areas	89.8%	90.0%	90.0%	92.2%	93.0%

Source: Highway Performance Monitoring System.

For small urban Interstate miles, 95.8 percent met the criteria for "Acceptable" ride quality. As a subset of the miles with "Acceptable" ride quality, 61.6 percent met the standards to be classified as "Good" ride quality in the year 2000.

Exhibit 23-6

Percent of Interstate Miles with Good Ride Quality for Selected Years

LOCATION OF INTERSTATES	1995	1997	1999	2000
Rural Areas	51.8%	56.9%	65.4%	68.5%
Small Urban Areas	49.8%	51.4%	58.2%	61.6%
Urbanized Areas	41.4%	39.3%	45.0%	48.2%

Source: Highway Performance Monitoring System.

In 2000, 93.0 percent of urbanized Interstate miles met the criteria for "Acceptable" ride quality. As a subset of this group meeting "Acceptable" ride quality, 48.2 percent of the urbanized Interstate miles met the standards to be classified as having "Good" ride quality.

Lane Width, Alignment, and Access Control

Another way of examining Interstate condition is by lane width. Currently, higher functional systems such as Interstates are expected to have 12-foot lanes. Approximately 97.1 percent of rural Interstate miles and 98.2 percent of urban Interstate miles have minimum 12-foot lanes widths (see also Exhibits 3-14 and 3-15 in Chapter 3).

Another way of examining Interstate condition is by alignment. As described in Chapter 3, 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 23-7 summarizes alignment for rural Interstates (alignment is normally not an issue in urban areas). More than 92.8 percent of rural Interstate miles are classified as Code 1 for vertical and 95.6 percent are classified as Code 1 for horizontal alignment.

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.

Exhibit 23-7

Rural Interstate Vertical/Horizontal Alignment Status for 2000 Percent Miles

	VERTICAL	HORIZONTAL
Code1: All curves and grades meet appropriate design standards.	92.8%	95.6%
Code 2: Some curves or grades are below design standards for new construction, but curves can be negotiated safely at prevailing speed limits. Truck speed is not substantially affected.	6.0%	1.3%
Code 3: Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits.	0.4%	1.1%
Code 4: Frequent grades occur that impair sight distance or severely affect truck speeds. Generally, curves are unsafe or uncomfortable at prevailing speed limit, or the speed limit is severely restricted due to the design speed limits of the curves.	0.7%	2.0%

Source: Highway Performance Monitoring System.

For these States, 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 remainder are in Alaska.

Bridge Conditions

Detailed information about Interstate bridge conditions is found in Chapter 3. Exhibit 3-29 notes, for example, that approximately 16 percent of all rural Interstate bridges were deficient in 2000. More specifically, 1,076 of all rural Interstate bridges were structurally deficient (about 3.9 percent of the total number) and 3,384 were functionally obsolete (12.2 percent of the total number). Among rural functional systems, only other principal arterials had a lower percentage of bridge deficiencies.

About 27 percent of all urban Interstate bridges were deficient in 2000. More specifically, 1,809 of all urban Interstate bridges were structurally

Q. How old are most Interstate bridges?

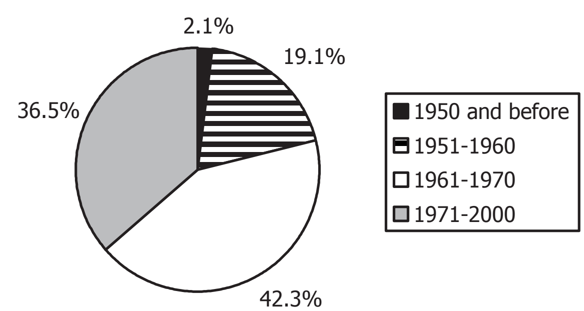
A. The aging of Interstate bridges is a significant concern for the Federal Highway Administration and its State and local partners.

Exhibit 23-8 describes the age of rural Interstate bridges. About 42.3 percent of rural Interstate bridges were built during the early years of the Interstate System, from 1961 to 1970. Approximately 63.5 percent of all rural Interstate bridges in 2000 were at least 30 years old.

Exhibit 23-9 describes the age of urban Interstate bridges. About 48.2 percent of urban Interstate bridges were built between 1961 and 1970. Approximately 69.3 percent of all urban Interstate bridges in 2000 were at least 30 years old.

Exhibit 23-8

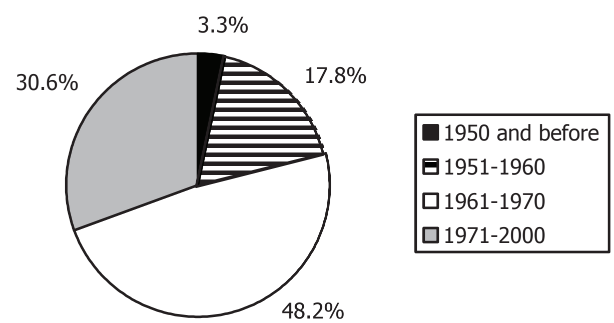
Age Composition of Rural Interstate Bridges



Source: National Bridge Inventory.

Exhibit 23-9

Age Composition of Urban Interstate Bridges



Source: National Bridge Inventory.

deficient (6.5 percent of the total) and 5,727 were functionally obsolete (20.5 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 1994, for example, 18.5 percent of rural Interstate bridges were deficient. That number had declined to 16.0 percent by 2000. The number of deficient urban Interstate bridges also declined, from 30.6 percent in 1994 to 27 percent in 2000.

Another way of examining bridge deficiencies is by the percent of deficient deck area. About 17.9 percent of rural Interstate bridge deck area was deficient in 1996. This number had decreased to 15 percent by 2000, the lowest of any rural functional system. The percent of deficient deck area on urban Interstate bridges declined from 34.2 percent in 1996 to 31.6 percent in 2000.

Operational Performance

Within urban areas, the level of operational performance for the Interstate system is a major concern and a growing problem. Based on the new performance measures adopted by the Federal Highway Administration (FHWA) and described in Chapter 4, congestion has continued to worsen between 1997 and 2000.

Each of the three new metrics—the percent of additional travel time, annual hours of delay, and the percent of travel under congested conditions—worsened since 1997 for the Interstate System in urban areas. Exhibit 23-10 presents the data from 1997 through 2000.

Exhibit 23-10

Urbanized Interstate Operational Performance Measures

	YEAR			
	1997	1998	1999	2000
Travel Time Index	1.559	1.572	1.599	1.627
Percent of Congested Daily Travel	26.650	27.360	28.170	29.130
Annual Delay per Person (hours)	10.131	10.189	10.969	11.430
Annual Delay (billion hours)	2.010	2.050	2.230	2.350
Annual Cost ($billion)	33.460	34.220	38.350	42.880

Source: Texas Transportation Institute

In rural areas, the level of operational performance on Interstates functioning under normal conditions is generally not a significant concern. However, there are some rural corridors that are becoming congested for increasing lengths of time during periods of heavy intercity travel.

Safety

Exhibits 23-11 and 23-12 describe the number of fatalities and the fatality rate for Interstates between 1994 and 2000. While the number of fatalities has increased on both rural and urban Interstates, these roads are still the safest functional systems. The most interesting distinction, however, is on Interstates, where the rural Interstate fatality rate in 2000 was double that of urban Interstates. More detailed information about highway safety can be found in Chapter 5.

Exhibit 23-11

Number of Fatalities on the Interstate System, 1994 - 2000

	1994	1995	1996	1997	1998	1999	2000
Rural Interstates	2,577	2,676	2,967	3,083	3,167	3,300	3,429
Urban Interstates	2,159	2,192	2,338	2,304	2,299	2,372	2,507

Source: Fatality Analysis Reporting System.

Exhibit 23-12

Fatality Rates (per 100 Million VMT) on the Interstate System, 1994 - 2000

	1994	1995	1996	1997	1998	1999	2000
Rural Interstates	1.2	1.2	1.3	1.3	1.3	1.3	1.3
Urban Interstates	0.7	0.6	0.7	0.6	0.6	0.6	0.6

Source: Fatality Analysis Reporting System.

Finance

All levels of government spent $14.1 billion for capital improvements on Interstate highways and bridges in 2000, which constituted 21.8 percent of the $64.6 billion of capital outlay on all functional classes. Exhibit 23-13 categorizes this total by type of improvement. System preservation expenditures constituted 53.7 percent of total capital spending on Interstates, with the remainder split between system expansion (39.6 percent) and system enhancements (6.7 percent). See Chapter 6 for definitions of the 3 improvement types.

Exhibit 23-13

Interstate Capital Expenditures, 2000

	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	$3.2	$5.9	42.1%	10.7%	12.2%	22.8%
Bridge Preservation	$0.4	$1.2	$1.6	11.6%	5.7%	15.7%	21.4%
Subtotal	**$3.2**	**$4.4**	**$7.6**	**53.7%**	**9.6%**	**13.0%**	**22.5%**
System Expansion							
Additions to Existing Roadways	$0.7	$1.8	$2.5	17.8%	5.0%	13.2%	18.3%
New Routes	$0.3	$2.4	$2.7	18.9%	2.6%	21.5%	24.1%
New Bridges	$0.0	$0.4	$0.4	2.9%	2.3%	32.6%	34.9%
Subtotal	**$1.0**	**$4.6**	**$5.6**	**39.6%**	**3.9%**	**17.6%**	**21.5%**
System Enhancements	**$0.2**	**$0.7**	**$0.9**	**6.7%**	**4.8%**	**13.7%**	**18.5%**
Total Investment	**$4.5**	**$9.6**	**$14.1**	**100.0%**	**6.9%**	**14.9%**	**21.8%**

Capital Investment Requirements

Exhibits 7-2 and 7-3 show the estimated average annual Cost to Improve Highways and Bridges and Cost to Maintain Highways and Bridge for 2001-2020, categorized by functional class and improvement type. For the Cost to Improve scenario, investment requirements for rural and urban Interstates total $5.8 billion (5.5 percent of total) and $21.1 billion (19.8 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 $4.5 billion for rural and $18.4 billion for urban. These amounts comprise 5.9 and 24.2 percent, respectively, of the total Cost to Maintain Highways and Bridges. At this level of investment, average user costs on all highways in 2020 would be maintained at their 2000 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 rural areas would increase and average user costs in urban areas would decrease slightly.

Exhibits 23-14 through 23-17 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 2000 dollars.

Exhibits 23-14 and 23-16 show the impact of different levels of highway preservation spending on pavement condition, and Exhibits 23-15 and 23-17 show the impact of combined highway preservation and expansion 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.

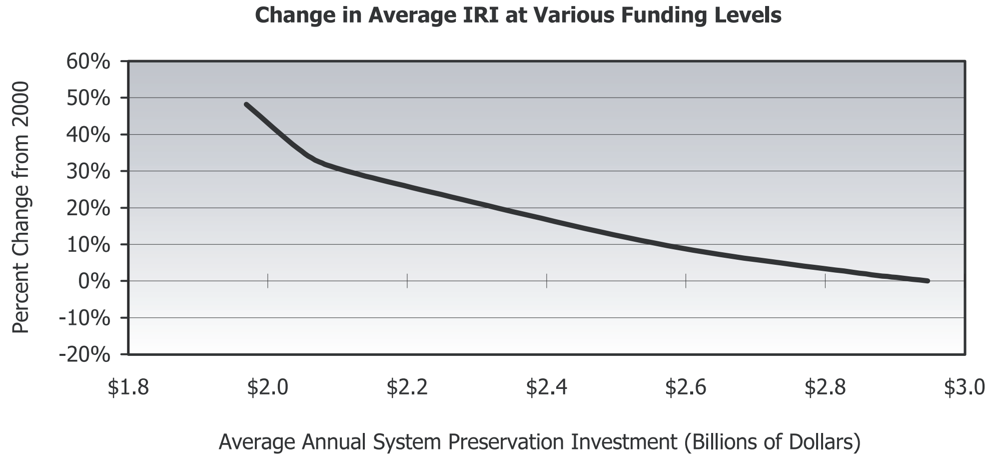
Rural Interstates

Exhibit 23-14 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 an average highway preservation investment of $2.95 billion on rural Interstates would be sufficient to maintain average pavement condition at its current level, while current levels of VMT on pavement with “Good” and “Acceptable” ride quality could be maintained at a lower level of investment. Rural Interstate highway preservation spending in 2000 was $2.78 billion, slightly below the level required to maintain average IRI. However, at this funding level, a larger share of rural Interstate travel would occur on “Good” or “Acceptable” pavements in the future.

Exhibit 23-15 shows how future values for average speed (an indicator of performance), 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 $4.65 billion. Average speed on rural Interstates would be maintained at an investment level between $3.90 and $3.68 billion; the 2000 level of highway preservation and expansion investment of $3.78 billion falls into this range. Travel time costs on rural Interstates would be maintained at an investment level slightly above $3.90 billion.

Exhibit 23-14

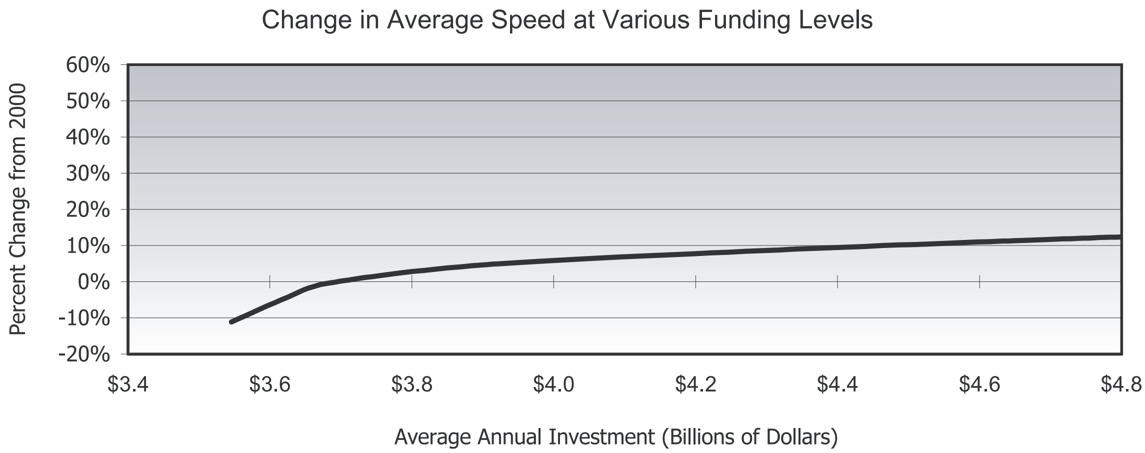
Projected Rural Interstate Pavement Condition in 2020 for Different Possible Funding Levels



AVERAGE ANNUAL HIGHWAY PRESERVATION INVESTMENT (RURAL INTERSTATES) (Millions of 2000 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...
$2.78		**70.3%**	**85.2%**	2000 Values
$2.95	**0.0%**	88.5%	95.8%	...Maintain Average IRI
$2.84	2.4%	85.9%	93.7%	
$2.57	9.6%	**78.1%**	**87.8%**	...Maintain VMT with IRI<95 and <170
$2.26	22.9%	**63.0%**	**76.5%**	
$2.09	31.3%	54.8%	69.8%	
$2.04	36.1%	51.0%	65.8%	
$1.97	48.2%	42.3%	57.4%	

Exhibit 23-15

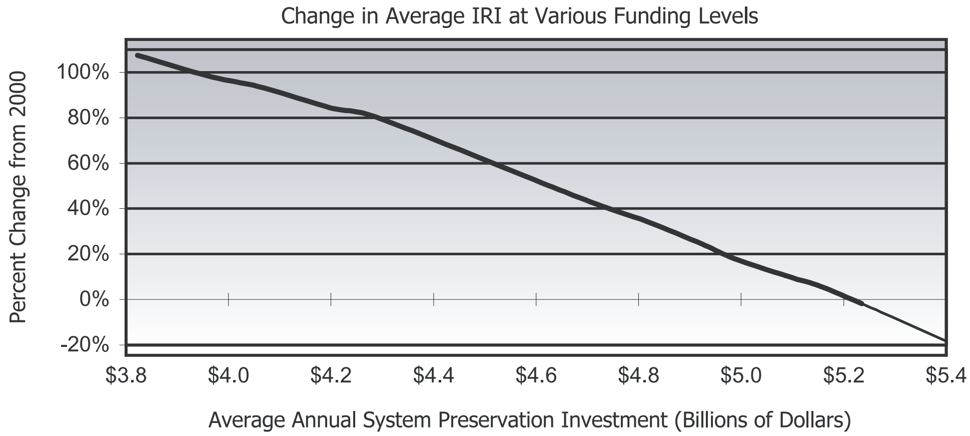
Projected Rural Interstate Conditions and Performance in 2020 for Different Possible Funding Levels



AVERAGE ANNUAL HIGHWAY PRESERVATION + EXPANSION INVESTMENT (RURAL INTERSTATES) (BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE IN AVERAGE SPEED	TOTAL USER COSTS	TRAVEL TIME COSTS	FUNDING LEVEL DESCRIPTION: INVESTMENT REQUIRED TO...
$3.78				2000 Values
$4.80	12.4%	-0.1%	-3.5%	
$4.65	11.4%	**0.0%**	-3.2%	...Maintain Average User Costs
$4.29	8.6%	0.5%	-1.9%	
$3.90	4.7%	1.5%	**0.6%**	...Maintain Average Travel Time Costs
$3.68	**-0.5%**	2.3%	3.2%	...Maintain Average Speeds
$3.62	-4.3%	2.7%	4.5%	
$3.55	-11.2%	4.1%	8.4%	

Exhibit 23-16

Projected Urban Interstate Pavement Condition in 2020 for Different Possible Funding Levels



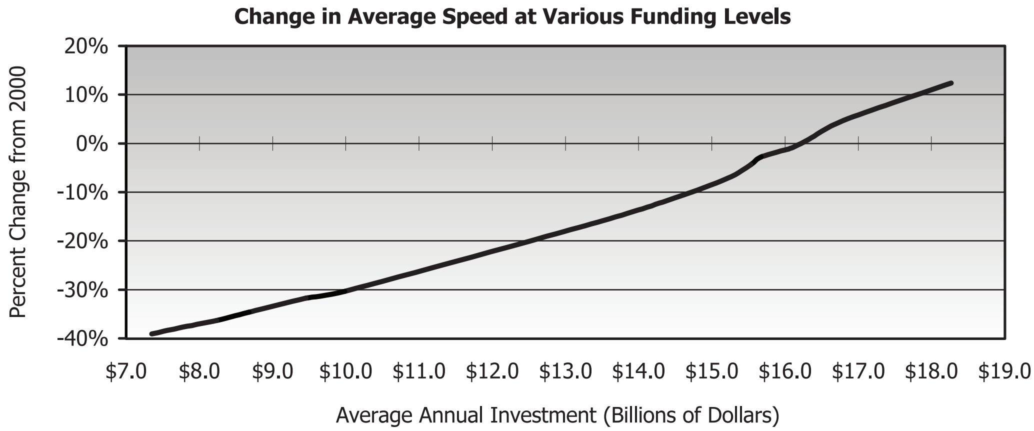
AVERAGE ANNUAL HIGHWAY PRESERVATION INVESTMENT (URBAN INTERSTATES) (BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE IN AVERAGE IRI	PERCENT OF VMT ON ROADS WITH IRI<95	IRI<170	FUNDING LEVEL DESCRIPTION: INVESTMENT REQUIRED TO...
$3.15		45.3%	52.8%	2000 Values
$5.41	-19.63%	88.9%	89.9%	
$5.24	**-1.87%**	69.7%	72.2%	...Maintain Average IRI
$5.15	6.54%	62.3%	65.2%	
$5.10	9.35%	60.4%	63.2%	
$4.99	17.76%	53.8%	57.1%	
$4.93	24.30%	**47.2%**	**50.9%**	...Maintain VMT with IRI<95 and <170
$4.81	34.58%	40.0%	43.7%	
$4.68	44.86%	34.1%	38.0%	
$4.29	80.37%	20.8%	24.1%	
$4.20	84.11%	20.0%	23.3%	
$4.06	93.46%	18.5%	21.5%	
$3.96	98.13%	17.2%	20.2%	
$3.82	107.48%	16.3%	19.3%	

Urban Interstates

Exhibits 23-16 and 23-17 show the impacts on the same measures of conditions and performance for different levels of capital spending on urban Interstates. Exhibit 23-16 shows that an average annual highway preservation investment of approximately $5.2 billion is required to maintain average IRI at 2000 levels. As with rural Interstates, the percentage of travel on urban Interstate pavements with "Good" or "Acceptable" ride quality would increase at this level of investment. Note, however, that all of the investment levels shown in Exhibit 23-16 are well above actual 2000 highway preservation expenditures of $3.15 billion. The results suggest that a substantial increase in urban Interstate investment would be necessary to prevent pavement condition on urban Interstates from deteriorating considerably in the future.

Exhibit 23-17

Projected Urban Interstate Conditions and Performance in 2020 for Different Possible Funding Levels



AVERAGE ANNUAL HIGHWAY PRESERVATION + EXPANSION INVESTMENT (URB INTERSTATES) (BILLIONS OF 2000 DOLLARS)	PERCENT CHANGE IN AVERAGE SPEED	TOTAL USER COSTS	TRAVEL TIME COSTS	FUNDING LEVEL DESCRIPTION: INVESTMENT REQUIRED TO...
$7.72				2000 Values
$18.27	12.4%	-7.5%	-13.8%	
$16.80	4.7%	-3.4%	-6.5%	
$16.32	0.8%	-1.3%	-2.8%	
$16.15	**-0.5%**	-0.5%	-1.5%	...Maintain Average Speeds
$16.09	-0.9%	**-0.3%**	-1.0%	...Maintain Average User Costs
$15.67	-2.8%	0.9%	**0.8%**	...Maintain Average Travel Time Costs
$15.53	-4.3%	1.9%	2.5%	
$15.21	-7.2%	3.8%	5.5%	
$14.49	-11.2%	6.6%	10.0%	
$13.51	-15.9%	10.1%	16.0%	
$9.99	-30.3%	23.5%	39.3%	
$9.46	-31.8%	25.1%	42.0%	
$8.68	-34.6%	28.5%	48.0%	
$8.24	-36.3%	30.7%	52.0%	
$7.71	-37.9%	32.9%	55.8%	
$7.35	-39.1%	34.5%	58.8%	

Exhibit 23-17 indicates that an average annual investment level in highway preservation and capacity expansion of between $15.7 and $16.3 billion would be adequate to maintain average speed, total user costs, and travel time costs on urban Interstates at their current levels. These amounts are more than double the comparable 2000 funding level of $7.7 billion. The results suggest that, if average annual funding were maintained (in constant dollars) at 2000 levels through 2020, average speeds on urban Interstates would drop by 38 percent, total user costs would increase by 33 percent, and travel time costs would increase by 56 percent.

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 Interstates. The current Interstate bridge preservation backlog is estimated at $9.8 billion.

Exhibit 23-18 describes what the Interstate bridge backlog after 20 years would be at different funding levels. An average annual investment in bridge preservation of between $1.27 and $1.35 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 $1.82 billion is 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 23-18

Projected Changes in the Interstate Bridge Preservation Backlog Compared to 2000 Levels for Different Possible Funding Levels

AVERAGE ANNUAL INVESTMENT (BILLIONS OF 2000 DOLLARS)	INTERSTATE BRIDGE BACKLOG
$1.64 1/	
$1.82	$0.0
$1.71	$3.3
$1.55	$6.3
$1.41	$8.7
$1.35	$9.3
$1.27	$10.7
$1.03	$12.7
$0.85	$17.2

1/2000 Value
Source: National Bridge Investment Analysis System

Current Spending Versus Investment Requirements

Exhibits 23-14 through 23-18 indicate that current levels of highway preservation and system expansion investment on rural Interstates are close to the levels necessary to maintain conditions and performance in the future. On urban Interstates, however, substantial increases in funding for preservation and expansion would be required to prevent both average physical conditions and operational performance from becoming severely degraded.

Exhibit 23-13 indicates that bridge preservation expenditures on Interstates totaled $1.6 billion in 2000. If this level of funding were maintained in constant dollars over 20 years, the Interstate bridge preservation backlog would decrease below $6.3 billion from the current level of $9.8 billion.

Chapter 24

National Highway System

Introduction

This chapter provides a snapshot of the physical conditions, operational performance, finance, and investment requirements of the National Highway System (NHS). The NHS integrates the Interstate System with 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, and 8.

History of the National Highway System

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. Until the system was designated, ISTEA prevented future NHS and Interstate Maintenance funds from being released to the States.

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 23, 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 12, includes highways important to military mobilization. **STRAHNET connectors**, also described in Chapter 12, provide access between major military installations and routes which are part of the STRAHNET. **Intermodal Connectors** are highways that provide access between major intermodal facilities and the other four subsystems making up the NHS. The NHS Freight Connectors, described in Chapter 25, are a part of this fifth subsystem.

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.

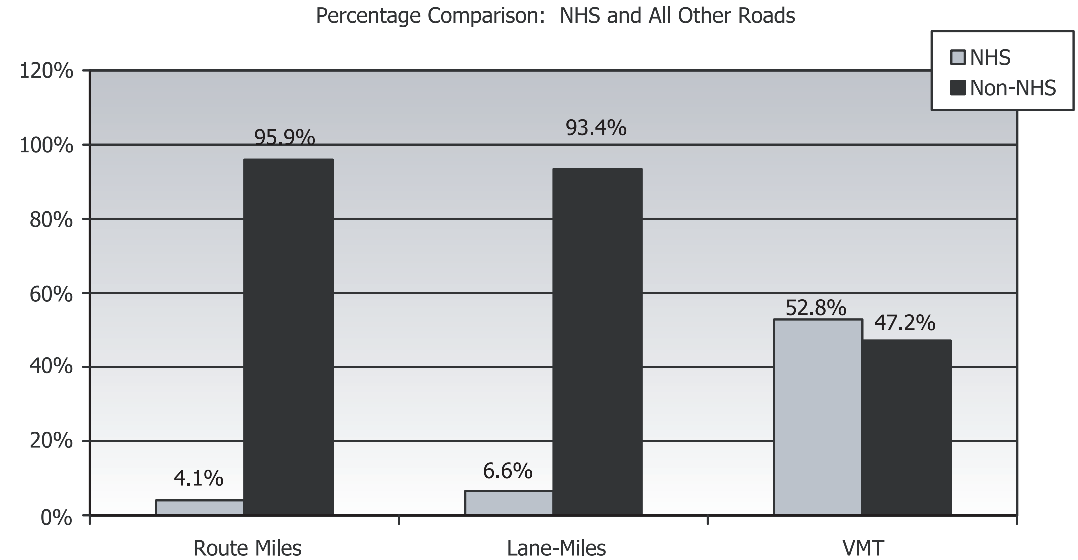
System and Use Characteristics

Exhibit 24-1 summarizes NHS route miles, lane miles, and vehicle miles traveled (VMT). The NHS is overwhelmingly concentrated on higher functional systems. All Interstates are part of the NHS, 84.1 percent of rural other principal arterials are part of the NHS, and 87.8 percent of urban other principal arterials are on the NHS. The NHS is designed to meet nationwide commercial and defense needs, so it is logical to expect that mileage would be concentrated on higher functional systems.

There are currently 161,187 route miles on the NHS. This does not include some sections not open to traffic. The total authorized number of NHS route miles in 2000 was 164,312 miles.

Exhibit 24-1

Highway Route Mileage, Lane Mileage, and Vehicle-Miles Traveled on the National Highway System Compared to All Roads, by Functional System, 2000



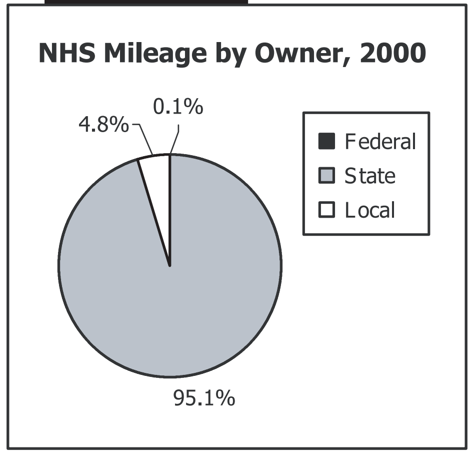
	Route Miles		Lane-Miles		Vehicle-Miles Traveled (Millions)	
	TOTAL ON NHS	PERCENT OF FUNCTIONAL SYSTEM	TOTAL ON NHS	PERCENT OF FUNCTIONAL SYSTEM	TOTAL ON NHS	PERCENT OF FUNCTIONAL SYSTEM
Rural NHS						
Interstate	33,152	100.0%	135,000	100.0%	270,314	100.0%
Other Principal Arterials	83,275	84.1%	217,680	86.0%	218,912	87.9%
Minor Arterial	1,854	1.3%	4,540	1.6%	4,241	2.5%
Major Collector	690	0.2%	1,480	0.2%	1,136	0.5%
Minor Collector	20	0.0%	42	0.0%	16	0.0%
Local	48	0.0%	98	0.0%	35	0.0%
Subtotal Rural NHS	**119,039**	**3.9%**	**358,840**	**5.7%**	**494,654**	**45.4%**
Urban NHS						
Interstate	13,523	100.0%	74,133	100.0%	397,291	100.0%
Other Freeway and Expressway	7,999	87.0%	37,167	89.0%	164,054	92.1%
Other Principal Arterial	19,061	35.6%	69,942	37.6%	162,362	40.5%
Minor Arterial	1,137	1.3%	3,409	1.5%	5,638	1.7%
Collector	301	0.3%	779	0.4%	1,028	0.8%
Local	127	0.0%	252	0.0%	253	0.1%
Subtotal Urban NHS	**42,148**	**4.9%**	**185,682**	**9.7%**	**730,623**	**43.5%**
Total NHS	**161,187**	**4.1%**	**544,522**	**6.6%**	**1,225,277**	**44.3%**

Source: Highway Performance Monitoring System.

While only 4.1 percent of the Nation's total road mileage is on the NHS, these roads carry 44.3 percent of VMT. This represents an increase since 1997, when only 43.5 percent of total vehicle miles traveled were on the NHS.

Exhibit 24-2 describes the ownership of NHS mileage. About 95.1 percent of route miles were State-owned in 2000. Only 4.8 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 19.6 percent of all route miles in the United States were State-owned, 77.4 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.

Exhibit 24-2



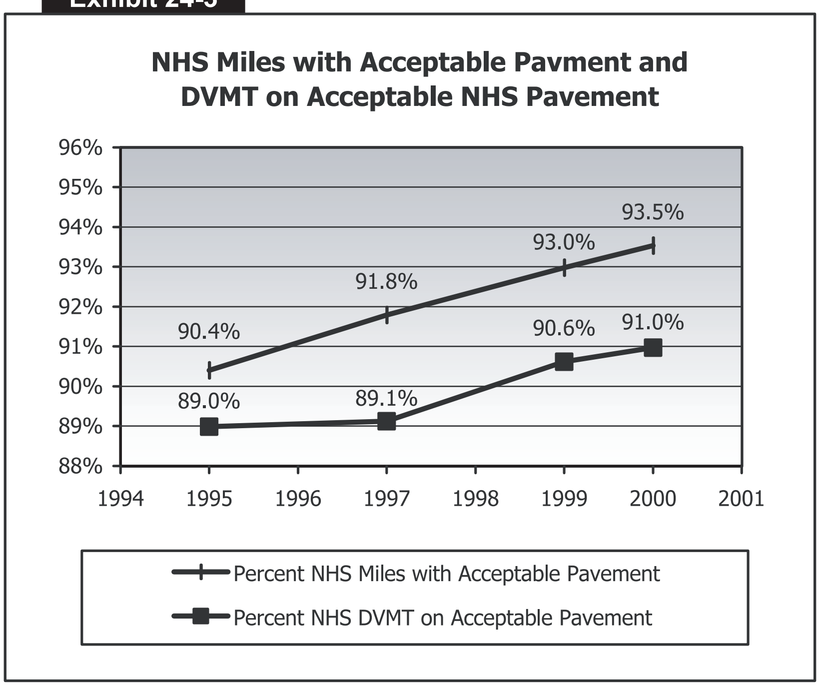
Source: Highway Performance Monitoring System.

Physical Conditions

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.

The FHWA has adopted a new metric based on the percent of vehicle miles traveled (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 2003 Performance Plan, FHWA aimed to have 92.5 percent of VMT on NHS be on pavements rated "acceptable" or better by 2003. In 2000, 90.9 percent of the VMT on the NHS were on pavements with "acceptable" ride quality. This is an increase of 0.4 percent over 1999.

Exhibit 24-3



Source: Highway Performance Monitoring System.

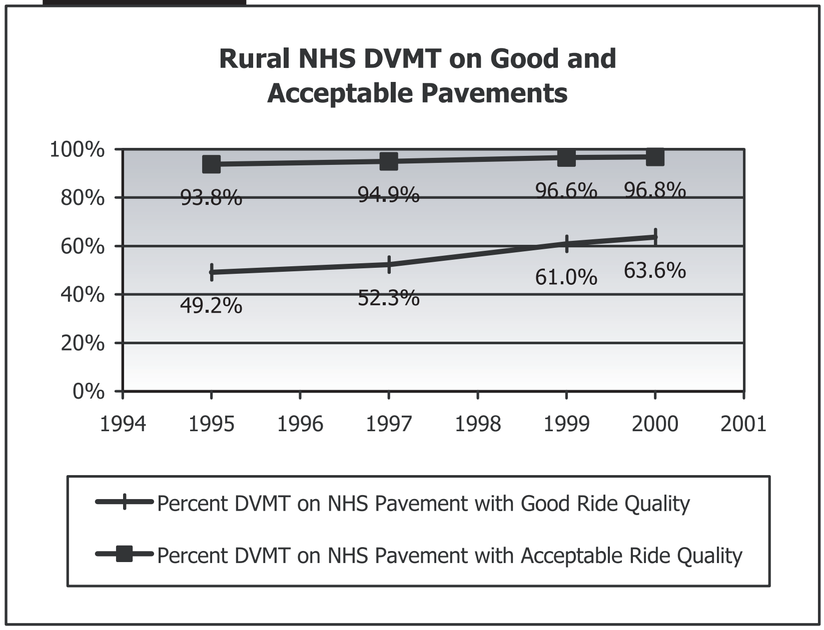
Rural NHS routes tend to have better pavement conditions than urban NHS routes, which is consistent with the results reported for all roads in Chapter 3. The percent of VMT on pavement with "Good" ride quality for rural NHS routes is 63.6 percent, compared to 37.9 percent for urban areas. The Interstate component of the NHS tends to have better ride quality than the non-Interstate component. The VMT on NHS pavements with "Acceptable" ride quality improved between 1999 and 2000, as described in Exhibit 24-3. The VMT on NHS pavements with "Good" ride quality increased in both rural and urban areas. Also, VMT on NHS pavements with "acceptable" ride quality increased in both areas. (See Exhibits 24-4 and 24-5.)

Q. How do NHS pavement conditions compare with pavement conditions on other roads?

A. The percentage of DVMT on pavement with "Good" ride quality in rural areas on the NHS is 63.6 percent, compared to 55.6 percent for all rural highways. The percentage of DVMT on pavement with "Good" ride quality in urban areas on the NHS is 37.9 percent, compared to 35.5 percent for all urban highways. The percentage of DVMT on pavement with "Acceptable" ride quality in rural areas on the NHS is 96.8 percent, compared to 93.8 percent for all rural highways. The percentage of DVMT on pavement with "Acceptable" ride quality in urban areas on the NHS is 87.0 percent, compared to 80.4 percent for all urban highways.

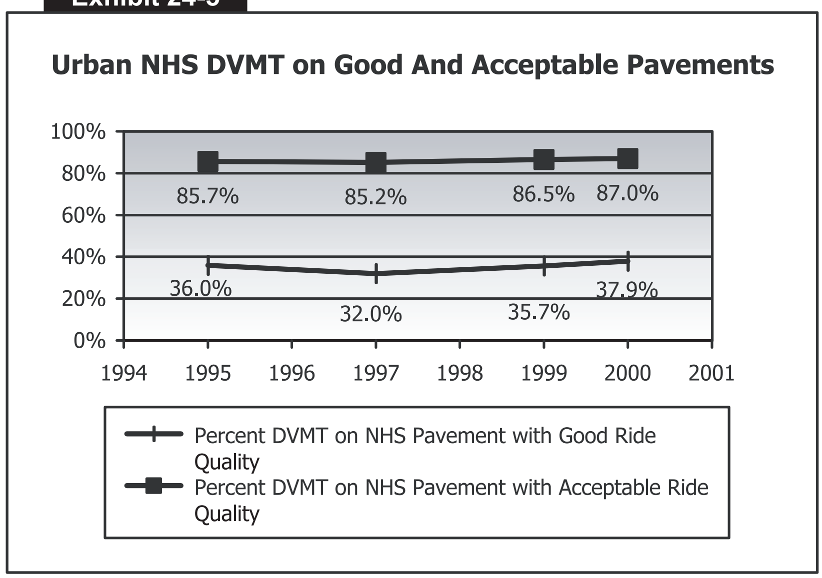
Exhibits 24-6 and 24-7 describe bridge condition using two measures from the FHWA FY 2003 Performance Plan. Both measures describe improving NHS bridge conditions. Exhibit 24-6 examines the percentage of NHS bridges rated deficient, which decreased from 25.8 percent in 1996 to 21.5 percent in 2000. Exhibit 24-7 examines the percentage of deck area on NHS bridges rated deficient, which declined from 35.9 percent in 1996 to 30.8 percent in 2000.

Exhibit 24-4



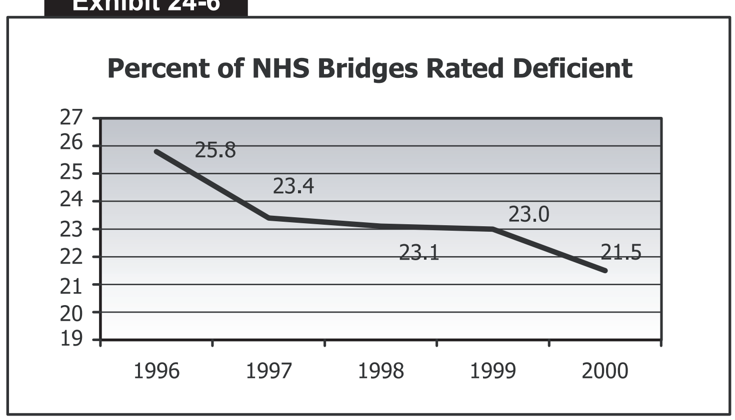
Source: Highway Performance Monitoring System.

Exhibit 24-5



Source: Highway Performance Monitoring System.

Exhibit 24-6

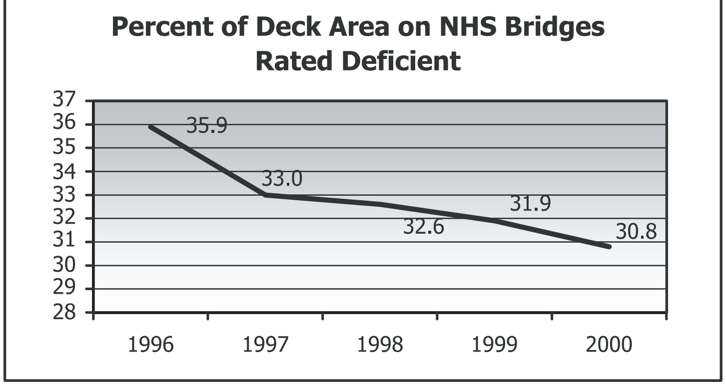


Source: FY 2003 FHWA Performance Plan.

Operational Performance

Since 1997, use of the NHS has increased more rapidly than its capacity has been expanded. From 1997 to 2000, DVMT per lane-mile on the NHS increased by 7.8 percent. The rate of increase during that period was greater in rural areas, 8.9 percent, than in urban areas, 6.8 percent. However, DVMT per lane mile on the NHS in urban areas is still almost three times larger than in rural areas.

Exhibit 24-7



Source: FY 2003 FHWA Performance Plan.

Measures of the three FHWA operational performance indicators (introduced in Chapter 4) are not separately available for the NHS. However, Chapter 4 contains the values of these indicators for principal arterials in urbanized areas, and Chapter 23 includes the values for Interstates, a key component of the NHS, in urbanized areas.

In the urban environment, 72.0 percent of principal arterials are on the NHS. As presented in Chapter 4 of this report, the operational performance of the urban principal arterial system is deteriorating. Exhibit 4-3 in Chapter 4 shows the Percent Additional Travel Time for the average commuter has increased 10 percentage points since 1995 for Urban Areas. Exhibit 4-5 shows an increase of 5.9 hours in Annual Hours of Traveler Delay since 1995, and Exhibit 4-8 shows the Percent of Travel Under Congested Conditions has increased from 31.5 percent in 1995 to 33.1 percent in 2000.

Exhibit 24-8

Highway Capital Outlay on the NHS by Functional System, 2000

FUNCTIONAL CLASS	TOTAL ($BILLIONS)
Rural Arterials and Collectors	
Interstate	$4.5
Other Principal Arterial	$7.0
Minor Arterial	$0.5
Major Collector	$0.2
Minor Collector	$0.0
Subtotal	**$12.1**
Urban Arterials and Collectors	
Interstate	$9.6
Other Freeway & Expressway	$3.6
Other Principal Arterial	$4.9
Minor Arterial	$0.3
Collector	$0.1
Subtotal	**$18.5**
Subtotal, Rural and Urban	**$30.6**
Rural and Urban Local	**$0.0**
Total, All Systems	**$30.6**

Source: Highway Statistics 2000 and unpublished FHWA data.

Finance

Exhibit 24-8 describes highway capital outlay on the NHS by functional system in 2000. Approximately $12.1 billion was invested on rural arterials and collectors in 2000, and another $18.5 billion was invested on urban arterials and collectors. Reported State government spending on NHS routes functionally classified as rural local or urban local was negligible in the year 2000. It is not currently possible to identify spending by local governments on these routes, which would mainly consist of intermodal connectors and STRAHNET connectors. NHS intermodal freight connectors are discussed in Chapter 25.

Investment Requirements

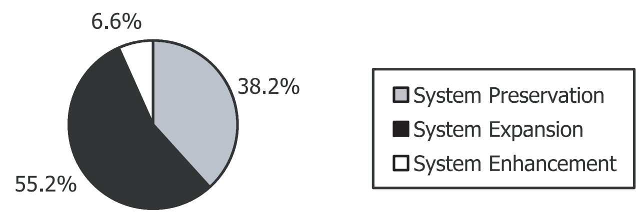
Of the $106.9 billion average annual Cost to Improve Highways and Bridges introduced in Chapter 7, approximately $47.4 billion, or 44.4 percent, is for the NHS. At this level of investment, all cost-beneficial highway improvements would be made and the backlog of deficient bridges would be eliminated. Exhibit 24-9 breaks down these totals into separate system preservation, system expansion, and system enhancement components for rural and urban NHS routes.

Of the $75.9 billion average annual Cost to Maintain Highways and Bridges discussed in Chapter 7, about $37.0 billion, or 48.7 percent, is for the roads on the NHS. At this level of investment, average highway user costs would be maintained at current levels and the current backlog of deficient bridges would be maintained. Note that this scenario attempts to maintain the conditions and performance of the overall system rather than individual functional classes or the NHS. Average NHS user costs or the bridge backlog on the NHS could increase or decline under this scenario, if they are matched by offsetting declines and increases for roads off the NHS.

Exhibit 24-9

NHS Component of Cost to Improve Highways and Bridges (Billions of 2000 Dollars)

Distribution by Improvement Type



	System Preservation					
	HIGHWAY	BRIDGE	TOTAL	SYSTEM EXPANSION	SYSTEM ENHANCE-MENT	TOTAL
Rural	$5.8	$1.1	$6.9	$3.6	$0.9	$11.4
Urban	$9.1	$2.0	$11.2	$22.7	$2.2	$36.1
Total	**$15.0**	**$3.2**	**$18.1**	**$26.2**	**$3.1**	**$47.4**

Q. **Is the NHS component of the Cost to Maintain and Cost to Improve different than the results that would be obtained if only NHS sections were analyzed?**

A. The NHS component of the Cost to Improve Highways and Bridges would be identical to the results that would be obtained by analyzing NHS sections alone. This scenario does not involve any tradeoffs; all cost-beneficial improvements are made on each sample highway section without any degree of competition with other sections.

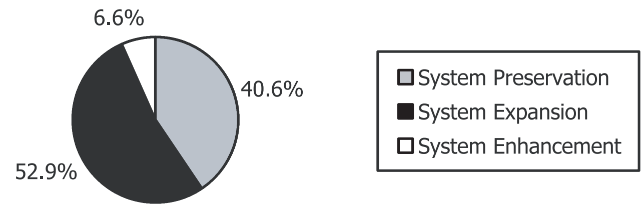
The NHS component of the Cost to Maintain Highways and Bridges can be different, since this scenario is designed to maintain average user costs for all roads combined; the analysis doesn't maintain average user costs specifically on the NHS. However, in this edition of the C&P report, it turns out that the Cost to Maintain analysis for all roads combined results in maintaining average user costs on both NHS and non-NHS roads. This was not the case in the 1999 C&P report, and may not be the case in the future editions.

Exhibit 24-10 breaks down the NHS component of the Cost to Maintain Highways and Bridges into separate system preservation, system expansion, and system enhancement components.

Exhibit 24-10

NHS Component of Cost to Maintain Highways and Bridges (Billions of 2000 Dollars)

Distribution by Improvement Type



	System Preservation			SYSTEM EXPANSION	SYSTEM ENHANCE-MENT	TOTAL
	HIGHWAY	BRIDGE	TOTAL			
Rural	$4.4	$0.9	$5.3	$2.6	$0.7	$8.6
Urban	$8.1	$1.6	$9.7	$16.9	$1.7	$28.4
Total	**$12.5**	**$2.6**	**$15.0**	**$19.6**	**$2.4**	**$37.0**

Comparison of Spending and Investment Requirements

Investment by all levels of government on the NHS would need to increase by approximately $6.4 billion above the 2000 level of $30.6 billion to reach the level of NHS component of the Cost to Maintain Highways and Bridges. This represents a 20.9 percent increase. NHS investment would need to rise by approximately 54.9 percent to reach the Cost to Improve Highways and Bridges.

As shown in Exhibit 24-11, while the relative increase in spending required to close the "gap" between current spending and the Cost to Improve is smaller for the NHS than for other roads, the relative increase in spending required to close the "gap" between spending and the Cost to Maintain is larger. This suggests that a larger share of future funding increases should be utilized on the NHS up to a point, but that there is also a large amount of cost-beneficial investment off the NHS that should be implemented if unlimited funding were available.

Exhibit 24-11

Average Annual Investment Required to Maintain and Improve Highways and Bridges Versus 2000 Capital Outlay on and off the NHS

	COST TO MAINTAIN HIGHWAYS AND BRIDGES			COST TO IMPROVE HIGHWAYS AND BRIDGES		
	ON NHS	OFF NHS	TOTAL	ON NHS	OFF NHS	TOTAL
Average Annual Investment Requirements (Billions of $2000)	$37.0	$38.9	$75.9	$47.4	$59.5	$106.9
2000 Capital Outlay	$30.6	$34.1	$64.6	$30.6	$34.1	$64.6
Percent Difference	20.9%	14.3%	17.5%	54.9%	74.6%	65.3%

Chapter 25

NHS Freight Connectors

This chapter describes the investment requirements of National Highway System (NHS) freight connectors. NHS freight connectors are the public roads that lead to major intermodal freight terminals (the entire NHS system is described in Chapter 24). As noted in Chapter 22, freight transportation is critical to our Nation's economy, so it is important to understand the conditions and needs of freight connectors.

Summary of the Nation's Freight Connectors

The NHS freight connectors were designated in cooperation with State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) based on criteria developed by the U.S. Department of Transportation. The criteria considered the level of activity of an intermodal terminal and its importance to a particular State.

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. Exhibit 25-1 displays NHS freight connector mileage by functional class and population density. It shows that the majority of mileage is in urban areas and is classified as arterials.

Exhibit 25-1

Total NHS Connector Mileage by Functional Class

TOTAL NHS COLLECTOR MILEAGE	POPULATION DENSITY		
FUNCTIONAL CLASS	RURAL	SMALL URBAN	URBANIZED
Rural Interstate	5		
Rural Other Principal Arterial	32		
Rural Minor Arterial	57		
Rural Major Collector	88		
Rural Minor Collector	7		
Rural Local	30		
Urban Interstate/Expressway		27	62
Urban Other Principal Arterial		134	304
Urban Minor Arterial		85	209
Urban Collector		35	82
Urban Local		16	50
Total	219	297	707

Source: Office of Freight Management and Operations, Federal Highway Administration.

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 main routes.

The report to Congress, however, did not include an assessment of needed improvements or investment requirements. A follow-up effort was initiated in 2001 to develop an estimate of current investment needs for the NHS freight connectors based on deficiencies identified by the 1998 inventory conducted for the 2000 report to Congress. This estimate is described in the next section.

Analytical Approach

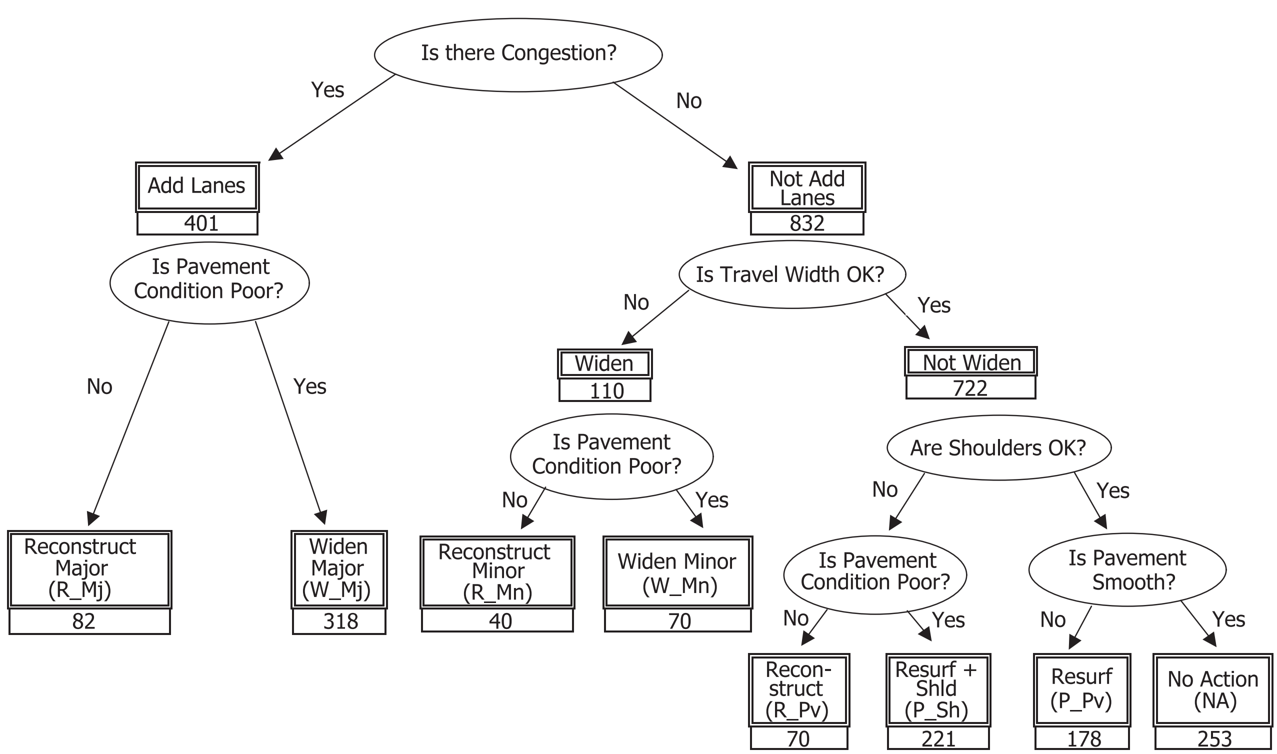
To estimate the investment needs of intermodal freight connectors, physical deficiencies were divided between "linear" and "spot." Linear deficiencies are those that affect the connector along its length and typically are related to pavement, lane width, or number of lanes. Spot deficiencies are localized and typically related to an intersection, railroad crossing, or structure. The investment requirements analyses in Chapters 7 and 24 address some (but not all) of these deficiencies.

Exhibit 25-2 describes the logic employed to examine each connector with respect to the need for linear improvements such as pavement repair and/or expansion of capacity. The analysis first determined if additional capacity was needed based on the identification of congestion in the 1998 field inventory. Capacity needs were met by adding two lanes, unless the connector already had four lanes or more. If additional capacity was needed, then the condition of the pavement was checked to determine the appropriate course of action. If additional capacity was not needed, then requirements for additional lane width were examined. If additional lane width was needed, then the condition of the pavement and shoulder determined the final course of action.

Spot improvements were based on deficiencies involving isolated locations that could act as a bottleneck to the efficient flow of traffic along the connector. The survey identified spot deficiencies for: (1) structures that impose horizontal (width), vertical (height) or structural (weight limit) restrictions on the free flow of freight

Exhibit 25-2

Freight Connectors Analysis Approach



Source: Office of Freight Management and Operations, Federal Highway Administration.

vehicles; and (2) highway intersections and railroad crossings that restrict the free flow of freight vehicles. The analysis identified spot deficiencies on each connector and used spot costs to estimate needed investments in addition to linear improvements.

Unit cost data for this analysis was obtained from a study currently being performed for the FHWA Office of Policy. That study, not yet completed, is designed to develop updated cost data for highway capital improvements for use in the HERS model. Costs are determined by highway functional class and improvement type. The improvement type initials used in the flow chart are also shown:

- Reconstruction - pavement plus adding 2 lanes
- Reconstruction - pavement plus incidentals
- Reconstruction - pavement only
- Widening - major, with adding 2 lanes
- Widening - minor, existing lanes only
- Resurfacing - existing lanes plus shoulders
- Resurfacing - existing lanes only

Unit costs for spot deficiencies were estimated and confirmed with several state DOTs. The unit costs (in millions) used for this analysis are:

- Bridge replacement for vertical, horizontal, or structural deficiency– $2,000,000
- Pavement repair for rough or abandoned railroad crossing – $50,000
- Repair for "humped" railroad arossing – $750,000
- Installation of left or right turn lanes at intersection – $450,000
- Improvement of turning radii at NHS junction – $30,000

Linear Deficiencies

Linear deficiencies were assumed to exist for the entire length of the connector or identified segment. Some connectors were segmented in the inventory when geometry or pavement changed significantly. For these deficiencies, the unit cost for the identified improvement type was multiplied by number of lanes and number of centerline miles.

Exhibit 25-3 shows approximately one third (401 of 1,222 miles) of the connector system was judged to be in need of additional capacity. Of the remaining connector mileage,

Exhibit 25-3

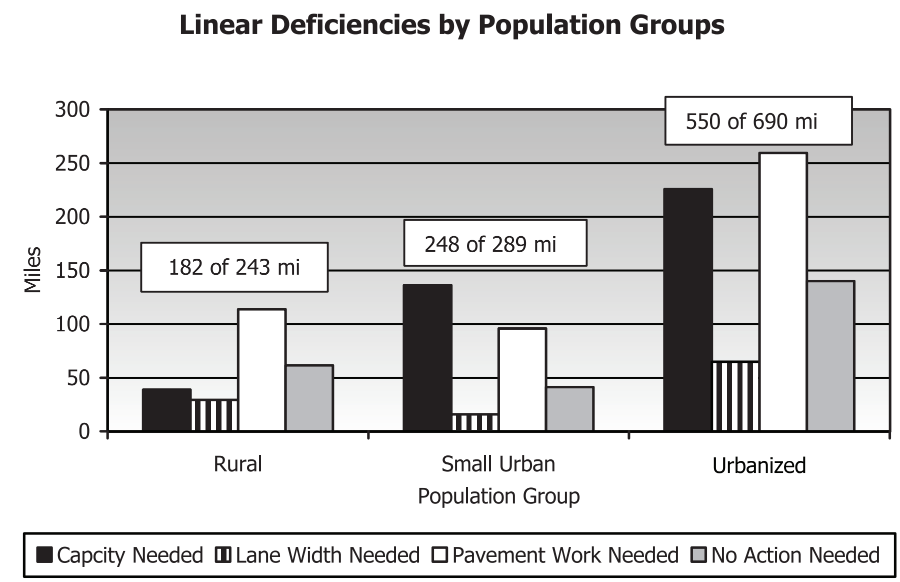
Linear Deficiencies by Improvement Type

IMPROVEMENT TYPES	MILES OF CONNECTORS BY POPULATION GROUP			TOTAL MILES
	RURAL	SMALL URBAN	URBANIZED	
Capacity Needed				401
Reconstruction, Major	7	22	53	
Widen, Major	32	114	173	
Lane Width Needed				110
Reconstruction, Minor	10	4	25	
Widen, Minor	19	12	40	
Pavement Work Needed				469
Reconstruction	24	15	31	
Resurface, Shoulders	63	38	121	
Resurface	27	43	108	
Needed Improvements	182	248	550	979
No Action Needed	62	41	140	243
Totals	**243**	**289**	**690**	**1,222**

Source: Office of Freight Management and Operations, Federal Highway Administration.

579 miles needed pavement or lane width improvements, while roughly twelve percent (243 miles) were considered to have adequate pavement, lane, and shoulder width. Exhibit 25-4 shows the deficiencies by population grouping.

Exhibit 25-4



Source: Office of Freight Management and Operations, Federal Highway Administration.

Spot Deficiencies

Only the existence and types of spot deficiencies were identified for each connector, so it was not always possible to determine the actual number of each type of deficiency on the connector. It was assumed that a positive indication of the existence of a deficiency meant that there was a single occurrence of the deficiency type on the segment. Exhibit 25-5 summarizes spot deficiencies.

The number of spot deficiencies on links with needed linear improvements is shown in Exhibit 25-6.

Exhibit 25-5

Spot Deficiencies

Spot Deficiency Types	NUMBER OF CONNECTORS WITH SPOT DEFICIENCIES BY POPULATION GROUP			TOTAL
	RURAL	SMALL URBAN	URBANIZED	
Bridge-Related				53
Vertical Clearance	2	3	15	
Horizontal Clearance	3	3	12	
Structural	4	2	9	
Rail Crossing-Related				148
Rough Abandoned	5	4	30	
Under Clearance	1	2	11	
Rough	12	22	61	
Intersection-Related				248
Left Turning Lanes	13	35	70	
Turning Radii	10	23	40	
Right Turning Lanes	5	21	31	
Total Spot Deficiencies				**449**

Source: Office of Freight Management and Operations, Federal Highway Administration.

Exhibit 25-6

Spot Improvements by Linear Type

SPOT IMPROVEMENT TYPE		RECONSTRUCT MAJOR & MAJOR WIDEN	MINOR WIDENING AND PAVEMENT WORK	NO OTHER IMPROVEMENT	TOTAL
	Vertical Clearance	9	10	1	20
	Horizontal Clearance	9	7	2	18
Bridge	Weight Limit	9	5	1	15
	Abandoned	14	22	3	33
	Underneath Clearance	2	10	2	14
Rail Crossing	Rough	36	48	11	95
	Turn Lane	77	32	9	118
	Junction Turn Lane	39	27	7	73
Intersection	Junction Turn Radii	27	20	10	57
	Total	**222**	**181**	**46**	**449**

Source: Office of Freight Management and Operations, Federal Highway Administration.

Improvement Strategies

Two needs estimates were developed. The first addressed backlog or existing needs based on costs for the functional class. The table below shows the application of linear unit costs based on deficiency type over the length of the segment. This approach yielded the results shown in Exhibits 25-7 and 25-8.

Exhibit 25-7

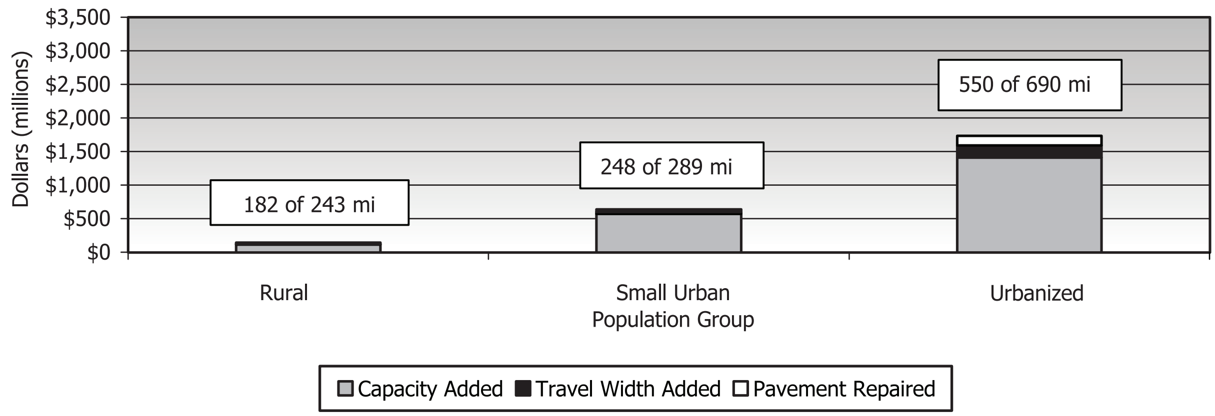
Cost to Eliminate Linear Deficiency Backlog (millions of dollars)

LINEAR DEFICIENCY TYPE	COSTS BY POPULATION GROUP			TOTAL
	RURAL	SMALL URBAN	URBANIZED	
Capacity Needed				$2,092
Reconstruction, Major	$19	$111	$454	
Widen, Major	$94	$458	$957	
Lane Width Needed				$218
Reconstruction, Minor	$3	$7	$102	
Widen, Minor	$6	$23	$78	
Pavement Work Needed				$200
Reconstruction	$7	$20	$51	
Resurface, Shoulders	$11	$8	$52	
Resurface	$3	$10	$39	
Total Costs	**$128**	**$619**	**$1,640**	**$2,510**

The second needs estimate was done with the objective of raising the performance level of connectors (i.e., design standards) because of expected increases in the level of activity. The identification of improvement types was the same as that employed for the first estimate except that the unit costs for the next higher functional class was employed. An exception was the assumption that all connector mileage in need of pavement improvements used the "reconstruction-minor" unit cost because of increased design standards. As a result, the total cost in the category of "pavement work needed" represented a much larger proportion of overall program cost than the first estimate because the costs for the next higher functional class are greater [See Exhibits 25-9 and 25-10].

Exhibit 25-8

Cost of Program to Eliminate Linear Deficiency Backlog



Source: Office of Freight Management and Operations, Federal Highway Administration.

Exhibit 25-9

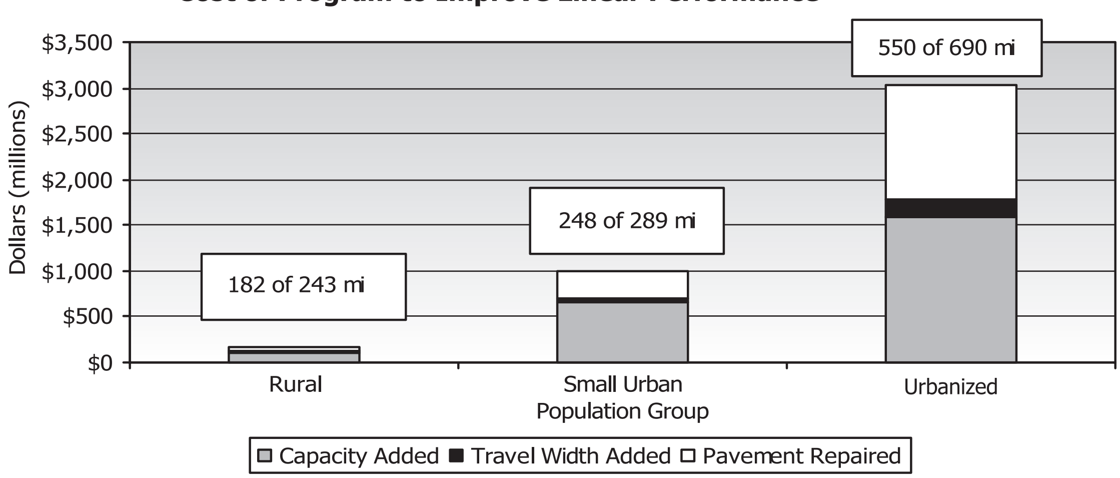
Cost to Improve Linear Performance Level by Population Group (millions)

IMPROVEMENT TYPE	COST BY POPULATION GROUP			TOTAL
	RURAL	SMALL URBAN	URBANIZED	
Capacity Needed	$113	$664	$1,588	$2,365
Lane Width Needed	$7	$31	$189	$227
Pavement Work Needed	$51	$311	$1,249	$1,611
Total Costs	**$171**	**$1,007**	**$3,027**	**$4,204**

Source: Office of Freight Management and Operations, Federal Highway Administration.

Exhibit 25-10

Cost of Program to Improve Linear Performance



Source: Office of Freight Management and Operations, Federal Highway Administration.

Spot Improvement Costs

In estimating costs for spot improvements, it was assumed that spot deficiencies occurring on links requiring major reconstruction or major widening were corrected as part of the linear improvement. Thus, the cost for these spot deficiencies was zero. Spot deficiency costs were estimated for other types of improvements and for links for which no other deficiencies were identified. The spot costs are shown in Exhibit 25-11.

Total NHS Freight Connector Investment Requirements

The cost for spot improvements was assumed to be the same for both the backlog needs and the costs for the enhanced connectors. Including the costs for spot deficiencies added $87.1 million to the total of both estimates. As shown in Exhibit 25-12, this resulted in a total cost for the backlog improvement estimate of $2.597 billion, while the cost for improving service due to expected increases in freight volumes would be $4.291 billion.

Exhibit 25-11

Spot Improvement Costs (millions)

SPOT IMPROVEMENT TYPE		RECONSTRUCT MAJOR & MAJOR WIDEN	MINOR WIDENING AND PAVEMENT WORK	NO OTHER IMPROVEMENT	TOTAL
	Vertical Clearance	$0	$20	$2	$22
	Horizontal Clearance	$0	$14	$4	$18
Bridge	Weight Limit	$0	$10	$2	$12
	Abandoned	$0	$1	$0.2	$1
	Underneath Clearance	$0	$8	$2	$9
Rail Crossing	Rough	$0	$2	$0.5	$3
	Turn Lane	$0	$14	$4	$18
	Junction Turn Lane	$0	$2	$1	$3
Intersection	Junction Turn Radii	$0	$1	$0.3	$1
	Total	**$0**	**$72**	**$15**	**$87**

Source: Office of Freight Management and Operations, Federal Highway Administration.

Exhibit 25-12

Cost to Eliminate Backlog Deficiencies (millions of dollars)

	Using Design Standards For	
IMPROVEMENT TYPE	EXISTING FUNCTIONAL CLASS	HIGHER FUNCTIONAL CLASS
Spot	$87	$87
Linear	$2,510	$4,204
Total Costs	**$2,597**	**$4,291**

Source: Office of Freight Management and Operations, FHWA.

Chapter 26

Highway-Rail Grade Crossings

Introduction

The amount of freight transported by railroads is expected to double over the next twenty years. Train volumes at some grade crossings will more than double as railroads consolidate traffic on major corridors to improve efficiency and cut costs. Some crossings currently serve as many as 140 trains per day, and the number of crossings serving more than 100 trains per day will more than double in the next 20 years. Crossings near intermodal facilities, ports, major rail yards, and classification and switching areas will experience high train and truck traffic increases due to increases in domestic and foreign trade.

> **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.

One result of the increased rail traffic will be that more grade crossings will be closed to highway traffic for long periods of time each day. Coupled with expected increases in auto and truck traffic, highway delay is likely to increase significantly at highway-rail grade crossings. The delay to motorists and pedestrians could reach unacceptable levels in many communities, blocking emergency vehicles, disrupting local commerce, inconveniencing residents, and creating societal divisions.

> **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 20.

The Federal Railroad Administration (FRA) has analyzed grade crossings located on the Federal-aid highway system characterized by high volumes of highway and rail traffic, each of which is currently protected by both flashing lights and gates. These crossings can be closed for large portions of the day, causing significant delay to both passenger vehicles and trucks.

The FRA analysis suggests that during the first ten years of the 20-year analysis period, total hours of delay for trucks, autos, and buses could increase by 7 percent per year. The annual increases could reach 15 percent annually in the last ten years of the analysis period, depending on whether trains travel through crossings when highway traffic volume is at its highest. Annual hours of delay for autos could increase to between 35 million and 123 million hours by 2022, and trucks could spend between 4.9 and 6.6 million more hours annually behind closed gates by 2022 than at the present, depending on how frequently trains arrived 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 $5.5 and $7.8 billion over the 20-year analysis period.

The solutions to this problem are either to separate the railroad and highway at the crossing, or to place restrictions on the frequency and duration of highway closures at grade crossings. While the former solution requires expensive construction, the latter restricts the capacity and flexibility of railroad operations, creates economic costs for the railroad and its shippers, and reduces the ability of railroads to serve as a substitute for truck traffic on increasingly crowded highways.

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 the train to pass. Most important is determining how many highway vehicles are affected each time a train arrives at the crossing. The analysis was done only for grade crossings on the Federal-aid highway system.

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 Figure 26-1 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.

Exhibit 26-1 shows the projected changes in different types of highway user and emissions costs in 2022 (compared to 2002 levels) at different annual levels of investment in grade separation improvements. The analysis indicates that:

- An average annual investment in highway-rail grade separation improvements of $300 million would be sufficient to maintain highway user costs at these crossings at the 2002 level. This investment level is comparable to the "Maintain User Costs" scenario for highways discussed in Chapter 7.

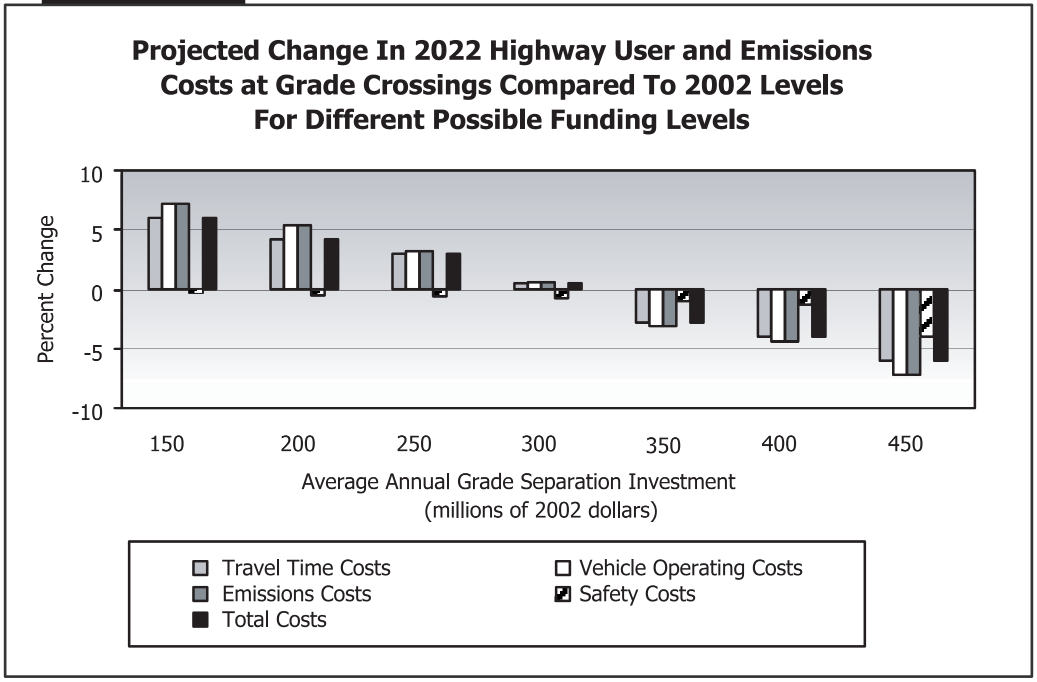
- Increasing average annual investment to $450 million would be sufficient to undertake all cost beneficial separation projects at grade crossings on the Federal aid system. This level is comparable to the "Maximum Economic Investment" scenario for highways discussed in Chapter 7.

- Grade separation improvements are at least partially captured in the external adjustments made in Chapter 7 to account for non-modeled capital investments. However, the grade separation projects analyzed by FRA may also include additional investments that are not fully reflected in the two highway investment scenarios.

As with the highway and bridge analyses presented in Chapter 7, the FRA analysis finds that there is a significant backlog of grade separation improvements that could be immediately justified. The backlog of such improvements in 2002 totals $2.0 billion.

In practice, grade crossing separations are planned in combination 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 the closed and the separated crossing. While a more thorough analysis would consider the benefits associated with the redirected traffic, they are not included in this analysis, nor is the residual value of capital investments in grade separation.

Exhibit 26-1



Grade Crossing Traffic Distribution Scenarios

Delays at grade crossings occur when highway and rail traffic meet at grade crossings. 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 distribution scenarios were analyzed: peak traffic and uniform traffic.

Peak Traffic

As shown in Exhibit 26-2, allowing both highway and train traffic to peak at grade crossings could result in auto delay increasing to 123 million hours annually by 2022. Similarly, trucks would likely experience an additional 6.6 million hours of delay annually in 20 years, and annual bus delay could increase to 6.0 million hours annually. The present value of delay for all vehicles for the 20year period is valued at $7.9 billion at the 50 percent confidence level. In other words, under these assumptions, one can be 50 percent certain that hours of delay would equal or exceed the values stated above. At the 50 percent confidence interval, annual carbon

Q. How were highway and railroad daily traffic volumes distributed over a 24-hour period?

A. 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 .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 remaining six hours. Train traffic is allowed to cluster at any time including the 6-hour peak period for highway traffic.

Exhibit 26-2

Annual Increase in Delay and Associated Costs for Sample Crossings in 2022 Compared to 2003 Levels

CONFIDENCE INTERVAL		50%	80%	20%
Scenario: Peak		**Average**	**Minimum**	**Maximum**
Delay (hours)	Auto	123,217,150	66,518,097	174,509,523
	Truck	6,661,616	3,540,633	9,478,470
	Bus	5,994,450	3,233,261	8,503,662
Emissions (metric tons)	CO	519,186	75,452	198,485
	HC	32,488	19,508	44,131
	NOx	11,144	6,694	15,095
Fuel Consumption (gallons)	Gasoline	969,352,821	581,967,155	1,318,567,725
	Diesel	147,395,271	147,395,271	147,395,271
	Oil	72,063,230	72,063,230	72,063,230

Present Value of All Costs for the Entire 2003-2022 Analysis Period

Costs (000's)	Safety	$457,242	$453,813	$460,180
	Delay	$7,854,596	$4,156,804	$11,360,507
	Emissions	$43,968	$24,779	$61,021
	Vehicle Operating Costs	$669,946	$377,815	$929,103
	Total	$9,033,694	$5,021,964	$12,817,903

monoxide emissions would increase by 519,186 metric tons, annual hydrocarbon emissions would increase by 32,488 metric tons, and annual nitrogen oxide emissions would increase by 11,144 metric tons. Total emissions for the 20-year analysis period add up to a present value of nearly $44 million. Again, at the 50 percent confidence interval, annual fuel burned idling at grade crossings increases by 969 million gallons of gasoline, 147 million gallons of diesel, and 72 million gallons of oil. Vehicle operating costs are the sum of additional fuel and oil burned while idling at grade crossings and add a present value of $669 million to total costs. All categories of accidents combined add an additional $457,242 in present value costs to the total.

Q. How was this analysis conducted?

A. 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 is allowed to vary from 30 to 90 cars, and the number of passenger rail trains varies between zero and four. All other variables were held constant.

On average, the total increase in costs for all years and all categories over the 20-year analysis period is valued at more than $9 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 the addition of passenger rail.

Uniform Traffic

Exhibit 26-3 shows that when highway and rail traffic is uniformly distributed, it is estimated that automobile traffic delay would increase over 35 million hours by the last year of the analysis period, trucks would spend 4.9 million hours delayed at crossings, and buses would be behind closed gates for 1.7 million hours more than in the base year (at the 50 percent confidence interval). The total value of time lost for all years in the analysis period amounts to a present value of $5.5 billion. Idling vehicles would emit 15,690 more metric tons of carbon monoxide annually, 988 more tons of hydrocarbons annually, and 359 more metric tons of nitrogen oxides annually than in 2002, the base year of the analysis. The changes in emissions over the analysis period convert to over $13 million present-value dollars. An additional 28.6 million gallons of gasoline, 6.5 million gallons of diesel, and 2.3 million gallons of oil would be burned at closed grade crossings than in the first year of the analysis period and would total $208 million in present-value dollars. Safety costs for all predicted categories: fatalities, injury, and property damage would be valued at $457,243. The total present-value costs of increased delay and safety at high volume grade crossings currently protected by flashing lights and gates on the Federal aid highway system would exceed $6.2 billion if all traffic is distributed evenly, which is an unlikely assumption.

In the uniformly distributed traffic scenario, 40 percent of the deviation from the mean is attributed to variation in the train length and 8 percent is attributed to the addition of passenger rail. This is expected because all traffic is uniformly distributed under this scenario, and thus the additional passenger trains would not be adding to congested conditions during peak traffic periods.

Exhibit 26-3

Annual Increase in Delay and Associated Costs for Sample Crossings in 2022 Compared to 2003 Levels

CONFIDENCE INTERVAL		**50%**	**80%**	**20%**
Scenario:Uniform		**Average**	**Minimum**	**Maximum**
Delay (hours)	Auto	35,442,034	18,885,489	50,791,114
	Truck	4,948,603	2,271,593	6,033,102
	Bus	1,653,771	881,544	2,367,674
Emissions (metric tons)	CO	15,690	8,265	22,525
	HC	988	520	1,418
	NOx	359	189	514
Fuel Consumption (gallons)	Gasoline	28,643,571	6,823,951	18,492,831
	Diesel	6,531,424	3,473,915	9,285,326
	Oil	2,272,354	1,198,495	3,258,217
	Present Value of All Costs for the Entire 2003-2022 Analysis Period			
Costs (000's)	Safety	$457,243	$453,813	$460,180
	Delay	$5,534,695	$2,924,706	$8,033,722
	Emissions	$13,788	$7,279	$20,012
	Vehicle Operating Costs	$207,752	$109,672	$301,459
	Total	**$6,218,933**	**$3,502,881**	**$8,818,933**

This analysis examines the warrants for grade separations related to highway traffic. Other promising research areas that may be addressed in the future include other warrants for grade separation, such as community cohesion.

Delay and Time in Queue at Individual Grade Crossings

The potential for rapid increases in grade crossing-related highway delay is easier to understand if one looks at what happens at an individual grade crossing as highway and train traffic increases.

Highway delay at grade crossings increases more than proportionally as highway and train traffic increase. As shown in the Exhibit 26-4, at lower highway traffic volumes, total delay for all vehicles is little more than 10 minutes if a grade crossing gate is closed for 3.6 minutes when there are 100 vehicles per lane per hour. In this case, 7 vehicles are affected, or lined up in the queue behind closed gates. But as highway traffic volumes increase, the number of affected vehicles increases from 7 to 110, so that at 900 vehicles per lane per hour, a total of 3.3 hours of delay would be experienced by all vehicles stopped behind the gates and total time in queue would equal 4 hours.

Q. What is the difference between delay and time-in-queue?

A. Delay is the amount of travel time lost while the grade crossings is closed. Time-in-queue differs from delay because it captures the amount of time it takes for vehicles to return to normal traffic flow. Delay is used to calculate changes in travel time, and time in queue is used to calculate vehicle operating costs and tons of emissions.

As train traffic volumes increase to near rail capacity, the average length of a train will also increase. Exhibit 26-5 shows that if the length of time a grade crossing is closed increases from 3.6 to 4.5 minutes, as would happen if a 60-car train added 20 additional cars, total hours of delay per train increases from 3.3 to 5 vehicle hours of delay, and time in queue would increase from 4 to 6 hours. The number of affected vehicles would increase from 110 for the 3.6-minute closure to 135 for the 4.5-minute closure at the 900 vehicles per lane per hour level.

As shown in Exhibits 26-4 and 26-5, as highway volumes and train lengths increase, so does the potential for significant increases in delay and time in queue. Also, at higher traffic volumes, the difference between delay and time-in-queue increases because it takes increasingly longer for the queue to disperse when the gates are opened. At these traffic volumes, the increases in highway user vehicle operating costs, or fuel and oil burned and resulting tons of emissions, outstrip travel time costs as the primary highway user cost associated with high volume highway rail grade crossings.

Exhibit 26-4

Delay and Time in Queue Per Lane for All Vehicles per 3.6 Minute Grade Crossing Closure

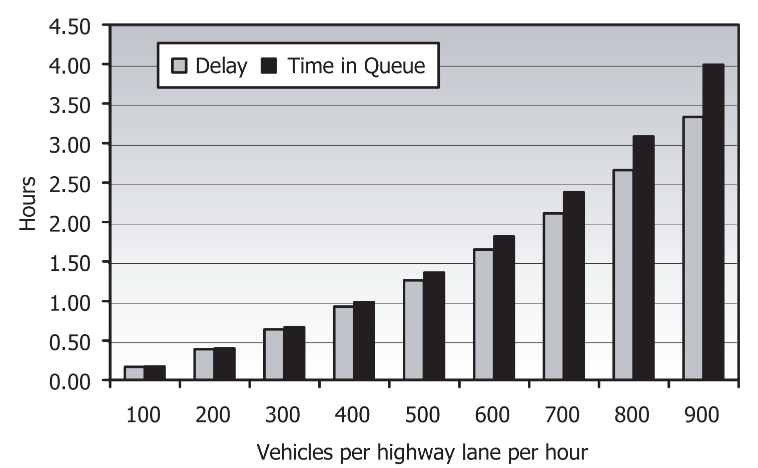
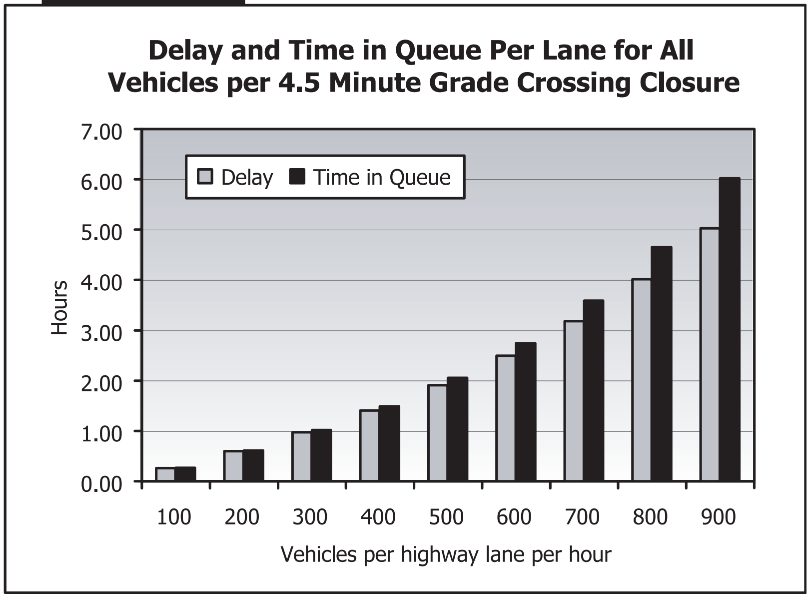


Exhibit 26-5



Delay and Time in Queue Per Lane for All Vehicles per 4.5 Minute Grade Crossing Closure
Delay
Time in Queue
Hours
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
100
200
300
400
500
600
700
800
900
Vehicles per highway lane per hour

Chapter 27

Transit on Federal Lands

Introduction

Federal lands account for about 29 percent of the land area of the United States, principally in the western part of the country. Over the past decade, these lands have been used increasingly for recreational purposes while business activities such as the extraction of minerals and lumber have declined. This section, which discusses transit needs on Federal lands, is provided as a complement to the section on the Federal Lands Highway System, in Appendix E of the 1999 C&P Report.

A large number of Federally-managed sites have the capacity to accommodate more visitors, but are unable to expand their roadway and parking capacity without incurring prohibitive costs or negatively affecting the natural environment. In many cases, transit can serve as a cost-effective method of accommodating additional visitors while preserving the natural environment and providing visitors with a pleasant experience. As more tourists continue to visit Federally-managed sites, additional investments in transit services will be needed to achieve the following goals within these lands and their adjacent communities:

- Relieve traffic congestion and parking shortages.
- Enhance visitor mobility and accessibility.
- Preserve sensitive natural, cultural, and historic resources.
- Provide improved interpretation, education, and visitor information services.
- Reduce pollution.
- Improve economic development activities for gateway communities.

Description of Federal Lands

Federal lands include the National Park Service (NPS), the Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS) and the U.S. Forest Service (USFS). NPS, BLM, and USFWS are administered by the Department of the Interior and the USFS by the Department of Agriculture. The extent of the geographical holdings of each of these Federal land areas and a brief description of some of the existing transit services on each are provided below.

- **National Park Service:** NPS currently manages 379 parks covering more than 81 million acres. There were 287 million recreational visitors to NPS sites in 1999. Transit services have been put in place or are in the process of being developed in the most heavily visited parks, including Grand Canyon, Rocky Mountain, Great Smokey Mountains, Acadia, and Yosemite. Transit also serves much smaller NPS sites without parking facilities, including residences of former public figures such as the Eisenhower farm and the Lyndon B. Johnson ranch. In FY 2001, the NPS and the Federal Highway Administration (FHWA) set aside about $8.4 million from the Federal Lands Highway Program (FLHP) for transit projects, of which $5.1 million went toward 28 planning projects and $3.3 million funded nine implementation projects.

- **Bureau of Land Management:** BLM's holdings constitute one-eighth of the U.S. land area and are located primarily in the western states. There are over 4,500 miles of National Historic, Scenic, or Recreational Trails through BLM lands in addition to multi-use trails. Around 60 million visitors use BLM lands for recreation annually. Some BLM sites are experiencing traffic congestion and parking shortages similar to those at some of the major NPS sites. Particularly severe congestion is occurring in the La Posa Long-Term Visitor Area along the Arizona-California border and its gateway community of Quartzite due to the influx of northern retirees who visit these areas during the winter.

- **U.S. Fish and Wildlife Service:** Although USFWS manages extensive properties—refuges, fish hatcheries, ecological services field stations, and thousands of small wetlands and other special management areas—most of its sites receive relatively few visitors. However, some heavily visited USFWS sites are located on beaches close to major tourist or urban areas. These 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.

- **The U.S. Forest Service:** USFS manages 151 national forests and 20 grasslands with a combined area of 191 million acres. USFS was established to provide quality water and timber for the Nation's benefit, although parts of the areas are open for recreational use. USFS does not monitor transit services on its properties, although municipalities adjacent to USFS areas may provide transit services to and/or through USFS areas. Commercial operators provide transit services at some recreational sites on Forest Service lands. A transit system is being developed on both USFS and NPS lands to serve the Grand Canyon National Park in Arizona, which is adjacent to the Kaibab National Forest.

Funding Sources

The majority of funding for the provision of 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 disburses funds exclusively to Federal Lands Management Agencies (FLMA). In the past, the bulk of FHLP funds have been used primarily 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 FHLP funds, only a very limited amount of funding for transit programs is expected to come from this source in the future.

Transit Needs

Over the past decade, several initiatives were undertaken to examine transit issues on Federal lands. A study mandated by ISTEA reported that over-crowding, traffic congestion, and pollution were affecting the quality of tourism in the more heavily visited National parks. In 1997, a memorandum of understanding was signed by the Secretaries of Transportation and the Interior in which the two Departments agreed to work together to address transportation and resource management issues in and around National parks. Section 3039 of TEA-21 mandated that the Secretaries undertake a comprehensive study of transit needs in National parks and related Federal lands managed by the Interior Department. The resulting study, *Federal Lands Alternative Transportation Systems*, (ATS), was published in August 2001 and identified significant transit needs at sites managed by NPS, BLM, and USFWS.

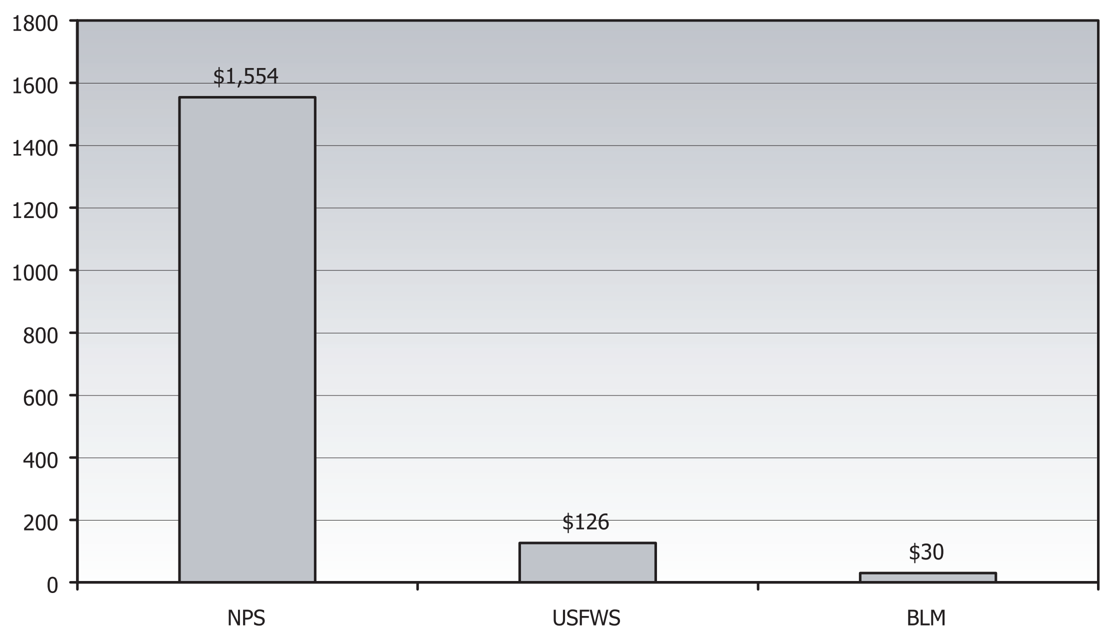
The ATS study evaluated 207 Federal land sites, 85 with extensive field visits and 122 with telephone calls or brief visits. Many of the NPS sites examined by the ATS study would not be easily accessible without transit. These sites include the Boston Harbor Islands National Recreation Area, the Statue of Liberty and Ellis Island, and the USS Arizona Memorial in Hawaii. Transit needs were identified at

118 of 169 NPS sites that were included in the study based on the recommendations of NPS. Needs were also identified at five of the 15 BLM sites visited, and 13 of the 23 USFWS sites. Transit needs include improving or expanding existing transit services and implementing new services. Transit needs were found to be modest and able to be served by a small number of vehicles operating on a seasonal basis in most of the Federal sites that were included in the study.

As shown in Exhibit 27-1, total transit needs for the 20-year period are estimated to be $1.71 billion in 1999 dollars as reported by the ATS study ($1.75 billion in 2000 dollars). NPS will have the largest transit needs, estimated at just under $1,554 million ($1,586 million in 2000 dollars), followed by USFWS with estimated needs of $126 million ($129 million in 2000 dollars), and BLM with $30 million ($31 million in 2000 dollars). Of this amount, $1.3 million will be needed for bus and rail/guideway (a very small percentage for rail/guideway), and $0.2 million for water services. Bus transit is, and will continue to be, the most common form of transit service on Federal lands, although water transportation needs are also expected to be significant. The majority of BLM transit needs will be for waterborne systems. (Note that 1999 dollars were converted to 2000 dollars with the GDP chained price index reported in the Budget of the United States, FY2003.)

Exhibit 27-1

Summary of Transit Needs on Federally Managed Lands 2001-2020 (Millions of 1999 Dollars)



Source: Federal Lands Alternative Transportation Study, Congressional Report, August 2001.

Transit needs were identified by the ATS study in 1999 dollars in two time segments— short-term (2001-2010) and long-term (2011-2020). Of the total 20-year period requirement of $1.71 billion, approximately $678 million, or 40 percent of the total, will be needed between 2001- 2010, and $1.03

billion between 2011-2020. Longer term transit needs are higher than shorter term needs as they include capital-intensive projects requiring long lead times for planning and obtaining funds.

The ATS study developed estimates for project development, vehicle capital costs, other capital costs, and operations and maintenance:

- *Project development costs* include conceptual planning, engineering, design, and environmental evaluation.
- *Vehicle capital costs* are incurred for the purchase of vehicles accounting for the largest percentage of capital cost expenditures.
- *Other capital costs* include capital investments in maintenance and storage facilities, parking areas, docks, piers, administrative facilities, shelters, and waiting areas, as well as the cost of managing construction projects.
- *Operations and maintenance expenditures* include the full range of administrative, operating, and maintenance costs, such as direct labor costs, employee benefits, marketing expenses, insurance, fuel, and parts purchases.

These costs, which are provided in Exhibit 27-2 and reported in 1999 dollars, are disaggregated according to whether they are short-term or long-term and whether they are needed to maintain and expand existing systems or develop new systems. *Total upfront costs are comprised of project development costs, vehicle capital costs, and other capital costs.* These costs combined are estimated to be $724 million and account for 42 percent of total projected costs. *Project development costs* account for five percent of the total 20-year period needs estimate. Over the 20-year period, these costs are estimated to be $90.4 million, $31 million to maintain and expand existing systems and $59 million to develop new systems. *Vehicle capital costs* account for 23 percent of the total needs estimate, at $396 million for the entire period. Vehicle capital costs required to maintain and expand existing systems are estimated to be just over $195 million, and those for developing new systems, just over $200 million. *Other capital costs* make up 14 percent of the total needs requirement, and are estimated to be $237 million over the 20-year period. An estimated $55 million would be required to maintain and expand existing systems and $182 million to put in place new systems. Operating and maintenance costs would be $986 million, or 58 percent of the total needs estimate. Thirty-three percent of these costs, or $322 million, would go toward existing systems, and 67 percent, or $664 million, to new systems. According to the ATS study, it would be possible to charge passenger fares at many sites to recover a portion of operations and maintenance expenditures.

Exhibit 27-2

Potential Transit Needs by Agency, System Status and Type of Expenditure, 2001-2020 (Thousands of 1999 Dollars)

Costs for Existing and Expansion of Existing Systems

Short-Term (2001-2010)	PROJECT DEVELOPMENT	VEHICLE CAPITAL COSTS	OTHER CAPITAL COSTS	TOTAL UPFRONT COSTS	OPERATIONS & MAINTENANCE	TOTAL UPFRONT, OPERATIONS & MAINTENANCE
BLM	$45	$450	$0	$495	$2,419	$2,914
FWS	$980	$2,995	$2,642	$6,617	$8,818	$15,435
NPS	$21,659	$93,298	$42,066	$157,023	$147,647	$304,670
Short-Term total	**$22,684**	**$96,743**	**$44,708**	**$164,135**	**$158,884**	**$323,019**
Long-Term (2010-2020)						
BLM	$22	$450	$0	$472	$2,420	$2,892
FWS	$282	$2,995	$0	$3,277	$8,818	$12,095
NPS	$8,368	$94,973	$10,743	$114,083	$151,896	$265,979
Long-Term Total	**$8,672**	**$98,418**	**$10,743**	**$117,832**	**$163,134**	**$280,966**
2001-2020						
BLM	$67	$900	$0	$967	$4,839	$5,806
FWS	$1,262	$5,990	$2,642	$9,894	$17,636	$27,530
NPS	$30,027	$188,271	$52,809	$271,106	$299,543	$570,649
TOTAL Existing	**$31,356**	**$195,161**	**$55,451**	**$281,967**	**$322,018**	**$603,985**

Costs for New Systems

Short-Term (2001-2010)	PROJECT DEVELOPMENT	VEHICLE CAPITAL COSTS	OTHER CAPITAL COSTS	TOTAL UPFRONT COSTS	OPERATIONS & MAINTENANCE	TOTAL UPFRONT, OPERATIONS & MAINTENANCE
BLM	$430	$1,375	$1,607	$3,412	$9,266	$12,678
FWS	$1,736	$4,665	$5,481	$11,883	$32,061	$43,944
NPS	$14,318	$54,480	$43,517	$112,314	$185,881	$298,195
Short-Term total	**$16,484**	**$60,520**	**$50,605**	**$127,609**	**$227,208**	**$354,817**
Long-Term (2010-2020)						
BLM	$162	$1,475	$50	$1,687	$10,444	$12,131
FWS	$2,208	$9,150	$3,912	$15,270	$39,843	$55,113
NPS	$40,223	$129,240	$127,904	$297,367	$386,456	$683,823
Long-Term Total	**$42,593**	**$139,865**	**$131,866**	**$314,324**	**$436,743**	**$751,067**
2001-2020						
BLM	$592	$2,850	$1,657	$5,099	$19,710	$24,809
FWS	$3,944	$13,815	$9,393	$27,153	$71,904	$99,057
NPS	$54,541	$183,720	$171,421	$409,681	$572,337	$982,018
TOTAL New	**$59,077**	**$200,385**	**$182,471**	**$441,933**	**$663,951**	**$1,105,884**
TOTAL Existing and New	**$90,433**	**$395,546**	**$237,922**	**$723,900**	**$985,969**	**$1,709,869**

Source: Federal Lands Alternative Transportation Study, Congressional Report, August 2001.

Appendices

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 addition of incident delay to the calculations of congestion levels; updating the routines for estimating vehicle emissions costs; and refinements to procedures incorporating travel demand elasticity in the model.

- The **National Bridge Investment Analysis System (NBIAS)** is used for the first time in this report as 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.

- **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. The results in this report reflect revisions in estimated depreciation schedules for rail vehicles, facilities and stations.

Appendix A

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 1999 C&P report, including changes in the travel demand elasticity procedures, congestion routines, emissions cost module, and the benefit cost analysis procedures.

Highway Economic Requirements System (HERS)

HERS 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 5year 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. HERS 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. HERS 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. 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 was cited in a June 2000 report by the United States General Accounting 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 Highway Performance Monitoring System (HPMS). In order to fully recognize all network effects it would be necessary to develop significant new data sources and analytical techniques.

High Cost Capacity Improvements

For each highway section in the HPMS, States code a Widening Feasibility rating. The investment requirements analysis in versions of the C&P prior to the 1999 report treated this rating as a measure of the number of lanes that could be added at "normal" cost. It was assumed that if additional lanes were justified, they could be added at "high" cost, representing the cost required to double-deck a freeway, acquire especially expensive right-of-way, or build a parallel highway or other transportation facility. When HERS was developed, a procedure for adding capacity on sections coded as infeasible to widen was built into the model as an optional setting. For technical reasons at the time, this feature was turned off in HERS for the baseline runs made for the 1999 report, thereby assuming that highway sections could not be widened beyond the width specified as feasible by the States. Instead, new roads and bridges were treated as non-modeled spending, and their current share of highway capital outlays was added to the HERS results through the external adjustment procedures.

Subsequent improvements to HERS since the 1999 C&P have made the high cost capacity improvements feature more tenable for investment analysis, so this feature was turned on for the HERS runs made in this report. However, since much of the investment in new roads and bridges occurs in corridors parallel to existing routes, such capacity expansion is now considered to be captured by the improvements modeled in HERS, and external adjustments are no longer made for new highway facility expenditures when estimating future investment requirements.

Allocating HERS and NBIAS Results Across 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. HERS 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 benefit/cost ratio 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.

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.

Q. What are some examples of the types of behavior that the travel demand elasticity features in 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 trips 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 further in a shorter period of time.

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.

Changes in HERS Elasticity Procedures

The travel demand elasticity values used in this report are lower than the values used in the 1997 C&P report. The reason for this change is that the HERS elasticity procedures have been adjusted to directly account for some traveler responses to changes in user costs that were previously implicit in the higher elasticity values. These adjustments include:

- Divisibility. Some components of user costs are vehicle-specific and can be shared among vehicle occupants (such as fuel costs), while others are person-specific (such as travel time costs) and cannot be divided. If divisible costs were to increase, highway users could react by increasing their average vehicle occupancy rates, thereby dampening the effect of the cost increase on VMT. The elasticity procedures now reflect this effect.

- Section Length. The HPMS sample sections used in the analysis vary in their length, and the HERS calculations now take the length of each section into account in the elasticity routines. A given section of road will generally be used for only a portion of a vehicle trip. Thus, a change in user costs on a particular section will have a less-than-proportional effect on the overall cost of the trip. Changes in user costs on a particular segment would then in turn be expected to have a smaller impact on travel on that segment than would a more universal change in user costs (such as an increase in area-wide fuel costs). In general, travel on longer sample segments should represent a larger share of the total trip cost for vehicles using the segment, so the adjustment to elasticity now takes section length into account when calculating the effect of user cost changes on travel.

- Route Diversion. The magnitude of an elasticity value is greater if there are many close substitutes. In the case of highway segments, parallel and connecting routes may provide a reasonable substitute if user costs (e.g., congestion) increase on a segment, and some traffic may be diverted onto these alternate routes. Since route diversion is likely to be a better substitute to highway users than forgoing a trip entirely, the appropriate elasticity value will be higher if it includes route diversion. Since route diversion is now being modeled separately within HERS, the elasticity value used in the calculations has been adjusted downward.

The particular values of elasticity used in this report are within the ranges of the available literature on this subject, and are intended to reflect that a change in highway user costs will have both short term and long term impacts on travel demand. For short term elasticity (the impact occurring within 1 or 2 years), HERS now uses a value of -0.6. An additional elasticity value of -0.4 is used for the share of the additional long term adjustment that takes place within the 5-year funding period (and in subsequent periods).

HERS Congestion Analysis

The HERS analysis of traffic congestion on each segment has undergone a number of modifications to bring it up to date with the latest research in highway traffic engineering. Some of these changes have been linked to changes in the HPMS database used in the analysis. The estimation of travel delay in

HERS is now made for three different types of delay: routine congestion delay, zero-volume delay, and incident delay.

Congestion Delay

The HPMS now also includes data on the number of lanes in the peak direction during peak travel periods. This has permitted HERS to be modified to calculate capacity and congestion delay separately for three periods: peak period/peak direction, peak period/counter-peak direction, and the off-peak period. The result is a more refined estimate of total congestion delay on each segment.

Zero-Volume Delay

The HERS procedures for calculating the delay associated with traffic signals and stop signs have also been updated. This delay is now referred to as “zero-volume delay”, since it would occur for each user even if there were no other vehicles on the road. It is now calculated separately as a component of total delay.

Incident Delay

One of the major changes to HERS highlighted within the report is the inclusion of estimates for delay due to traffic incidents. This type of non-recurring delay has not been previously considered by HERS or its predecessors when calculating highway user costs, and as such represents a new area of modeled user benefits that may be affected by changing traffic conditions and highway improvements. HERS calculates the projected incident delay as a function of roadway characteristics. When translating incident delay into travel time costs, the revised model also allows it to be valued at a user-specified premium over routine travel time, reflecting the greater disutility that highway users face when dealing with unanticipated delays (See Chapter 10).

Operations Strategies

The new congestion equations in HERS also allow highway operations strategies (such as intelligent transportation systems [ITS]) to have an impact on the estimates of delay. The investment requirements projections made for this report incorporated impacts from two such strategies into the calculations: advanced traffic signal control and incident management. The model currently considers only existing deployments of these two technologies. Future modifications to HERS will increase the range of operations impacts that it considers, including both currently implemented strategies and projections of future technology deployments.

HERS Emissions Cost Estimates

HERS includes changes in estimated costs associated with air pollutant emissions from motor vehicles among the benefits (or disbenefits) resulting from improvements to sample highway sections. The costs resulting from emissions of each air pollutant are the product of the rate (in tons per vehicle-mile) at which it is emitted by the mix of vehicles typically using sections of each type, and the estimated cost of damages to human health and property caused by each ton. For some types of vehicle emissions, these impacts are directly observed, while other emission types (which serve as precursors to other air pollutants) may have an indirect effect on the environment. In either case, the costs (measured in dollars per vehicle-mile) for each individual pollutant can be calculated and summed to determine the total cost of air pollutant damages caused per vehicle-mile of travel on each section type.

As part of the revisions to HERS made in preparation for this report, the emission rates for each pollutant emitted by motor vehicles were updated to reflect newly available data on the mix of vehicles typically using different classes of highways. The rates used in HERS were also affected by recent changes to EPA models used to estimate emission rates for different types of motor vehicles operating at various speeds. HERS' previous estimates of damage costs for different pollutants were adjusted only to account for price inflation; a comprehensive overhaul of pollution damage costs is planned as part of future model updates.

The first step in this process was to update the distribution of travel among seven vehicle classes for each of the nine highway section types used by HERS. These data were tabulated from estimates of the distribution of VMT among 13 vehicle classes and 12 roadway functional classes, derived from 1999 HPMS data (previous versions of HERS used vehicle distributions based on 1982 data). The 13 vehicle classes employed in the HPMS were consolidated into the seven HERS vehicle classes by comparing and matching as closely as possible the weight limits, vehicle body styles, and wheel configurations used to define individual vehicle classes in HPMS and HERS. The 12 functional classes used in HPMS were consolidated to the nine highway section types employed in HERS by discarding data for the lowest-order functional classes (which are not analyzed in HERS) and grouping the remaining functional classes.

At the same time, the 13 vehicle classes in the HPMS data were mapped into the 16 vehicle classes employed by the Environmental Protection Agency's recently-released MOBILE6 vehicle emission factor model, which estimates emission rates for gaseous air pollutants. Finally, the 13 HPMS vehicle classes were also consolidated further to the 12 vehicle classes employed by EPA's PART5 emissions factor model, which is used to analyze emissions of particulate air pollutants from motor vehicles. This was again accomplished by matching as closely as possible the weight limits and vehicle characteristics used to define vehicle classes in HPMS with those employed by the MOBILE6 and PART5 emission factor models. This process resulted in a detailed correspondence of vehicle classes among the underlying HPMS data on vehicle-miles of travel, the MOBILE6 and PART5 emission factor models, and the distribution of vehicle travel on each HERS highway section type.

Next, MOBILE6 was used to compute emission rates for carbon monoxide (CO), volatile organic compounds (VOC), and nitrogen oxides (NOx) by each of its 16 vehicle classes. Emission rates for these pollutants were computed at 5-mph increments at speeds ranging from 5 mph to 70 mph, and values for 1-mph increments were interpolated using the procedure recommended in guidance documents prepared by EPA for use of the model. The PART5 model was subsequently used to compute emission rates per vehicle-mile of travel for sulfur dioxide (SO_2) and particulate matter of varying sizes (PM2.5 and PM10) by each vehicle type; these rates are estimated by PART5 to be independent of vehicle speed.

Using the previously-developed correspondence among the vehicle classes used by HERS, MOBILE6, and PART5 (derived from their common linkage to the vehicle classes employed in the underlying HPMS data on VMT), the emission rates for individual vehicle classes were combined to produce composite emission rates of each pollutant for the nine HERS section types. Each of these composite emission rates is the weighted average emissions per VMT of a single pollutant caused by the mix of vehicle classes operating on one of the nine highway types employed by HERS. As indicated previously, emission rates for CO, VOC, and NOx vary according to the average speed of travel, while those for other pollutants do not. Composite emission rates for the same pollutant and average speed differ among HERS' nine section types because the mix of vehicle classes typically operating on each section type differs, reflecting their different locations (urban vs. rural) and functions in the highway system (freeway, arterial, or collector).

Finally, emissions per mile of each pollutant occurring at each speed were weighted by the estimated average cost of damages to human health and property caused by each pollutant. These estimated damage costs are the same as those used in the previous version of HERS, updated to reflect current prices; as with the previous version of HERS, damage costs for localized pollutants are scaled upward to reflect the higher population exposure to emissions likely to occur in urban areas. The resulting damage costs for each pollutant are then summed to determine total air pollutant damage costs per VMT at each speed on each of the nine HERS section types. Again, these costs vary among individual section types even for the same average speed of travel because the mix of vehicle classes typically operating on each section type is different.

Because air pollutant damage costs differ depending on the average speed of travel, improvements to a sample highway section that increase average speed (those that increase its effective capacity) can change damage costs per vehicle-mile. Starting at low speeds, increasing speeds typically reduce air pollutant emission rates and thus damage costs up to a speed in the 40-50 mph range, after which emission rates for some pollutants and thus damage costs from all pollutants combined increase fairly rapidly.

Total air pollution damage costs with the improvement in place are the product of the per-mile damage cost associated with the (higher) average speed on the improved section and annual VMT achieved after the improvement is made. Depending on how this total compares to air pollution costs without the improvement in place, changes in air pollution damage costs from improving a HERS sample section can represent an additional benefit of the improvement or a reduction in benefits.

HERS Benefit Cost Analysis

Two key modifications have been made to the structure of the benefit cost analysis that HERS performs when considering potential improvements, involving the length of the benefit cost analysis (BCA) period and the calculation of benefits accruing outside of the analysis period.

BCA Period Length

In previous versions of HERS, the initial screening of potentially cost beneficial improvements (in which each improvement was compared to a "do nothing" base case) was based on a 5-year BCA period. The length of subsequent comparisons among improvements was based on the expected lifetime of the less-aggressive improvement. In the updated version of HERS used for the analyses in this report, all benefit cost calculations are made on the basis of a 20-year analysis period.

One implication of the change in the analysis period length is that the calculated benefit cost ratios for some improvements may be much higher than would be estimated by earlier versions of the model. The reason for this is that the "do nothing" base case against which improvements are initially compared is much less tenable over a 20-year period than over a 5-year period (see sidebar), due to the increased pavement deterioration and traffic congestion that would occur over the longer period, resulting in a larger relative benefit from improving the roadway.

Q. What would the "do nothing" base case for benefit cost analysis used in HERS look like?

A. To illustrate what would happen if no improvements were made over the entire length of the 20-year analysis period considered by HERS, the model was run with funding constrained at the minimum possible level ($1 million per funding period). The results of this "doomsday scenario" showed average pavement roughness increasing by over 300 percent, travel time costs increasing by over 160 percent, and total user costs more than doubling. Average highway speeds would drop from 42 to 16 miles per hour, and highway use would be so deterred that VMT would decline by 25 percent.

Remaining Service Life

A complete analysis of the benefits and costs of an improvement must include a measure of the remaining value of the improvement at the end of the analysis period. In previous version of HERS, the calculation of this "residual value" was based on the future costs of bringing a highway section up to the level of condition and performance that it would have attained had the improvement been implemented at an earlier time. For this version of the model, this calculation has been replaced with a simplified concept based on the remaining service life of the improvement at the end of the analysis period. The residual value is simply calculated as a "rebate" of a portion of the project's costs, based on the ratio of the remaining service life to the total service life of the improvement.

Appendix B

Bridge Investment/Performance Methodology

This appendix contains a technical description of the methods used to predict future nationwide bridge conditions and investment requirements. It primarily describes the National Bridge Investment Analysis System (NBIAS), the latest and most comprehensive bridge model used by the Federal Highway Administration (FHWA).

NBIAS is the successor to the Bridge Needs and Investment Process model (BNIP), developed by FHWA in 1991. It incorporates analytical methods from the Pontis Bridge Management System model (Pontis), developed by the American Association of State Highway and Transportation Officials (AASHTO) in 1989 and licensed by AASHTO to over 45 Ssstate transportation departments.

Overview of the Model

NBIAS users can construct a variety of scenarios that simulate nationwide bridge needs and investments. These scenarios can examine bridge repair, rehabilitation, and improvement needs, in dollars and number of bridges; the distribution of work done, in dollars and number of bridges; and aggregate and user benefits, and the benefit/cost ratio, for performed work. Outcomes can be presented several ways, including by the type of work, functional class, and whether the bridges are part of the National Highway System (NHS).

NBIAS starts with the National Bridge Inventory (NBI) database. To estimate improvement needs, it applies a set of improvement standards and costs that can be modified by the user. To measure preservation needs, NBIAS uses a Markov modeling, optimization, and simulation approach, along with default cost and deterioration models derived from Pontis. Because this approach relies on having element-level condition data, NBIAS applies a series of stochastic models to the NBI information to generate synthesized element condition data. Then, deterioration models are applied to estimate changes in element data over time, and an optimal preservation policy is developed and applied to the bridge stock.

NBIAS Structure

NBIAS is comprised of two distinct modules:

- The Analytical Module allows the user to create a database from NBI files, specify technical parameters, and define a budget scenario for analysis.

- The "What If" Analysis Module provides interactive screens, displaying the outcomes for a selected scenario.

The Analytical Module creates budget scenarios based on user-defined parameters for needs and costs. The budget scenarios are based on four distinct components:

- The module generates improvement needs for widening, raising, and strengthening bridges.

- A bridge replacement need is recognized when one of three conditions are met: (1) when a bridge has an improvement need that is considered infeasible for the structure's design type; (2) when a bridge has multiple improvement needs; or (3) when the benefit/cost ratio for replacement is greater than that for improvement.

- Based on the NBI description of each structure, NBIAS creates a statistical model that assigns a typical assortment of elementary components to the bridge. These elements include specific deck types, railings, girders, and piers. The total quantity of each element that is likely to be present on a given bridge is estimated, as well as the condition state distribution of the element. In the database, this element-level data is stored in an aggregated form. Totals are accumulated for each stratum of the bridge stock.

- The database retains much of the auxiliary input data that was used to generate improvement needs for both individual structures and element quantities and condition states by stratum.

The scenario approach allows NBIAS users to see how variations in assumptions affect estimates of future needs and expenditure patterns. Each scenario produces results in the form of a set of measures of effectiveness that result from an assumed budget. Alternatively, the user may create a benefit/cost cutoff scenario, which results in a set of measures of effectiveness that result from an assumed minimum benefit/cost ratio. The measures of effectiveness are quantitative indicators of the outcome of a simulation of needs and investments over time. The following types of measures of effectiveness are produced:

- Bridge repair, rehabilitation, and improvement needs, in terms of dollars and numbers of bridges;
- The distribution of work done, in terms of dollars and number of bridges;
- The benefits of work done (total and user); and
- The benefit/cost ratio for work done, weighted by project costs.

Separate indicators are included for different types of needs (local maintenance, federally-eligible repair and rehabilitation, and federally-eligible widening, strengthening, raising, and replacement projects).

NBIAS and Earlier Models

NBIAS retains several general capabilities from BNIP—the ability to rely on the NBI for all bridge level output, to forecast over 20 years for multiple funding periods, and to analyze different budget scenarios; however, the main analytical concepts of the NBIAS methodology are inherited from Pontis. Bridges, for example, are considered to be collections of elements. On a particular bridge, elements are characterized by their quantities and their fractional distribution across a number of discrete condition states corresponding to the degradation levels.

Although NBIAS inherits its analytical approach from Pontis, the functional implementation of the two systems is very different. NBIAS does not perform a bridge-by-bridge analysis of preservation needs, and although it does examine decomposition of the bridge stock, its object of analysis is the entire national bridge network. NBIAS generates its output not through bridge-level projects, but through quantitative indicators that demonstrate the impact of policy and budgeting decisions on multiple measures of effectiveness obtained for the entire bridge network.

Compared to Pontis, NBIAS has some input limitations. While Pontis works with databases of individual states that contain both bridge and element-level data, NBIAS is limited in its input to the NBI, the standard database of bridge-level data institutionalized on the federal level. To overcome this limitation, NBIAS relies on a set of Synthesis-Quantity-Condition (SQC) stochastic models that synthesize and quantify the element condition data using information contained in the NBI.

One area where NBIAS is far more advanced than Pontis is its user interface and the ability to support the "What If" analysis in a true interactive mode.   All simulation results are calculated in a separate storage area, so very few calculations are performed during the interactive phase. Furthermore, BIAS adds consideration of user costs to the preservation models, an important factor not explicitly considered in Pontis.

Planned Modifications to NBIAS

A basic characteristic of NBIAS is that it models preservation needs at an aggregate level. This approach was adopted when NBIAS was developed in 1994, primarily due to limits in computer memory. The SQC models in NBIAS, in their current form, provide reliable aggregate estimates, but they are not suitable for predicting which elements are on a particular structure.

Work is currently underway to incorporate full individual bridge analysis into NBIAS.   This involves modifying the NBIAS infrastructure to accommodate data on individual bridges and optimizing analytical procedures in NBIAS to take advantage of the additional information provided by a bridge-by-bridge analysis.

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 assets 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 growth in transit use.

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 (2020) that is the same as the asset condition that existed at the beginning of the period (2000). The model does not necessarily maintain the weighted-average condition of the assets in each year over the 20-year period because replacements and rehabilitations are only made when the condition of assets falls below industry standards. These minimum condition levels vary according to asset type. With TERM, the average condition of the asset base improves during the initial year of investment and then fluctuates between this improved level and the initial condition level, which is reached at the end of the 20-year period.

- **Maintain Performance**

  The Maintain Performance scenario assumes that passenger miles traveled (PMT) increase over time at the same rate as a weighted-average of transit PMT projections by Metropolitan Planning Organizations (MPOs). Based on a sample of PMT forecasts available from the Nation's 33 largest metropolitan areas, passenger miles are assumed to increase at an average annual rate of 1.6 percent between 2001 and 2020. TERM adds assets at a rate necessary to accommodate the increase in PMTs to achieve the base year (2000) level of average vehicle utilization and average vehicle speed at the end of the 20-year period (2020).

- **Improve Conditions**

  In the Improve Conditions scenario, transit asset rehabilitation and replacement is accelerated in order to improve the average condition of each asset type in the existing asset base to at least a level 4, or "good" level, by 2020. Assets are replaced at a higher level of condition 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 trending down gradually with year-to-year variations to a "good" condition level by 2020.

- **Improve Performance**

  The Improve Performance scenario simulates capital investments that increase average vehicle speeds and lower average vehicle occupancy to threshold levels by the end of the 20-year period (2020). 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 by transit operators in urbanized areas with populations over 500,000 and with average operating speeds below a specified minimum threshold. This minimum 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 investments until each of the operators in these urbanized areas has an average transit speed at or above this minimum threshold. To lower the nationwide vehicle occupancy rate, TERM makes investments by agency and by specific mode (e.g., articulated buses) 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.

Description of Model

TERM is comprised of four distinct modules:

- Asset Rehabilitation and Replacement Module
  - Reinvests in existing assets to improve their physical condition.

- Asset Expansion
  - Invests in new assets to maintain operating performance to meet projected increases in transit use.

- Performance Enhancement
  - Invests in new assets to improve operating performance as measured by speed and capacity utilization.

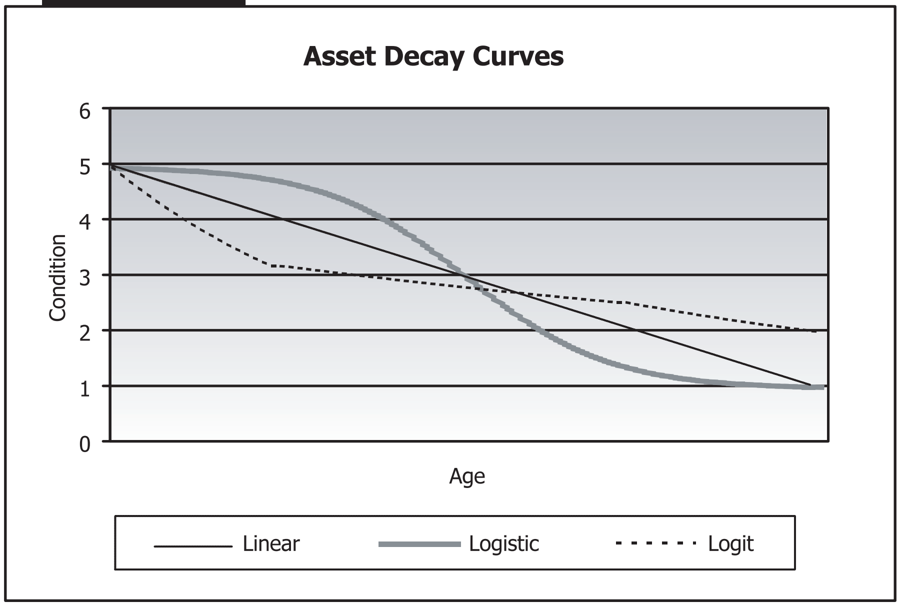
- Benefit-Cost Tests
  - Only investments with a cost-benefit ratio greater than 1.0 are included in TERM's estimate of investment requirements. This process roughly corresponds to the "Maximum Economic Investment" concept in BIAS.

Asset Rehabilitation and Replacement Module

The Asset Rehabilitation and Replacement Module uses statistically determined decay curves to simulate the deterioration of transit vehicles, facilities, and other infrastructure components. As the assets deteriorate, their condition declines, requiring investments in rehabilitation and replacement.

The vehicle, maintenance facility, and station decay curves are based on data collected by the Federal Transit Authority (FTA) through engineering surveys performed between 1999 and 2001. The surveys found that these assets depreciate rapidly in early years, followed by slower decay for an extended period, and with a sharp decline in asset condition towards 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 a "logit" function, differ significantly from the decay curves that continue to be used for other asset types. National Transit Database (NTD) data are applied to these "logit" decay curves to estimate conditions, which are subsequently used to estimate rehabilitation and replacement costs. Decay curves for commuter rail vehicles, for which no condition surveys were undertaken, continue to follow the same decay pattern as the remaining transit assets as discussed in the next paragraph.

Exhibit C-1



The decay curves for other non-vehicle infrastructure—guideways, systems, and stations—are "logistic." 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. Data applied to these decay curves were collected by FTA with a special survey in 1995. Transit operators were asked to list all their assets in operation as well as the type, age, purchase price, and—when available—the quantity of each. This information has been inflated to a 2000-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 year of construction.

Starting with the 1999 Report, TERM has been able to consider varying replacement scenarios for each of the five major asset categories. Each asset type is assigned a target condition level on the basis of the same 1 to 5 rating used to determine condition. 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 Rating "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 2000) available from the 33 largest MPOs. 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 of the FTA region in which that metropolitan area is located. For New York, a simple average of the forecasts from all reporting east coast metropolitan areas was used, since The New York Metropolitan Transportation Council does not forecast transit travel growth. The weighted-average transit PMT growth rate calculated from the MPO forecasts and used in TERM was 1.6 percent. Passenger travel forecasts for individual urbanized areas range from an average annual rate of -0.05 percent in Philadelphia to 3.56 percent in Los Angeles.

Performance Enhancement Module

The Performance Enhancement Module simulates investments that "Improve Performance" either by increasing the average transit operating speed or reducing the average vehicle occupancy rate. Investment is shifted from bus to rail infrastructure in urbanized areas with average operating speeds below the national average and additional infrastructure is purchased for areas and modes with vehicle utilization rates (occupancy) 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 are comprised of 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 are also evaluated by agency and by mode, but investments to increase operating speeds are evaluated on urbanized area basis rather than on an agency and modal basis to take into account the shift from bus to rail investments. TERM calculates and compares for each mode in each agency, or in the case of speed improvements for each urbanized area, the discounted stream of capital investment and operating and maintenance expenditures combined with the discounted stream of anticipated benefits accruing from the particular type of transit service investment being evaluated during a 20-year period. If the benefit cost ratio is greater than 1.0, i.e., the discounted stream of benefits exceeds the discounted stream of costs, the model's estimate of the capital investment is included in the overall national investment needs estimate. If the benefit-cost ratio is less than 1.0, the investment is excluded.

The Benefit-Cost module identifies three categories of benefits:

- Transportation System User Benefits
  - Travel-time savings, reduced highway congestion and delay, and reduced automobile costs (parking costs and taxi expenditures).

- Social Benefits
  - Reduced air and noise emissions, roadway wear, and transportation system administration.

- Transit Agency Benefits
  - Increased revenues from increases in ridership and reductions in operating and maintenance costs.

Whenever possible, the total level of benefits associated with each investment type is modeled on a per-transit PMT or per-auto VMT basis. Most of the benefits from transit investment are estimated by TERM to be "Transportation System User Benefits" and accrue to both new and existing passengers under both the Asset Expansion and the Performance Enhancement modules. Transit agency benefits—increased fare revenues and 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 does not incorporate demand or supply demand elasticities. On the demand side, TERM does not analyze how changes in transit service improvements will affect future ridership growth, i.e., the demand for transit. On the supply side, TERM does not take account the cost interactions between concurrent transit investments in the same urbanized area or between current and future investments.

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 the total number of vehicles in each vehicle category by an estimated average vehicle purchase price based on information reported to FTA by transit operators for vehicle purchases made between 1998 to 2000. (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. 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 3.5 percent over the 20-year projection period. As discussed in Chapter 7, 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, but is believed to be sufficient since the populations of rural areas are declining. Between 1990 and 2000, the population in areas with less than 50,000 inhabitants decreased by 3.4 percent.

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.