1999 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance

Report to Congress



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

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

May 2, 2000

The Honorable Albert Gore, Jr.
President of the Senate
Washington, D.C. 20510

Dear Mr. President:

The enclosed report to Congress entitled Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report is submitted in accordance with the requirements of Section 502(g) of 23 United States Code (U.S.C.) and Section 308(e) of 49 U.S.C., for the highway and transit portions, respectively. This report also incorporates as Appendix A, the Interstate Needs Study required by Section 1107(c) of the Transportation Equity Act for the 21st Century. The analyses contain condition, performance, and investment information on the Nation's highway, bridge, and transit systems.

This report provides the Congress with an objective appraisal of highway, bridge, and transit physical conditions, operational performance, finance, and future investment requirements. It highlights the need to maintain our commitment to infrastructure investment to keep our highway and transit systems functioning effectively. Recognizing the close relationship between an efficient transportation system and economic productivity, this Administration has increased our emphasis on maintaining and improving our transportation infrastructure over the past several years. In light of the Nation's growing transportation needs, the Department has moved aggressively to find ways to stretch the Federal dollar. These include streamlining Federal programs, using innovative financing techniques to attract private investment to transportation, and adopting new technologies.

The unique contribution of this report is its analysis of future national investment requirements to meet the anticipated demand in both highway travel and transit ridership. An average annual highway capital investment by all units of government over the next 20 years of $56.6 billion could maintain the 1997 physical conditions and make worthwhile expansion and enhancement improvements. To make all beneficial highway improvements would require an average annual investment of $94.0 billion. The average annual investment required to maintain the same physical conditions and operating performance of our Nation's transit systems is $10.8 billion. The average annual cost to improve transit conditions and performance is estimated to be $16.0 billion.

The physical condition of our Nation's highway system continues to improve, while congestion, particularly in the largest urban areas, is still a concern. The condition of the urban bus fleet remains adequate, while the condition of the heavy rail fleet has declined.

All levels of government spent $101.3 billion for highways and bridges in 1997, an 8.4 percent increase over 1995. Of this total, $48.7 billion was for capital improvements. Governments also spent $25.1 billion for transit, of which $7.6 billion was for capital improvements.

In keeping with the principles of the Transportation Equity Act for the 21st Century, this report is evidence of the Department's commitment to an intermodal view of the Nation's transportation system. Combining information about our highways, bridges, and transit provides decision makers with a valuable intermodal perspective as we seek to make the best use of each mode in satisfying our Nation's growing transport requirements. We look forward to continuing the intermodal perspective in this report series so that the Department can provide the breadth of information needed to deal with our ever increasing and complex transportation requirements.

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

Sincerely,

Rodney E. Slater

Enclosure

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INTRODUCTION

This is the fourth in a series of combined biennial documents prepared by the Department of Transportation which 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 in 1999 by Section 502(g) of Title 23 United States Code (U.S.C.), as well as transit system information required in 2000 by Section 308(e) of Title 49 U.S.C. This edition also includes the results of a study on Interstate Needs required by Section 1107(c) of the Transportation Equity Act for the 21st Century (TEA-21).

Beginning in 1993, the Department combined two existing report series that covered highways and transit separately to form this report series. Prior to this, eleven 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.

Report Purpose

This document is intended to provide Congress and other decision makers with an objective appraisal of highway, bridge and transit finance, physical conditions, operational performance, and future investment requirements. This report offers a comprehensive, factual background to support 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 these underlying data are available through the Department's regular statistical publications. The future investment requirements analyses are developed specifically for this document and provide national level projections only. The Department does not project future investment requirements for individual States or localities.

Report Changes

Section 5102 of TEA-21 designated the highway and bridge portion of this document as the "Infrastructure Investment Needs Report," and required several changes in the content.
This edition of the report has responded to these requirements by adding estimates of the current backlog of cost-beneficial highway and bridge projects, and adding a table to each chapter that

directly compares the key statistics from the current report with those from the 1997 edition. An investment requirements scenario showing the costs of maintaining the physical conditions of the highway system has been added, to improve comparability of this report to the 1993 and 1995 versions and to the bridge and transit investment requirements scenarios.

Highlights of the Report

The ***1999 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance*** report to Congress continues in the tradition of this series, providing the American people with an important national perspective on the physical and operating characteristics of the highway, bridge, and transit portions of our Nation's intermodal transportation system. The Report draws together information on multiple aspects of the systems, which not only describes the systems but also provides indicators of their performance and contribution to our vital national interests and quality of life. Further, it characterizes the financial resources applied to these systems to date and the future investments necessary if they are to perform as designed and complement other national efforts to improve productivity.

Strikingly obvious is the immense scale of these systems: the extent to which the facilities themselves stretch across the Nation, representing the net result of technology and financial investments made over the past century; the sheer magnitude of the demands placed on these systems by a people for whom mobility is basic to their existence; the transportation services provided every day, around the clock; and the collective commitment necessary to maximize the benefits of these assets. The picture that comes through reflects achievements reached and goals still being strived for.

Key findings of the report include:

- Although most of our citizens are highly mobile, the findings of the latest National Personal Transportation Survey (NPTS) show there are disparities in transportation system usage among groups within our society. This indicates that significant barriers to mobility persist for people with disabilities, the elderly, low-income households, recent immigrants, and people of color.
- The priority of safety is reflected in the inclusion of safety statistics in the report as an indicator of system performance. The reduction in the fatality rate from 25.9 per 100,000 population in 1966 to 15.7 per 100,000 population in 1997 in an environment where licensed drivers grew by nearly 80 percent and automobile travel has grown by 177 percent is impressive. However, with 42,013 deaths and 3.35 million injuries in 1997, and rates per 100 million vehicle miles traveled (VMT) of 1.6 deaths and 131 injuries, significant opportunities for improvement remain.
- The balance among jurisdictional ownership, functional class, and location of highways and bridges has been relatively stable, with public road mileage overwhelmingly local and rural. With VMT increasing on every functional system, usage trends reinforce the dominance of travel in urban areas. Interestingly, from 1995 to 1997, rural highway VMT growth outpaced urban highway VMT growth at 7.2 percent as opposed to 4.1 percent in contrast to the 10-year trend in favor of urban travel growth.
- Transit system route mileage shows a 10-year increase of 44.2 percent in rail service and 10.4 percent in non-rail service. Service capacity, measured in bus-equivalent vehicle revenue miles, increased 22.4 percent for rail, while non-rail capacity increased 17.1 percent over the period. After declining slightly between 1987 and 1993, passenger travel on public transit

showed renewed growth between 1993 and 1997, as rail passenger miles increased by 18.3 percent and non-rail passenger miles increased 3.8 percent. In 1997, rail transit accounted for nearly 53 percent of passenger miles while providing 50 percent of vehicle capacity operating on just 5 percent of the Nation's transit route miles.

- Overall, highway system conditions as measured by pavement condition, ride quality, alignment adequacy, and bridge ratings are improving although they fluctuate by location and functional class. The estimated average condition of the urban bus fleet is adequate, and has been relatively constant for the last decade. Rail vehicle conditions have declined since 1987, due primarily to the deterioration of the Nation's heavy rail fleet. The condition of other rail capital assets has improved since the mid-1980s, reflecting the rehabilitation and replacement of these assets and the investments in new rail systems and extensions.
- Capturing the quality of operational performance, as represented by various measures of traffic congestion, is very difficult. However, there is a strong recognition of the significance of congestion to transport safety, cost, and time as the reliability of the system decays. Measures of congestion differ in whether congestion is getting better, worse, or is continuing about the same. Measures of travel density clearly show increasing density, in travel per lane mile. However, the effect of this increase in density is less clear. A traditional measure of congestion, the volume/capacity ratio during the peak hour has remained at about the same value in urban areas for the past decade. Delay per vehicle mile of travel, which was added to the report this year, is intended to capture the effects of congestion throughout the day. This measure is available only for the past 4 years. Over these past 4 years, overall urban delay per VMT has increased. However, for the past 2 years, this measure has decreased. Whether this 2-year track is the beginning of a trend remains to be seen. More work is needed to develop a useful metric of congestion that will be consistent, credible, and feasible to collect.

Public investment in surface transport is at its highest level ever. All units of government, including Federal, State and local jurisdictions, share the responsibility of developing and maintaining our transportation systems. The private sector is also involved in certain toll roads and transit systems.

- All levels of government spent $101.3 billion for highways and bridges in 1997, an 8.4 percent increase over 1995. Of this total $48.7 billion was for capital improvements, a 10.2 percent increase. The Federal government contributed 41.1 percent of the capital outlay, down from 44.5 percent in 1995.
- All levels of government spent $25.1 billion for transit, a 5.5 percent increase over 1995. Of this total $7.6 billion was for capital improvements, an increase of 8.6 percent. Fares and other system generated revenues were 33 percent of total revenues. In 1997, contributions from the Federal government accounted for 54 percent of transit capital expenditures, 27 percent of public funding for transit, and 18 percent of total system revenues. Each of these percentages represented a slight increase in the federal share relative to 1995.

The unique contribution of this report is its analysis of future national investment requirements to meet the anticipated demands in both highway travel and transit ridership. The analysis focuses on two sets of investment requirement scenarios, and identifies the impacts of investment levels on various system performance benchmarks. These projections are developed using economics-based analysis tools described in detail for highways, transit, and bridges.

- If average annual capital investment on highways and bridges by all levels of government for the next 20 years reaches $56.6 billion in 1997 dollars, it is projected that the physical conditions of highways and bridges would be maintained. This level of investment would not maintain the same level of operational performance. This estimate includes a mix of preservation, expansion, and enhancement improvements intended to attain the highest possible level of benefits for highway-users, while achieving the goal of maintaining pavement and bridge conditions. An additional $3.5 billion would be required annually to maintain user costs at the current level. Maintaining travel times at current levels would require an additional $17.1 billion. To accomplish all beneficial improvements to the highway and bridge systems is estimated to take an average annual investment of $94.0 billion.
- The estimated average annual investment required to maintain the same physical conditions and operating performance of our Nation's transit systems as in 1997, by replacing and rehabilitating deteriorated assets and expanding capacity to accommodate expected transit passenger travel growth, is $10.8 billion. The cost to improve conditions and performance is estimated to be $16.0 billion.
- Capital spending on highways and bridges would need to rise 16.3 percent above 1997 levels to reach the $56.6 billion projected as the "Cost to Maintain" the physical conditions of highways and bridges. Over the life of TEA-21, this difference is expected to decline to 5.7 percent. Capital spending on transit would need to increase 41.0 percent to reach the $10.8 billion projected as the "Cost to Maintain" transit systems. This difference is expected to decline to 12.9 percent over the life of TEA-21. To reach the level of the investment requirements to "improve" the systems would require an increase in capital spending of 92.9 percent for highways and bridges and 110.2 percent for transit.
- If average annual highway investment remains at 1997 level in constant dollars over the next 20 years, urban VMT would be expected to grow at an average annual rate between 1.78 and 1.83 percent. Rural VMT would be expected to grow at an average annual rate of between 2.68 and 2.72 percent. Travel growth for urbanized areas over one million population would be expected to grow at an average annual rate of between 1.66 and 1.70 percent. Increased investment would be expected to result in higher travel growth rates. These projections recognize that if additional highway capacity is provided, more travel is expected to occur than if the capacity additions are not provided. If congestion on a facility increases, some travelers will respond by shifting to alternate modes or routes, or will forgo some trips entirely. In the long term, increased congestion may lead to changes in lifestyles and industrial practices. Such adjustments will affect the productivity and economy of the Nation.

Report Organization

In this edition, the four major sections contained in previous versions of the report have been divided into ten smaller chapters, each of which focuses on a narrower topic area. Most chapters begin with a combined summary of highway and transit issues, followed by separate sections discussing highways and transit in more detail. This structure is intended to accommodate report users who may only be interested in one of the two modes. Information that relates to only one of the two modes represented in this report is included in appendices.

- The Executive Summary contains one page of highlights each on the highway and transit components in each chapter;
- Chapter 1 discusses issues relating to personal mobility;

- Chapter 2 describes recent trends in highway and transit demand and system characteristics;
- Chapter 3 depicts 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 systems;
- Chapter 6 outlines highway and transit revenues sources and expenditure patterns for all units of government;
- 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 future investment would have; and
- 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.
- Chapter 11 identifies limitations in the current analysis, and raises issues for future discussion.
- Appendix A reports the results of the Interstate System Needs Study required by Section 1107(c) of TEA-21;
- Appendix B provides information about the National Highway System that corresponds to the information provided in Chapters 2-10 for all highways and bridges;
- Appendix C provides information on the condition of NHS intermodal freight connectors;
- Appendix D discusses issues relating to asset management and investment strategies;
- Appendix E provides information on the conditions and performance of Federal Lands Highways;
- Appendix F discusses how Federal highway safety programs work to address the issues raised in Chapter 5;
- Appendix G describes changes in the highway investment requirement methodology;
- Appendix H discusses the costs and benefits of transit; and
- Appendix I includes supplementary technical information on the transit investment requirement methodology.

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 about 130,000 highway sections. All HPMS data and estimates of future travel demand 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 completeness, consistency, and uniformity.

State and local finance data are derived from the financial reports provided by the States to FHWA in accordance with the “Guide to Reporting Highway Statistics.” This is 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. All bridge information is verified for completeness, consistency and adherence to reporting guidelines.

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 information collected directly from transit operators provides a complete picture of the Nation’s transit facilities and equipment.

Investment Requirement Analytical Procedures

The earlier versions of the reports in this series relied exclusively on engineering-based estimates for future investment requirements, which considered only the costs of transportation agencies. This philosophy failed to provide another critical dimension of transportation programs; that is, to provide service to users while minimizing overall costs. Executive Order 12893, *Principles for Federal Infrastructure Investments*, 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 approaches to this analysis 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) that uses marginal benefit/cost analysis to optimize highway investment. The HERS addresses highway deficiencies by quantifying the agency and user costs of various types and combinations of improvements, including vehicle operating, travel time, and safety costs.

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 on the basis of costs and benefits in order to select future investments.

This report introduces the National Bridge Investment Analysis System (BIAS) which adds an economic component to the bridge analysis. However, the bridge investment requirements still rely in part on an older engineering-based model.

Plans for Future Reports

The Department intends to submit the fifth in this series of combined highway, bridge and transit reports by June 2001. This document will incorporate the highway and bridge information required in 2001 by Section 502(g) of Title 23 United States Code (U.S.C.), as well as transit system information required in 2002 by Section 308(e) of Title 49 U.S.C. This report will be developed utilizing 1999 data.

EXECUTIVE SUMMARY

Personal Mobility

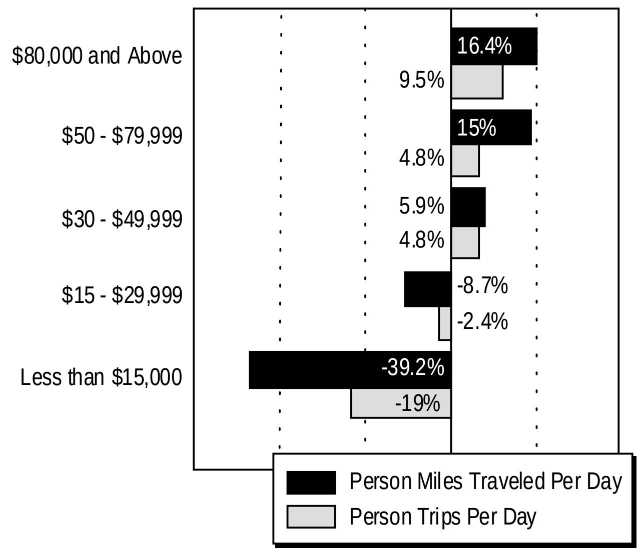
Mobility links us to the economic, social and political benefits of our society. A transportation system that provides mobility is accessible, integrated and efficient and offers flexibility of choices. Our extensive intermodal transportation system helps make Americans one of the most mobile populations in the world.

Measures of Mobility for the 1995 NPTS Sample

Percent Aged 16+ Licensed to Drive	89%
Percent in Households With a Vehicle	94%
Average Daily Travel per Person:	
Person Trips	3.88
Person Miles	29.3
Vehicle Trips	2.42
Vehicle Miles	19.3

Per Capita Trips and Miles by Income

Percent Above or Below U.S. Average



However, there are groups in our society that face significant mobility challenges. The Nationwide Personal Transportation Survey (NPTS) provides information so we can better understand how income, gender, age, and race impact mobility.

While travel by single adults and adults without children does not vary by gender, travel by men and women with younger children is starkly different. **In particular, working mothers make more trips and cover more miles than at any other time in the past three decades**.

Household income appears to be the single most significant determinant of mobility. All aspects of travel are related to income – the amount of travel, the area in which a person travels, and vehicle ownership.

People in low-income households have fewer travel options and a much smaller radius of access to goods and services than those in higher income households. The high cost of acquiring, registering, insuring and maintaining a vehicle places vehicle ownership out of range for many low-income households.

Different mobility issues face the elderly because they typically drive less, live in more remote locations, and may require special services and facilities. Many of the poor elderly are single women, often minorities, who live alone. As our population ages, these issues will become more critical.

Examining income in conjunction with race adds another dimension to the discussion of mobility. For example, even in the same income group, African-Americans take 15 percent fewer trips and travel almost a quarter less miles per person per day than whites.

Although all elements of the population have increased their mobility over time, many challenges still exist. A transportation system that meets the mobility needs of all Americans must use both traditional and innovative approaches.

EXECUTIVE SUMMARY

System and Usage Characteristics: Highway and Bridge

Public road mileage in 1997 reached 3.95 million miles. **This mileage was overwhelmingly *local* and *rural*.** However, while locally owned mileage increased between 1987 and 1997, rural mileage has decreased as metropolitan areas have expanded to incorporate mileage that was formerly rural.

About 3.11 million miles were in rural areas in 1997, or 79 percent of total mileage. **The share of rural mileage decreased** by about 0.2 percent annually between 1987 and 1997.

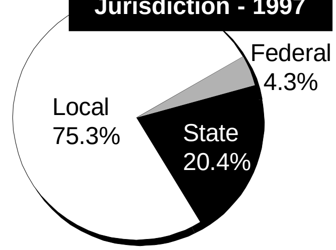
Percentage of Highway Miles, Lane Miles, and Vehicle-Miles Traveled by Functional System - 1997

Functional System	Miles	Lane-Miles	VMT
Rural Highways			
Interstate	0.8	1.6	9.4
Other Principal Arterial	2.5	3.0	8.9
Minor Arterial	3.5	3.5	6.4
Major Collector	10.9	10.6	7.9
Minor Collector	6.9	6.6	2.1
Local	54.1	51.8	4.5
Subtotal Rural	**78.7**	**77.1**	**39.1**
Urban Highways			
Interstate	0.3	0.9	14.2
Other Freeways & Expressways	0.2	0.5	6.3
Other Principal Arterials	1.4	2.2	15.1
Minor Arterials	2.3	2.8	11.6
Collector	2.2	2.3	4.9
Local	14.9	14.3	8.7
Subtotal Urban	**21.3**	**22.9**	**60.9**
Total Highway	**100.0**	**100.0**	**100.0**

About 2.97 million miles were locally owned in 1997, 75.3 percent of the national road system. Federally owned roads comprised 169,000 miles in 1997 (4.3 percent), and State-owned roads comprised 808,000 miles (20.4 percent). Locally owned road mileage has steadily increased, by an average of 0.4 percent annually. State road mileage has remained relatively constant.

Federal ownership has dropped by about 2.3 percent annually largely because of reclassification of some routes to non-public road status.

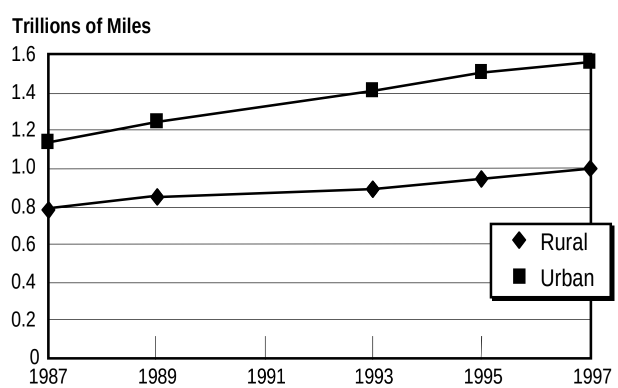
Highway Mileage by Jurisdiction - 1997



While highway mileage is mostly rural, a majority of highway travel occurs in urban areas. Overall, nearly 61 percent of total vehicle miles traveled (VMT) of 2.5 trillion miles in 1997 was urban travel. Urban travel grew at an average annual rate of 3.2 percent since 1987, while rural travel increased by about 2.6 percent annually. **VMT increased on every highway functional system.**

VMT for combination trucks has grown faster than VMT for passenger vehicles since 1987, increasing at an average annual rate of 3.8 percent.

Highway Vehicle (VMT): 1987-1997



The 582,976 bridges in the Nation are a critical element of the infrastructure network. Approximately 47 percent of bridges are State-owned, while 51 percent are locally owned. The remaining 2 percent are federally owned, privately owned, or their ownership is unknown or unclassified.

EXECUTIVE SUMMARY

System Characteristics: Transit

Mass transit in the U.S. performs three public policy functions: providing *basic mobility* to the poor, disabled, young, and old; encouraging *location efficiency* through dense, mixed-use development; and assisting in *congestion management* by providing an alternative to automobile travel, especially in peak periods.

Data from the 1995 NPTS indicate that congestion management accounts for 35 percent of transit trips, while basic mobility and location efficiency account for 40 percent and 25 percent, respectively. Transit trips fulfilling a congestion management function are predominantly work trips and are significantly longer on average than trips associated with the other two functions. They are also considerably more peaked during the morning and afternoon rush hours. A significantly larger percentage of basic mobility trips are made by bus.

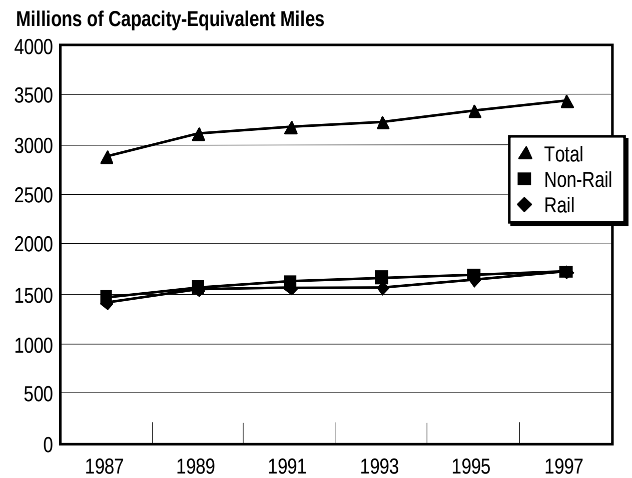
In 1997, there were 149,468 transit vehicles, 9,922 miles of track, 2,681 stations, and 1,179 transit maintenance facilities in operation in the U.S.

Transit systems operated 8,602 route miles of rail service in 1997, an increase of 44.2 percent since 1987. Non-rail route miles were up 10.4 percent since 1987 to 156,733.

Transit system capacity, measured in vehicle revenue miles (adjusted for vehicle capacity), increased 19.7 percent from 1987 to 1997. Rail capacity increased 22.4 percent, while non-rail increased 17.1 percent. Capacity for rail and non-rail in 1987 was almost identical, at 1.72 billion miles each.

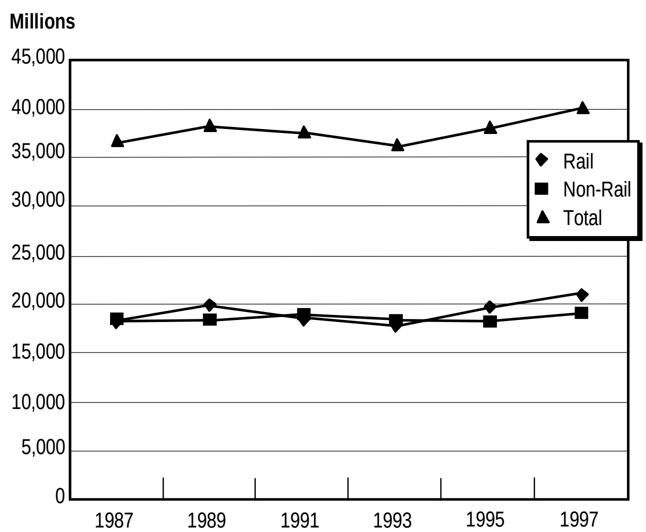
Transit passenger miles increased by 10.9 percent between 1993 and 1997, from 36.22 billion to 40.18 billion. This reversed a slight decline

Transit Capacity 1987-1997



from 1989 to 1993. Growth was most pronounced for rail transit modes, which increased 18.3 percent, from 17.87 billion to 21.14 billion passenger miles.

Transit Passenger Miles 1987-1997



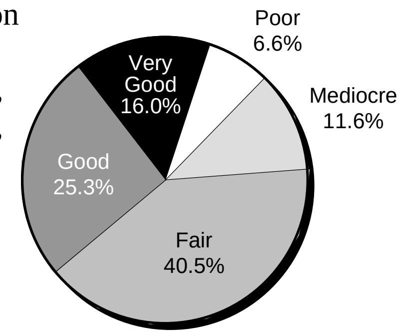
Transit vehicle occupancy decreased from 1987 to 1997, from 12.7 passengers per vehicle (adjusted for capacity) to 11.7. Vehicle occupancy increased from 1993 to 1997, however, with rail modes going from 11.4 passengers per vehicle to 12.3, and non-rail modes remaining constant at 11.1 over that period.

EXECUTIVE SUMMARY

System Conditions: Highway and Bridge

In 1997, overall pavement condition was rated 16.0 percent very good, 25.3 percent good, 40.5 percent fair, 11.6 percent mediocre and 6.6 percent poor. These ratings are based on the International Roughness Index (IRI), a measure of “ride quality” for higher functional classes, and on the Present Serviceability Rating (PSR) for lower functional classes. **Since 1993, the percentage of road miles in poor condition has dropped from 8.6 percent to 6.6 percent.**

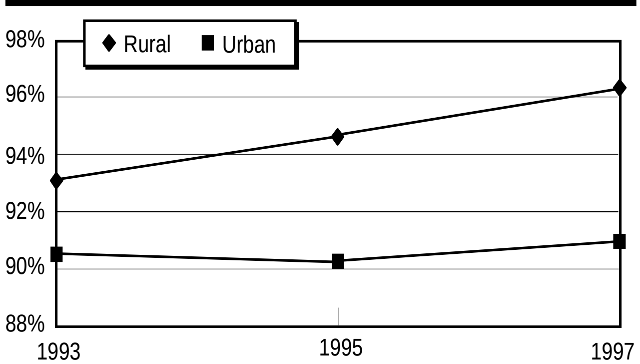
Pavement Condition 1997



Supporting the largest share of vehicle travel, Interstate pavement condition has continued to improve. **The percentage of all Interstate mileage with acceptable ride quality increased from 91.2 percent in 1993 to 92.4 percent in 1997.**

The percentage of Interstate mileage in the urban areas with acceptable ride quality (not “poor”) increased from 90.5 percent in 1993 to 90.8 percent in 1997. In the rural areas, Interstate pavement mileage with acceptable ride quality increased from 93.1 percent to 96.2 percent since 1993.

Percentage of Interstate Mileage with Acceptable Ride Quality

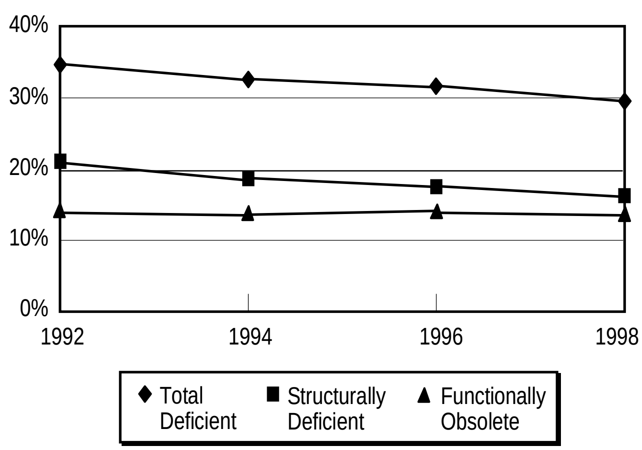


Generally, for all functional systems, the pavement conditions in rural areas were slightly better than in urban areas.

In 1997, approximately 65 percent of rural roads meet horizontal (curve) design standards and 60 percent meet vertical design standards. In addition, 53 percent of urban mileage and 66 percent of rural mileage have 12+ foot lanes.

The common indicator used to evaluate the condition of our Nation’s bridges is the number of deficient bridges. There are two types of deficient bridges: structurally deficient and functionally obsolete. **The number of deficient bridges on our transportation system have been steadily declining. In 1998, only 29.6 percent of our Nation’s bridges were deficient;** 16.0 percent of bridges were structurally deficient while 13.6 percent were functionally obsolete.

Bridge Conditions: 1992-1998



Bridges on the Interstate have the lowest percentage of deficient bridges (16.4 percent in rural areas and 26.8 percent in urban areas) of all functional classes. A larger percentage, 32.5, of bridges in urban areas are deficient than those in rural areas, 28.8. Over half of the deficient bridges are under local governments’ jurisdiction.

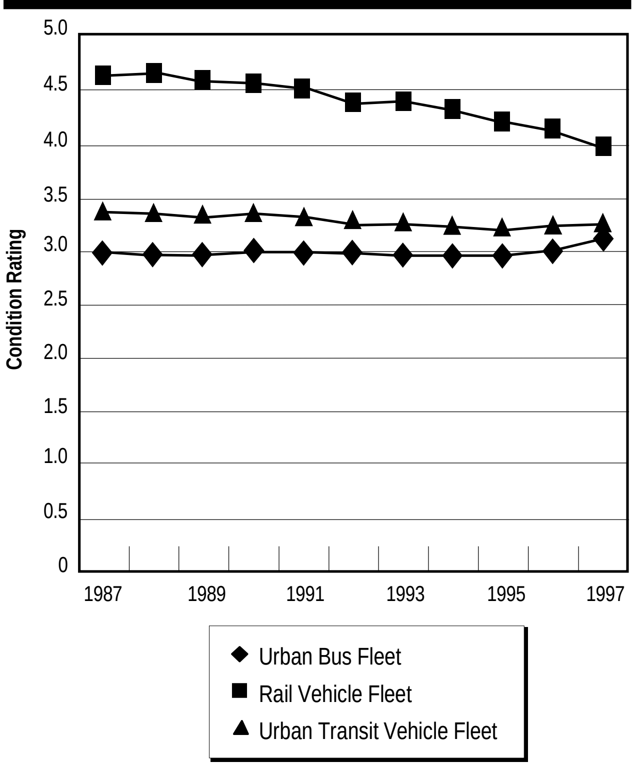
System Conditions: Transit

This report incorporates new information on and improved modeling of bus vehicle and maintenance facility conditions, based on a national sample of vehicles and facilities. Similar improvements for rail vehicle conditions will be in the next report.

Rating	Condition Definition
5.0	Excellent
4.0	Good
3.0	Adequate
2.0	Substandard
1.0	Poor

The average condition of urban bus vehicles in 1997 was 3.1, or “adequate.” Sixty-three percent of the urban bus vehicle fleet consists of full-size buses, whose average condition has remained steady at 3.0 for the last decade.

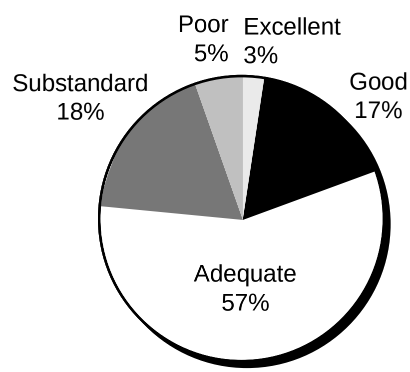
Urban Transit Vehicle Fleet Condition



The average condition of rail vehicles in 1997 was 4.0, or “good.” The downward trend in rail vehicle condition is primarily due to the deterioration of the Nation’s heavy rail vehicle fleet, comprising 60 percent of rail vehicles, whose average condition rating declined from 4.7 in 1987 to 3.9 in 1997. Fourteen percent of urban bus facilities are less than 20 years old. Fifty-three percent are between 10 and 30 years old, and 33 percent are over 30 years old.

Most urban bus maintenance facilities, 57 percent, are considered to be in adequate condition. Twenty percent are in good or excellent condition, and 23 percent are in substandard or poor condition.

Condition of Urban Bus Maintenance Facilities



The decrease in the condition rating of urban buses and urban bus maintenance facilities relative to conditions reported in previous cycles is due primarily to updated and improved modeling of bus vehicle condition derived from the National Bus Condition Assessment.

The percentage of urban transit rail track in good or excellent condition increased from 43 percent in 1984 to 73 percent in 1997. The percentage of rail maintenance facilities in good or excellent condition increased from 28 percent in 1984 to 60 percent in 1997.

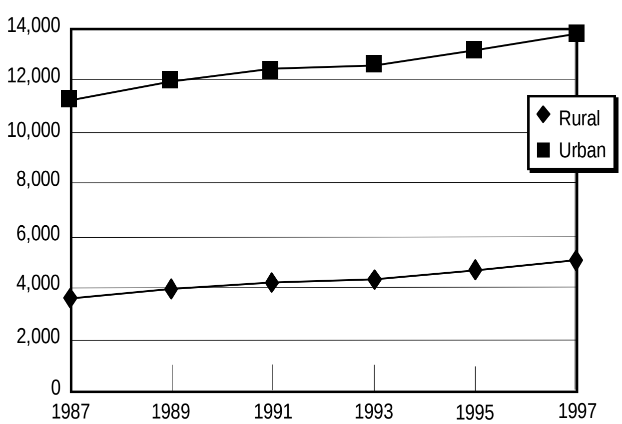
EXECUTIVE SUMMARY

Operational Performance: Highway and Bridge

Congestion is a growing concern on the nation's transportation system. Not only does congestion make driving more inconvenient and unsafe, but it increases transportation costs for many American businesses. The Texas Transportation Institute (TTI) estimates that in the 68 metropolitan areas studied in 1997, **Americans wasted 6.7 billion gallons of fuel and 4.3 billion hours of time because of delay. The total cost to American motorists in these areas is about $72 billion annually**.

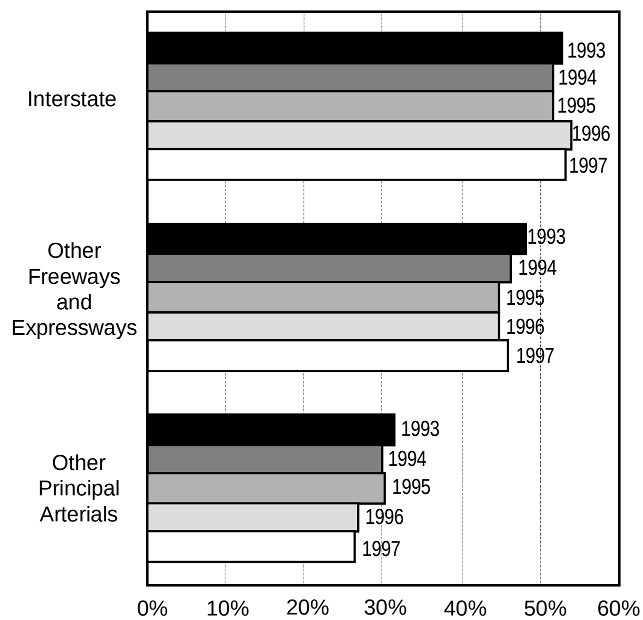
Travel (DVMT) per lane mile has increased on all systems over the past 10 years. While DVMT has grown for both rural and urban highways, it increased at a faster rate on rural routes. **DVMT grew by 3.40 percent on rural Interstates between 1987 and 1997**.

Interstate DVMT per Lane-Mile



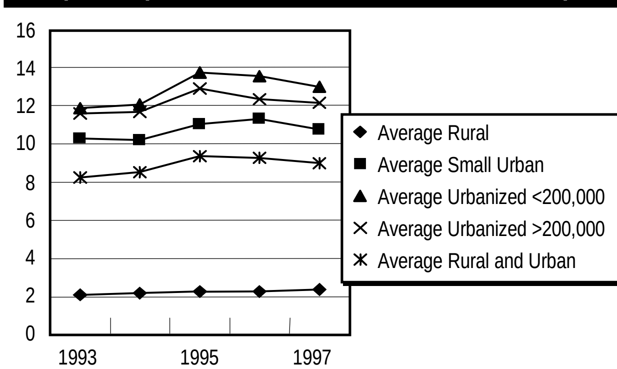
Another way to measure operational performance is to examine peak-hour travel equal or greater than the 0.80 volume-service flow (V/SF) threshold. This measures only the severity of peak-hour congestion, not its extent or duration. **More than half of peak-hour Urban Interstate travel occurs under congested conditions**.

Peak-Hour Congested Travel on Urban Principal Arterial Highways



Delay increased on all highways between 1993 and 1997, rising from 8.3 to 9.0 hours per 1000 VMT. While calculated delay declined on most urban highway systems from 1995 to 1997, the reason for this is unclear. A longer time period is needed to determine if this is the beginning of a trend. Daily delay is measured by hours per thousand vehicle miles traveled, and it primarily occurs in urbanized areas (over 50,000 population).

Daily Delay (Hours per Thousand Vehicle Miles Traveled)



EXECUTIVE SUMMARY

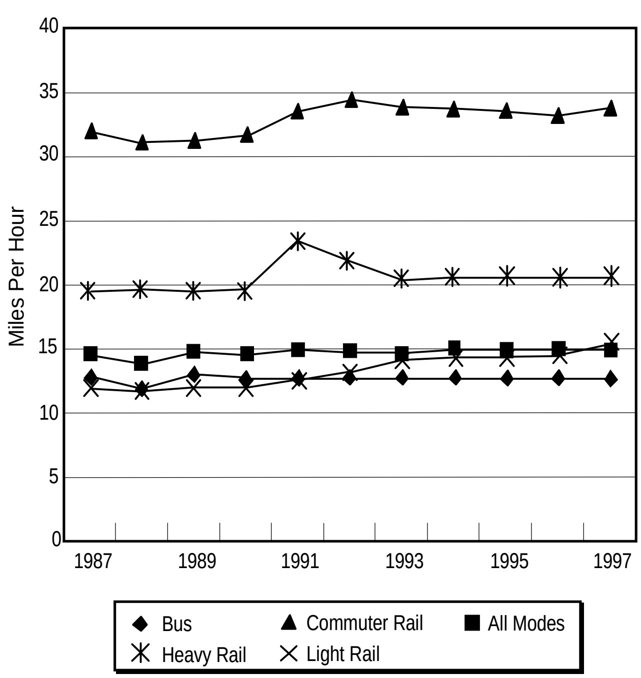
Operational Performance: Transit

Transit operational performance is measured at the system level by average operating speeds and vehicle utilization. Transit performance is measured at the passenger level by waiting times, reliability, and seating conditions.

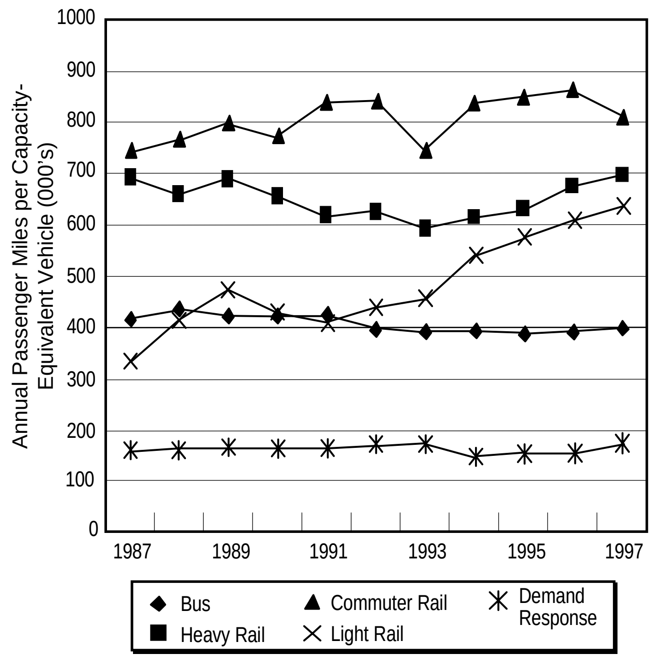
Average transit operating speeds were 20.3 miles per hour in 1997. The average speed for rail modes was 26.1 miles per hour, while average speeds for non-rail modes was 13.8 miles per hour. These figures have been relatively constant for several years.

Vehicle utilization is measured as passenger miles per vehicle, adjusted to reflect differences in vehicle capacity among different modes. Vehicle utilization is heaviest for rail modes, including commuter rail (815 thousand passenger miles per capacity-equivalent vehicle), heavy rail (696 thousand), and light rail (638 thousand). Utilization is substantially lower for non-rail modes, such as bus (400 thousand) and demand response (170 thousand), even accounting for the smaller size of these vehicles.

Average Transit Mode Operating Speeds 1987-1997



Vehicle Utilization Rates 1987-1997



Average waiting times and reliability (variation in waiting times) vary by public policy function. Average waiting times for basic mobility passenger were greater (at 12.1 minutes) than for location efficiency (8.9 minutes) and congestion management (7.3 minutes), and were also more variable.

Seating conditions, measured by the percentage of passengers who find a seat unavailable upon boarding, are roughly equivalent for each of the three market niches filled by transit, at 25 to 30 percent.

Seating Conditions by Market Niche

	Seat Unavailable Upon Boarding
Basic Mobility	29.7%
Location Efficiency	26.3%
Congestion Relief	25.0%

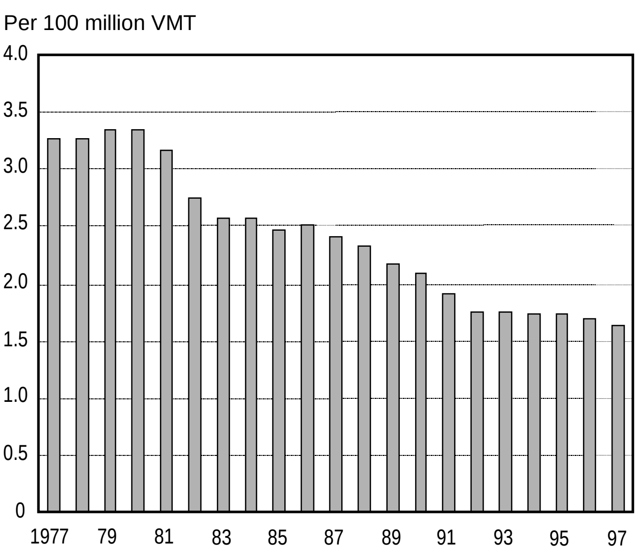
EXECUTIVE SUMMARY

Safety

Through a variety of measures including education programs, aggressive law enforcement, and infrastructure-related safety improvements, significant improvements in highway safety have been achieved. While much remains to be done, the progress to date is one of the most important transportation "success stories" of the past 20 years.

Fatalities have fallen from 50,331 in 1978 to 42,013 in 1997. The fatality rate has plunged over a longer period. In 1966, the fatality rate was 5.5 per 100 million VMT; it had dropped to 1.6 by 1997. **This plummeting fatality rate occurred even as the number of licensed drivers grew by nearly 80 percent.**

Fatality Rate (1977-1997)

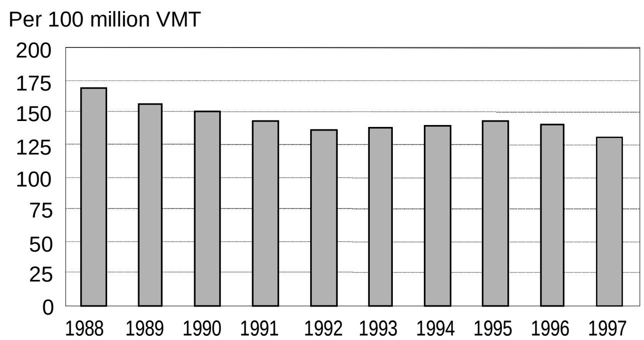


The injury rate has also declined, dropping from 169 per 100 million VMT in 1988 to 133 in 1997.

Four types of crashes have been identified for emphasis in future programs:

- Single vehicle run-off-the-road crashes account for 36 percent of all highway-related fatalities. This represents about 15,000 fatalities each year.

Injury Rate (1988-1997)



- Pedestrian crashes represent 13 percent of all highway-related fatalities. This includes about 5,300 fatalities, and approximately 77,000 pedestrians are injured each year.
- Speeding is a contributing factor in a third of all fatal crashes. This represents about 13,036 fatalities and 742,000 injuries annually.
- Large truck crashes resulted in about 5,350 fatalities and 133,000 injuries in 1997.

The reduced fatality rates can be attributed to several factors, including increased safety belt use, air bags, road safety devices, and a sharp decline in alcohol-related crashes. **Surveys showed that 69 percent of vehicle occupants used seat belts by 1997**. Seat belt usage in conjunction with vehicular air bag systems provide additional protection in potentially fatal crashes. **The proportion of fatalities attributable to alcohol dropped from about 57 percent in 1982 to 39 percent in 1997.**

Transit safety incidents involving injuries and deaths had noticeable decreases from 1990 to 1997. Over this seven-year period, safety incidents involving transit fell from 251 per 100 million PMT (persons-miles-traveled) to 165, and fatality rates declined considerably, from 0.89 per 100 million PMT to 0.73.

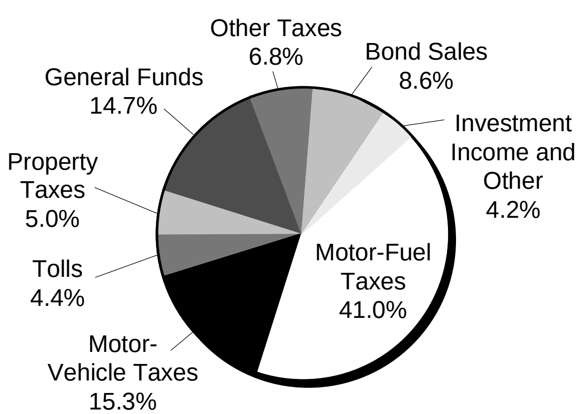
EXECUTIVE SUMMARY

Finance: Highway and Bridge

Taken together, **all levels of government spent $101.3 billion for highways in 1997.** The Federal Government funded $21.1 billion (20.8 percent). States funded $52.7 billion (52.1 percent). Counties, cities and other local government entities funded $27.5 billion (27.1 percent).

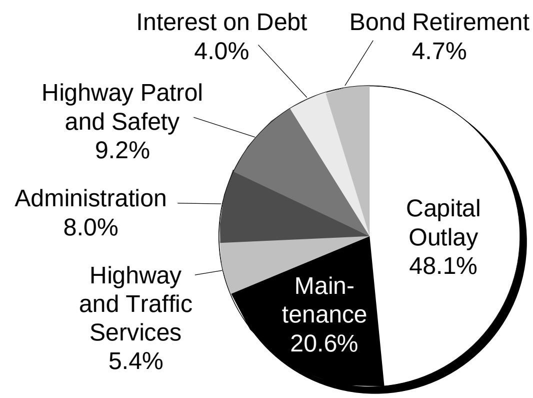
Highway-user revenues—the total amount generated from motor-fuel taxes, motor-vehicle fees, and tolls—were $89.9 billion in 1997. Of this, $64.7 billion was spent on highways. This represented 60.8 percent of total revenues generated for highways in 1997 (including amounts placed in reserves for expenditure in future years). Highway-user revenues would have been sufficient to cover 88.8 percent of all highway expenditures if the full amount had been used for highways.

Revenue Sources for Highways - 1997



Total highway expenditures increased 8.3 percent between 1995 and 1997. Highway spending rose faster than inflation over this period, growing 2.0 percent in constant dollar terms. Since a low point in 1981, highway spending has grown 50.2 percent in constant dollars. Expenditures for highway law enforcement and safety have been growing faster than other types of highway expenditures.

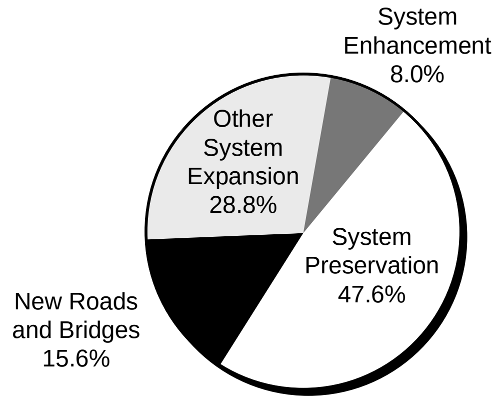
Highway Expenditures by Type - 1997



Capital outlay grew to $48.7 billion in 1997, a 10.2 percent increase since 1995. **Federal funds accounted for $20.0 billion, or 41.1 percent of total capital outlay.** Since 1987, the Federal share has remained in a range from 41 to 46 percent.

Approximately $23.2 billion of capital funds (27.2 percent) were used for system preservation; $7.6 billion went for new roads and bridges; $14.0 billion went for adding new lanes to existing roads; and $3.9 billion went for system enhancements, such as safety, operational or environmental improvements.

Distribution of Highway Capital Outlay by Improvement Type - 1997

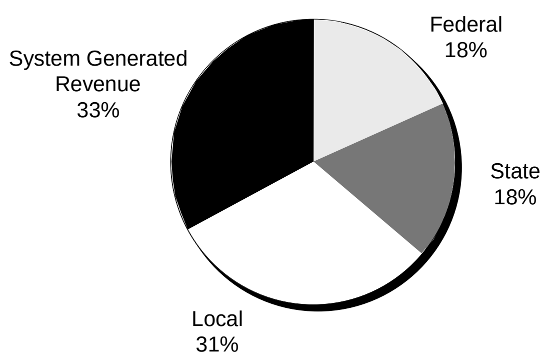


EXECUTIVE SUMMARY

Finance: Transit

Public funding for transit in 1997 totaled $17.5 billion. Twenty-seven percent of public funding came from the Federal government, an increase over recent years. Public funding for transit increased at an annual rate of 1.3 percent in real (inflation-adjusted) dollars from 1990 to 1997. This growth was substantially greater than that seen during the 1980s, but is well below the large growth rates in public funding for transit experienced in the 1960s and 1970s.

Transit System Revenue Sources



Public funding accounted for just over two-thirds of transit revenues in 1997. Local government was the largest jurisdictional source, at $8.1 billion. The most significant tax sources were general appropriations (18.7 percent of revenues), fuel taxes (16.5 percent), and sales taxes (14.7 percent). Passenger fares accounted for 27.5 percent of revenues, and other system revenues (e.g., advertising) accounted for 5.2 percent.

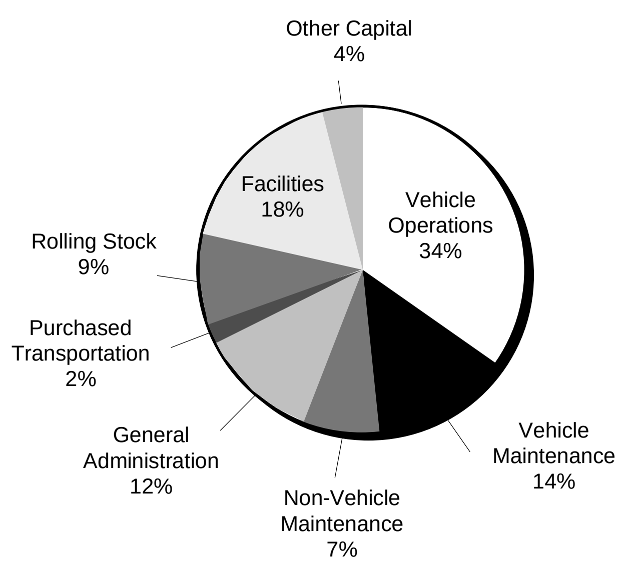
Federal capital assistance increased significantly between 1994 and 1997, from $2.5 billion to $4.1 billion. State and local capital spending remained relatively constant between 1995 and 1997, after increasing steadily since 1990. As a result, the Federal share of capital funding reversed its previous declines and stood at 54 percent in 1997.

In 1997, total spending for transit capital projects was $7.6 billion. Fifty-eight percent of capital spending was for facilities, while 29 percent was spent on vehicles and the remaining 13 percent was spent on other capital expenditures.

Operating expenses for transit totaled $17.5 billion in 1997. Fifty percent of operating expenses went to vehicle operations, 31 percent to vehicle and non-vehicle maintenance, and 20 percent on administration and purchased transportation.

Bus operations accounted for a majority of operating expenditures in 1997, totaling $9.8 billion. Heavy rail operations were next largest at $3.5 billion, followed by commuter rail at $2.3 billion. From 1988 to 1997, operating expenses increased 40 percent for bus operations, 300 percent for demand response services, 139 percent for light rail, and 21 percent for commuter rail. Operating expenses for heavy rail decreased by 1 percent.

Transit Capital and Operating Expenditures by Type - 1997



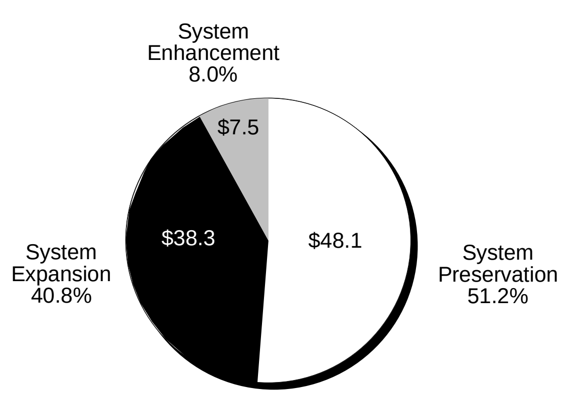
Capital Investment Requirements: Highway and Bridge

The scope of the investment requirements outlined in this report has been expanded to cover all types of highway capital outlay. In previous editions of the report, improvements primarily related to system enhancement (including safety, traffic operations and environmental improvements) and economic development were excluded.

The average annual **Cost to Improve Highways and Bridges** for the 20-year period 1998–2017 is **$94.0 billion.** This represents the investment by all levels of government required to implement all cost beneficial improvements on highways ($83.4 billion Maximum Economic Investment scenario) plus the investment required to eliminate all bridge deficiencies ($10.6 billion Eliminate Deficiencies scenario).

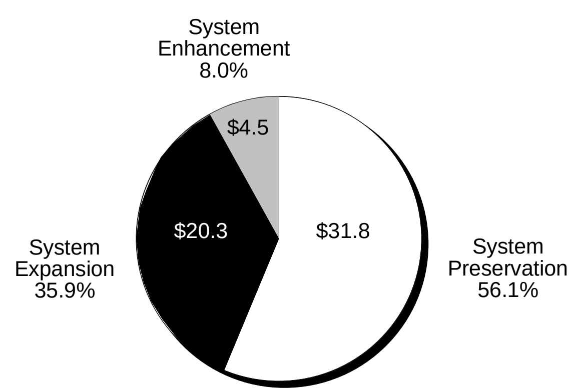
Investment requirements for system preservation comprise 51.2 percent of the total $94.0 billion Cost to Improve Highways and Bridges. Investment requirements for system expansion account for 40.8 percent, while investment requirements for system enhancement make up 8.0 percent of the total.

Distribution of Cost to Improve, by Improvement Type



The average annual investment over 20 years by all levels of government required for the **Cost to Maintain Highways and Bridges is $56.6 billion.** Included in this total are the highway Maintain Conditions scenario ($50.8 billion) which maintains pavement condition, and the bridge Maintain Backlog scenario ($5.8 billion), which maintains the backlog of current bridge deficiencies.

Distribution of Cost to Maintain, by Improvement Type



This highway Maintain Conditions scenario consists of a mix of preservation, expansion, and enhancement improvements intended to attain the highest possible level of benefits for highway users, while achieving its goal of maintaining pavement conditions. At this level of investment, **pavement condition would be maintained, but highway system performance would decline.** Average highway user costs (including travel time costs, vehicle operating costs, and crash costs) would rise.

An additional $3.1 billion from all levels of government would be required annually to maintain highway user costs. Maintaining travel time costs would require an additional $17.1 billion annually.

EXECUTIVE SUMMARY

Capital Investment Requirements: Transit

This report uses combinations of four scenarios to estimate capital investment requirements for the Nation's transit systems over the period 1998-2017. The Maintain Conditions scenario invests in transit capital in order to maintain average asset conditions over the 20-year period. The Improve Conditions scenario makes additional investments in order to bring the average condition for each major asset type up to at least a level of "good." The Maintain Performance scenario adds new transit capacity in order to maintain current vehicle usage levels as transit passenger travel increases. The Improve Performance scenario makes additional improvements to improve the quality of service provided by reducing headways and/or increasing coverage.

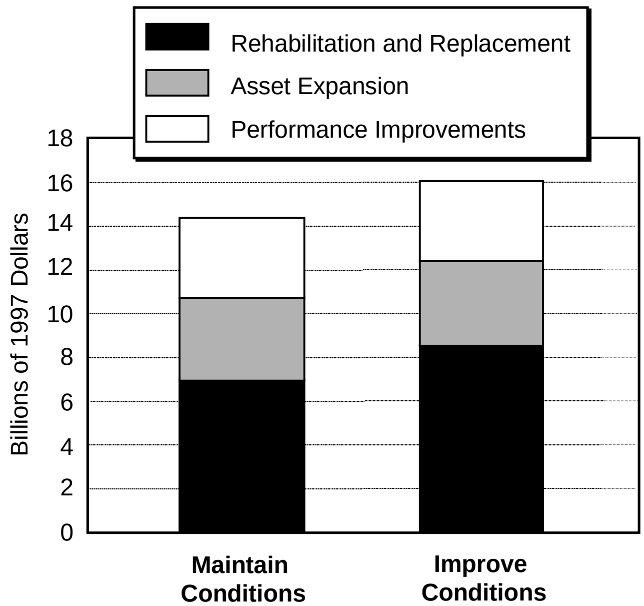
Summary of Transit Average Annual Investment Requirements 1998-2017 (in Billions of $1997)

Conditions	Performance	Average Annual Cost
Maintain	Maintain	10.8
Maintain	Improve	14.4
Improve	Maintain	11.1
Improve	Improve	16.0

The average annual investment required under the Cost to Maintain Conditions and Performance is $10.8 billion in 1997 dollars. The average annual Cost to Improve Conditions and Performance is $16.0 billion.

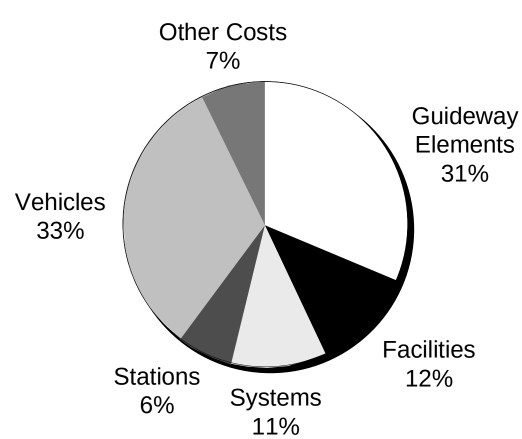
Sixty-five percent of investment under the Maintain Conditions and Performance scenario is in Rehabilitation and Replacement. Fifty-four percent of investment under the Improve Conditions and Performance scenario is devoted to Rehabilitation and Replacement, while the remainder is split between Asset Expansion and Performance Improvements.

Annual Cost to Maintain and Improve Conditions by Improvement Type



The greatest investment requirements are for vehicles and for guideway elements, such as tracks, tunnels, and bridges. Vehicles are the largest expense under the Maintain Conditions and Performance scenario, while guideway elements are the largest expenditure under the Improve Conditions and Performance Scenario.

Cost to Maintain Conditions and Performance by Asset Type



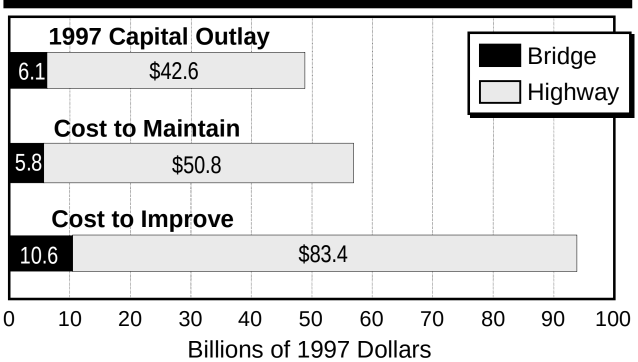
EXECUTIVE SUMMARY

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 attained.

Federal, State, and local highway and bridge capital outlay expenditures totaled $48.7 billion in 1997. Capital outlay expenditures by all levels of government would need to increase by 16.3 percent above this 1997 value to reach the $56.6 billion Cost to Maintain Highways and Bridges level. Similarly, an increase of 92.9 percent would be required to reach the $94.0 billion Cost to Improve Highways and Bridges level.

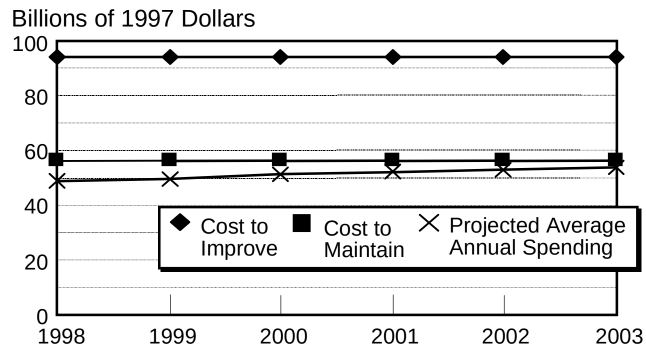
1997 Capital Outlay vs. Highway and Bridge Investment Requirement Scenarios



Capital improvements to existing bridges totaled $6.1 billion in 1997, above the $5.8 billion level of the bridge Maintain Backlog scenario (included in the Cost to Maintain).

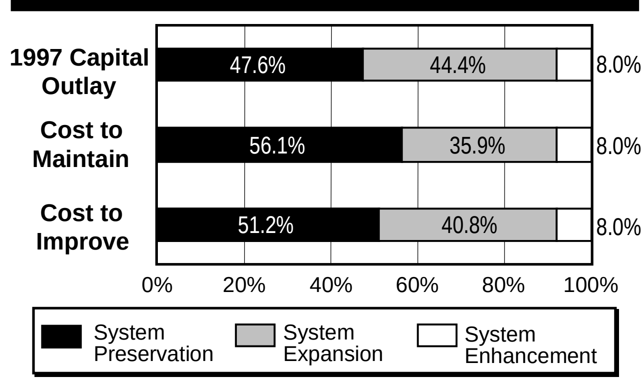
Recent editions of the C&P report have shown that capital spending has been growing more quickly than the investment requirements. This trend is expected to continue in the near future, as the implementation of the TEA-21 will result in significant increases in Federal highway funding. Assuming the continuation of recent trends in State and local government funding patterns, capital spending should reach the Cost to Maintain level by 2003. While the Cost to Maintain is 16.3 percent higher than 1997 capital spending, this difference is expected to shrink to 5.7 percent over the full 1998-2003 period.

Projected Average Annual Spending vs. Cost to Maintain and Cost to Improve, 1998-2003



In 1997, 47.6 percent of highway capital outlay went for highway and bridge preservation. If future funding remains near current levels, the analytical models used to develop the investment requirement scenarios in this report suggest that a greater share of capital investment should be devoted to system preservation. For the Cost to Maintain, 56.1 percent of the projected investment requirements are for system preservation. If funding increases significantly, the models recommend increasing system expansion investment more quickly, so only 51.2 percent of the Cost to Improve is for system preservation.

Investment Requirements and 1997 Capital Outlay, Distribution by Improvement Type



Comparison of Spending and Investment Requirements: Transit

Transit capital expenditures totaled $7.636 billion in 1997. This total is well below the estimated annual investment requirements for the 20-year period from 1998-2017. The estimated annual capital investment that would be necessary to Maintain Conditions and Performance is 41 percent greater than actual 1997 spending by all levels of government. The investment required to Improve Conditions and Performance is more than double actual 1997 capital spending by Federal, State and local governments. The relative differences between actual spending and the investment requirement scenarios are similar to those estimated in the 1995 and 1997 reports.

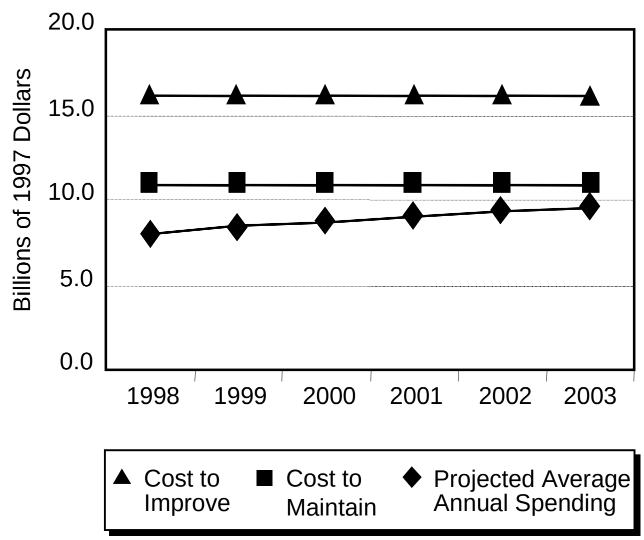
The percent difference between spending and investment requirements is larger for investments in vehicles than in non-vehicles under the Maintain Conditions and Performance scenario, while the opposite is true under the Improve Conditions and Performance scenario.

Average Annual Transit Investment Requirements Versus 1997 Capital Expenditures

	Percent Above Actual Spending
Cost to Maintain Conditions & Performance	41.0%
Cost to Maintain Conditions & Improve Performance	88.7%
Cost to Improve Conditions & Maintain Performance	45.5%
Cost to Improve Conditions & Performance	110.2%

TEA-21 authorizes substantial increases in Federal funding for mass transit. This increase in funding is expected to lead to large increases in capital spending by transit operators. At the guaranteed funding levels specified in TEA-21, total annual transit capital expenditures are projected to grow from $8.1 billion in 1998 to $12.3 billion ($10.8 billion in 1997 dollars) in 2003.

Average Annual Spending Versus Investment Requirements 1998-2003



This increase in transit capital expenditures under TEA-21 would substantially reduce the gap between actual expenditures and investment requirements. Investment requirements to Maintain Conditions and Performance exceed projected capital spending for the period 1998–2003 by just 13 percent, while the investment needed to Improve Conditions and Performance is 68 percent larger than projected expenditures.

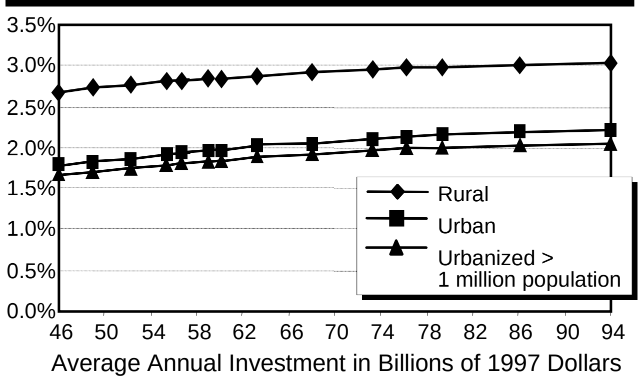
Investment requirements under both the Maintain and the Improve Conditions and Performance scenarios are slightly backloaded, with greater investment in the latter half of the 20-year period. Substantial investment also occurs in the initial 5-year period, as the backlog of existing vehicle and infrastructure deficiencies is eliminated.

EXECUTIVE SUMMARY

Impacts of Investment: Highway and Bridge

The highway VMT forecasts used to develop the 1995 C&P report and earlier editions were static; one fixed growth projection was used for each highway segment. The VMT forecasts used to develop the investment requirements in this report are dynamic. A single set of forecasts is entered into the Highway Economic Requirements System (HERS) for each sample section, but the model then applies **travel demand elasticity procedures** which change the VMT projections depending on how the conditions on that section are predicted to change over time. If lanes are added, the model assumes that additional travel will be induced. If a highway becomes more congested, the model assumes some drivers will shift to other routes, switch to transit, or forgo some trips entirely. As a result, HERS predicts that travel will grow at different rates, depending on the overall level of investment.

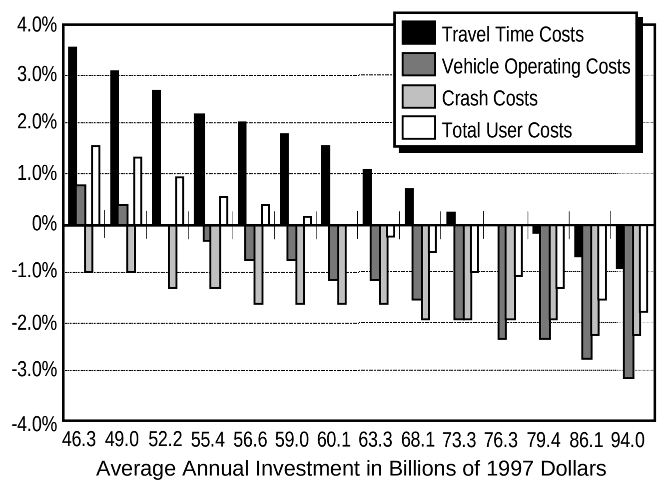
Projected Average Annual VMT Growth Rates 1998-2017, for Different Possible Funding Levels



For example, at current funding levels, HERS predicts VMT in urbanized areas over 1 million in population will grow by an average annual rate between 1.66 and 1.70 percent. (This is consistent with an aggregate projection of 1.68 percent, compiled from a survey of Metropolitan Planning Organizations.) If average annual spending increased from $48.7 billion to $94.0 billion, this rate would increase to 2.06 percent.

The mix of improvements recommended by the HERS model would have different impacts on each component of total highway user costs. If the recommended mix were to be followed, crash costs would be reduced at all levels of investment, as the model predicts there would be a relatively greater rate of return on improvements aimed at reducing crashes than on those aimed at reducing congestion. Maintaining travel time costs at current levels would be significantly more expensive than maintaining overall user costs.

Projected Change in 2017 Highway User Costs Compared to 1997 Levels, for Different Possible Funding Levels



There has been a change in the types of highway capital improvements being made in recent years away from new construction, and towards system preservation. This shift is consistent with recent improvements in pavement and bridge conditions.

Recent increases in travel density have not resulted in corresponding increases in delay or congestion. This implies that existing facilities are being used more effectively. This may be due in part to increased investment in traffic operational improvements.

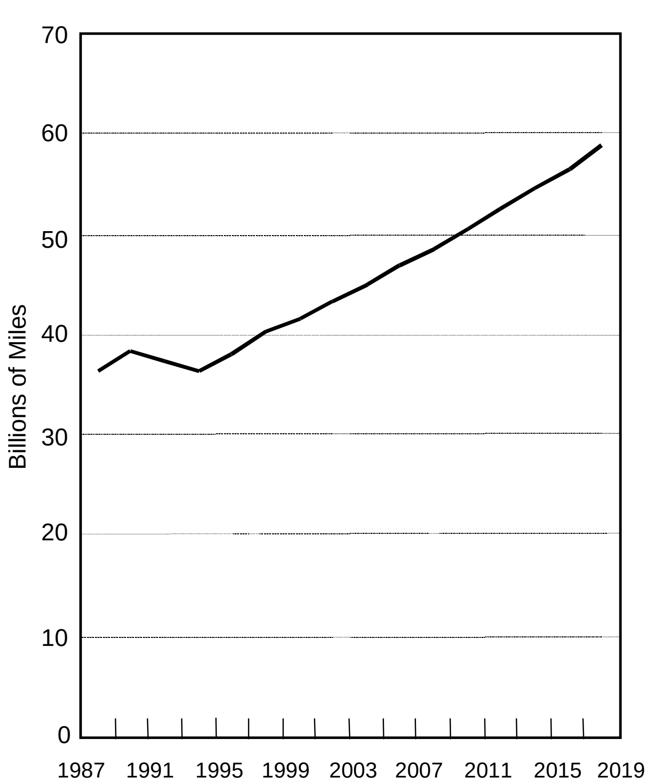
EXECUTIVE SUMMARY

Impacts of Investment and Sensitivity Analysis: Transit

The Transit Economic Requirements Model (TERM), from which the estimated transit investment requirements are obtained, is structured to accommodate transit passenger growth by adding more capacity, rather than actively affecting travel growth rates by improving service and lowering the user costs of transit riders.

Projections of future transit travel growth are obtained from metropolitan planning organizations (MPOs) in large urbanized areas. The weighted average transit passenger mile growth rate of the most recently available forecasts is 1.9 percent. At this rate, total annual transit passenger miles in the U.S. would grow from 40.2 billion in 1997 to 58.7 billion in 2017.

Projected Transit Passenger Mile Growth



Despite the estimated gap between funding and investment requirements, transit conditions and performance have been relatively stable over the past 10 years, with the exception of the Nation's heavy rail vehicle fleet, which has shown significant aging and deterioration.

One of the most important parameters used in estimating investment requirements is the annual growth rate in transit passenger miles, obtained from the MPO forecasts. In order to test the sensitivity of the estimated investment needs to the growth rate forecasts, investment needs were additionally estimated using three alternative growth rates: 2.85 percent (50 percent greater growth than forecast), 0.95 percent (50 percent less growth), and zero percent growth. Investment requirements under the Maintain Conditions and Performance scenario would be 20 percent larger under the higher growth rate, 18 percent smaller using the lower growth rate, and 35 percent smaller under zero passenger mile growth. Investment requirements under the Improve Conditions and Performance scenario are somewhat less sensitive to the growth rate than they are under the Maintain scenario.

The most significant improvements made to TERM for this report were in the way it relates asset age to asset condition. Data on urban buses and urban bus maintenance facilities were obtained during the National Bus Condition Assessment, an effort aimed primarily at providing data to improve the statistical specification of asset deterioration over time. The new deterioration curves imply a more rapid decrease in bus condition in the early years of use, and a more gradual decline in condition over the remainder of the useful life of the vehicle.

EXECUTIVE SUMMARY

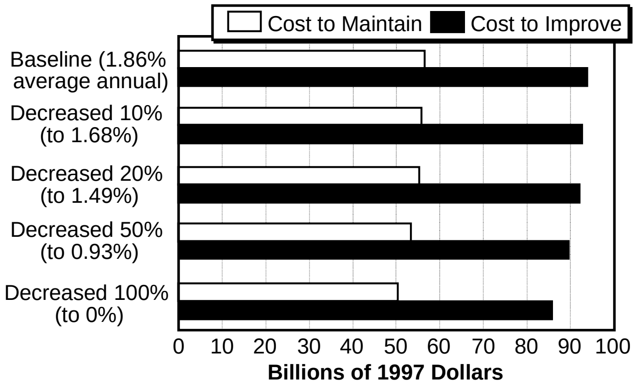
Sensitivity Analysis: Highway and Bridge

The accuracy of the investment requirements in this report depends on the validity of the underlying assumptions used to develop the analysis. Changing these assumptions would reduce or increase the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges.

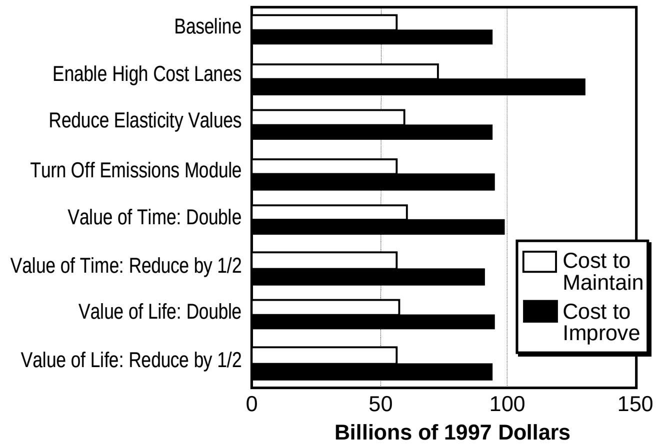
The HERS model assumes that the travel baseline forecasts for each highway section in the model represent not what future travel will be, but what it would be, if investment rose to the level required to keep highway user costs constant. **If the State-supplied baseline HPMS projection of 2.16 percent average annual growth were increased to the 2.84 annual rate observed over the last 20 years, the Cost to Maintain and Cost to Improve Highways and Bridges would increase by 15.5 and 14.1 percent respectively.**

If the baseline HPMS projection for large urbanized areas were reduced by 10 percent (0.18 percentage points) from 1.86 percent to 1.68 percent, the Cost to Maintain and Cost to Improve would fall by 1.6 percent and 1.1 percent respectively. Reducing the large urbanized area baseline growth rate to zero would reduce the Cost to Maintain and Cost to Improve by 11.0 percent and 8.6 percent respectively.

Impact of Reducing Baseline VMT Growth Projections in Urbanized Areas > 1,000,000 on Average Annual Investment Requirements



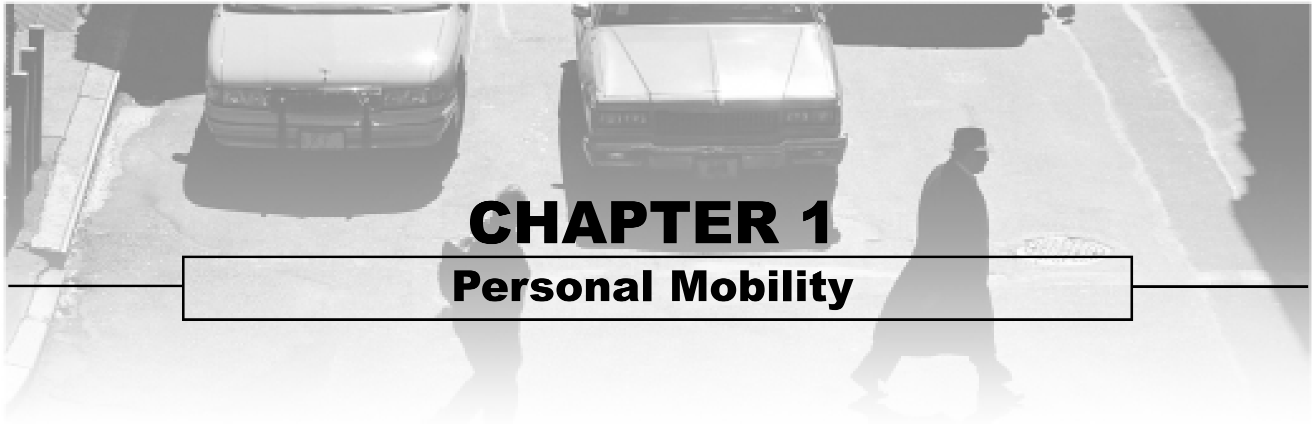
Impact of Other Alternate Assumptions on Average Annual Investment Requirements in 1998-2017



In previous reports, the HERS model was allowed to consider adding "high cost" lanes to a section, even if widening wouldn't ordinarily be feasible. High cost lanes represent the cost required to double-deck a freeway, build a parallel route, or purchase expensive right-of-way. This feature was turned off for this report. **Allowing HERS to consider high cost lanes would increase the Cost to Maintain and Cost to Improve by 28.7 percent and 38.0 percent respectively.**

The HERS travel demand elasticity values were increased in this report, and the HERS emissions module was turned on. Reducing the elasticity values to the levels used in the 1997 C&P report would increase the Cost to Maintain by 4.9 percent but reduce the Cost to Improve by 0.8 percent. Turning off the HERS emissions module would increase the Cost to Maintain and Cost to Improve by 0.1 percent and 1.1 percent respectively.

Doubling the value of time or value of life in HERS would increase the Cost to Improve by 4.9 percent or 0.5 percent respectively. Cutting them by half would reduce the Cost to Improve by 3.8 percent or 0.2 percent respectively.



CHAPTER 1
Personal Mobility

Introduction

By most measures, the United States is the most mobile nation, accommodating over 4 trillion miles of passenger travel and 3.7 trillion ton-miles of freight annually in the late 1990s. A vast system of transportation infrastructure makes this possible: 4 million miles of road, 200,000 miles of rail track, 580,000 bridges, 350 commercial ports, 5,500 airports. Every day, the U.S. maintains, patrols, and moves goods the length of enough commercially navigable waterways to span the globe—25,000 miles if stretched end-to-end.

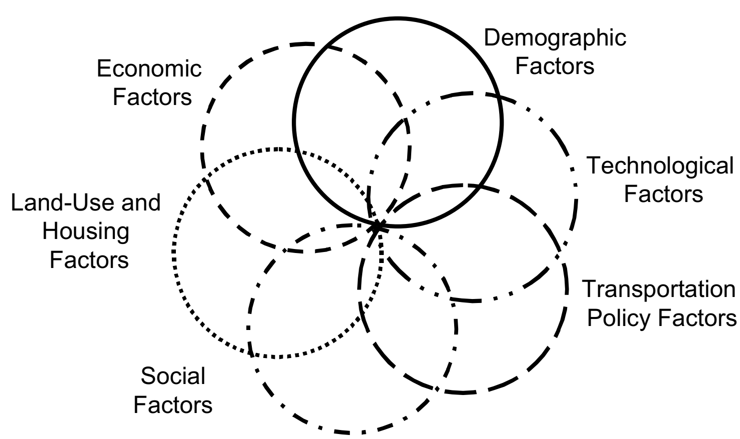
A mobile society is an open society, where seamless access to diverse economic, social, and cultural marketplaces fosters the opportunities, competition, and choices that fuel the economy and enrich the daily lives of millions. Transportation investment choices contribute to such an open society by increasing access to new activity centers, reducing bottlenecks in existing facilities, and extending mobility to the least advantaged members of society.

Our transportation system is constantly in flux, adapting to the changing frontiers of the U.S. economy and its people. Once principally geographic and geological, the frontiers of transportation have become increasingly technological, economic, demographic, and geopolitical. Exhibit 1-1 illustrates the combined forces that interact in determining the way that people travel.

A comprehensive treatment of all issues related to mobility is beyond the scope of this chapter. However, evidence has accumulated that not all segments of U.S. society share in the high quality mobility that most Americans have come to expect. Significant barriers to mobility persist for people with disabilities, elderly people, low-income households, recent immigrants and people of color. The system for distributing goods and services fails to reach into some places where

Exhibit 1-1

Factors Affecting U.S. Travel Patterns: Economic, Social, Technological, Land Use and Housing, Demographic, Transportation Policy



millions of Americans live and work. Without a concentrated effort to address the mobility problems of these groups, and their access to goods and services, the participation and success of these groups in the larger economy will continue to be limited.

Today's transportation decisions will create the infrastructure for decades to come. In response to new challenges, the Transportation Efficiency Act for the 21st Century (TEA-21) calls for new approaches to shaping the U.S. transportation infrastructure to the economy. There is increased emphasis on market principles.

The purpose of this chapter is to place in context the profile of unmet transportation needs in the midst of transportation "plenty." The qualities of the U.S. surface transportation systems are reported throughout the succeeding chapters.

The data from the Nationwide Personal Transportation Survey (NPTS) is the source of the figures and analysis in this chapter. The periodic survey provides a snapshot of travel by Americans and allows us to view differences in transportation patterns by income, age, gender and race, and to understand how travel changes over time. The reports and data analyses of the following people were used as source material: Sandra Rosenbloom of University of Arizona, Patricia S. Hu and Jennifer Young of Oak Ridge National Laboratory, Daphne Spain of University of Virginia, William Mallett of the Bureau of Transportation Statistics, U.S. Department of Transportation, John Pucher, Tim Evans, and Jeff Wenger of Rutgers University, Steven Polzin of University of South Florida, and Nancy McGuckin, Travel Behavior Consultant. Patricia Hendren of University of California at Davis and Nancy McGuckin provided considerable support in reviewing, restructuring and editing the material.

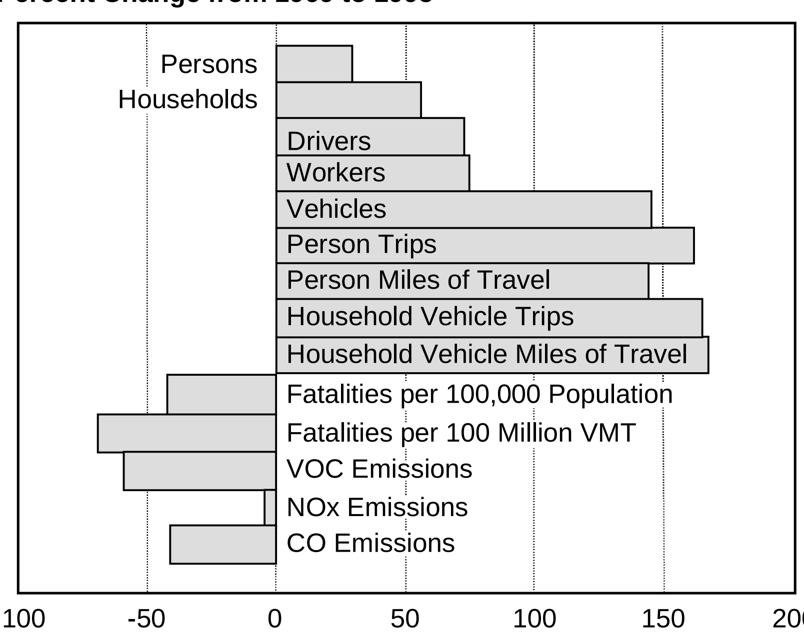
Measuring Mobility

Technological advances, government policies, and public acceptance of safety initiatives have accomplished much over the 1969 to 1995 period. Exhibit 1-2 shows key 1995 demographic, travel, safety and air quality indicators indexed to 1969. There were substantial increases in personal travel over this time, yet there were significant decreases in highway fatalities and the most crucial emissions indicators.

The most commonly discussed inequity is the failure of transportation systems to connect under-employed workers who reside in central cities to growing entry level suburban jobs. Also, as a matter of civil rights, transportation is the key for people with disabilities who are denied the same access to opportunities as is available to the majority of Americans. Another current issue

Exhibit 1-2

Demographics, Personal Travel, Safety and Air Quality, Percent Change from 1969 to 1995



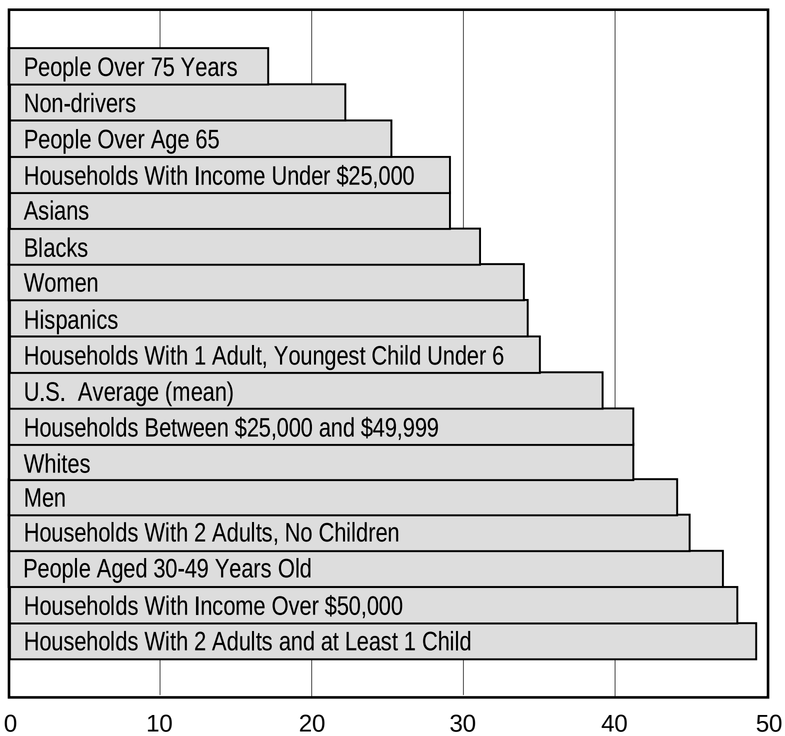
involves single-parent households who have unique logistical challenges and need flexible and sensible transportation options.

Mobility appears to decrease sharply with retirement. In 1995, annual average vehicle miles for drivers of all ages was 13,476, while for drivers 65 to 69 the average was 9,054. This trend is reflected in the average trip length, which drops by about one quarter after 65 years of age. Most of this change represents the elimination of commute trips by retired workers. However, since 1969 the average annual miles driven by people 65 to 69 has increased by 50 percent, reflecting the aging of cohorts with a higher ratio of drivers to non-drivers. As the baby boom begins to retire around the year 2010, the total ratio of seniors to working age people on the road is likely to increase rather sharply. Is the infrastructure in place to maintain safety standards when older drivers become the rule rather than the exception?

Converting these aggregate trends into specific impacts on individuals and households reflects much about our changing society. Exhibit 1-3 shows the very different levels of travel within various sub-groups, and raises the issue of the dimensions of geography and personal choice. Real-world complexities make untangling this issue difficult: for example, densely developed neighborhoods may have shopping and employment opportunities within short distances of residential areas lowering a person's daily travel miles. On the other hand, families in city neighborhoods may pay higher costs at neighborhood shops compared to suburban super-stores.

Exhibit 1-3

Average Daily Miles Traveled per Person in Different Groups (All Modes)



The remainder of this chapter attempts to filter through some of today's complexities relative to their influence on travel patterns.

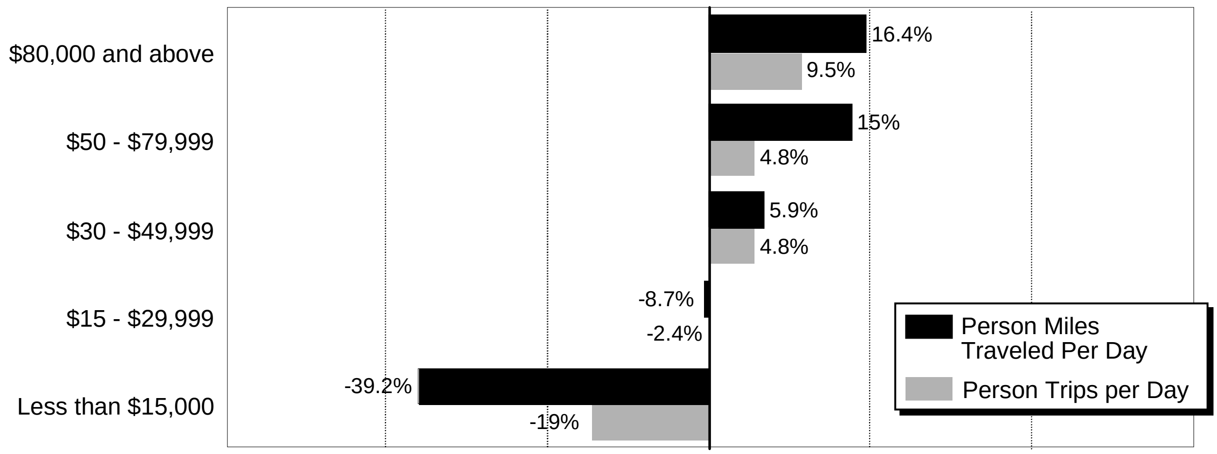
The Role of Income

Household income is the most important influence on mobility. African-Americans, Hispanic-Americans, newly arrived immigrants, the elderly, and people with disabilities all travel fewer miles and take fewer trips than the U.S. average. Part of the explanation for these differences in travel is related to income class. Residential location and auto ownership influence travel patterns, but household income heavily influences housing choices and auto purchases. Similarly, the logistical hardships on a single parent are severe, but these hardships are ameliorated with disposable income.

According to 1995 data, individuals in low-income households, earning less than $15,000 per year, make 19 percent fewer trips annually and travel nearly 40 percent fewer miles annually (9,060 compared to 14,924) than the average American household (see Exhibit 1-4). Income differences are even more dramatic on the household level. VMT per household in low-income households is approximately half that in other households (11,594 miles compared to 23,427).

Exhibit 1-4

Per Capita Trips and Miles by Income (Percent Above or Below U.S. Average)



When compared with the highest earning households (those making $80,000 a year), households with less than $15,000 income make 1.2 fewer trips per day. The difference in person miles traveled is even more striking—low-income households travel 15.9 fewer miles (almost 50 percent less) than high-income households. One reason for these differences, especially the disparity of person miles traveled, is the lower vehicle ownership rates in low-income households.

A personal vehicle enables a driver to choose departure time and route. However, the high cost of acquiring, registering, insuring and maintaining a vehicle places vehicle ownership out of range for many low-income households. Twenty-six percent of low-income households do not have a car, compared to 4 percent of other households.

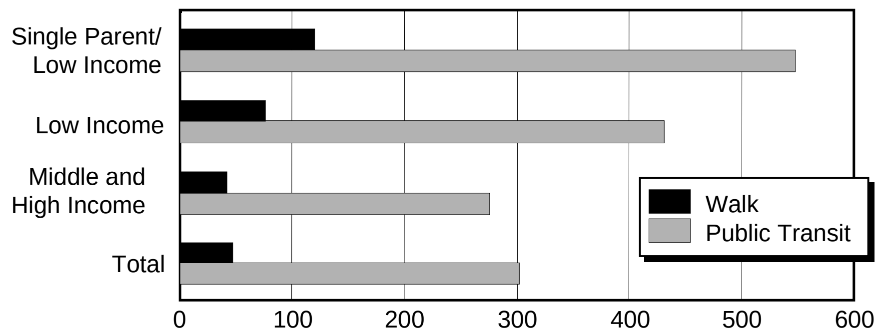
Without a vehicle many low-income households obtain a level of mobility through trips in vehicles owned by others, walking and mass transit. Approximately 8 percent of trips in low-income households are made in vehicles owned by others compared to 1 percent in other income groups. People in low-income households are more than twice as likely to make a walk trip as those in other income groups. Regarding transit use, households with income less than $15,000 represent 11.7 percent of the population, yet make 27 percent of all transit trips. The 8 percent of households without a vehicle account for 47 percent of all transit trips.

Exhibit 1-5 helps illustrate the link between income and travel-mode choice. The difference in the use of walk and transit is especially clear between single parent/low-income households compared to middle and high-income households.

In addition to the significant effects of racial and ethnic preferences in housing and jobs, the concentration of many low-income households is also influenced by the opportunity to pay lower housing costs. Due to the fact that a larger share of trips made in cars owned by others, walking, and public

Exhibit 1-5

Annual Person Miles of Travel per Person by Public Transit and Walking



transit, the area in which low-income people travel is geographically confined. For all other households, about 50 percent of their trips are within three miles of home. For low-income, this rises to 60 percent, and for low-income single-parent households, it reaches 66 percent.

The difference in the travel radius, or area that one can access, expands geometrically. A 3-mile radius gives you access to 28 square miles, while a 10-mile radius allows access to 300 square miles. Traveling over a larger radius opens opportunities for employment, shopping, and services. For example, when a supermarket closes in a lower-income neighborhood, residents are left with fewer options for basic needs.

Transportation limitations are especially critical for work trips. The growth in employment opportunities in the past two decades has largely been in the suburbs of major metropolitan areas. This points to the "spatial mismatch" of having large groups of low-skilled workers in the inner city or close-in suburbs, while the growth in jobs is occurring in the suburbs or exurbs.

With high residential density and low auto ownership, areas with low housing costs create natural markets for public transit, taxi and jitney services, and neighborhood retail and commercial services. If these services are effective, the concentration of the poor and their relative "immobility" need not worsen their condition or constrain their life activities. The public sector can play a key role in enhancing these opportunities by providing resources for transportation investments and encouraging private sector involvement in these areas.

Role of Age

Mobility can help cure isolation. All the disadvantaged groups experience a multifaceted isolation from American life. But this isolation is most severe, debilitating, and progressive for senior citizens. As the proportion of Americans who are elderly begins to increase, and as expected medical advances improve longevity and continue capabilities, the senior population is expected to make new demands on the transportation infrastructure. They will prolong their involvement in the mainstream of society and, what is more, they will have the economic power and votes to enforce accommodation in the infrastructure.

The American society is aging rapidly. The median age of America's population rose from 28 to 34 between 1970 and 1995. One reason for this increase is the proportion of those age 75 and older is increasing. By 2030 the proportion of the population over the age of 75 is projected to rise from 6 percent to 9 percent. The fastest growing segment of the elderly, the population aged 85 and over is expected to double (to 7 million) by 2020.

Different mobility issues face the elderly because they typically drive less, have lower incomes, have health problems and may require special services and facilities. The majority of older people age in the places they lived while working. Increasingly these are suburban or rural communities where it is difficult to access services or facilities without a car, and where it has generally been difficult to provide transit services.

Exhibit 1-6 shows how annual miles driven decreases as age increases. It also shows annual miles driven by the elderly has steadily increased since 1969, which correlates with the growing number of elderly with driver's licenses. According to 1995 NPTS data, 55 percent of women and 84 percent of men aged 75 and over have licenses. More importantly, almost 100 percent of men and 90 percent of women who will be over the age of 70 in 2012 are currently licensed drivers. As a result we can expect the elderly will be driving more in the future than at present.

Exhibit 1-6

Average Annual Miles by Driver Age, 1969-1995

	1969	1977	1983	1990	1995
All Ages	8,685	10,006	10,588	13,181	13,476
60-64	8,112	8,002	8,568	10,314	11,354
65-69	5,850	6,277	6,804	8,347	9,054
70+	4,644	4,828	4,348	6,138	6,779

The expected increases in driving by the elderly pose some serious highway safety issues. Currently, the elderly are second only to teens in their crash involvement rate and have the highest fatality rate of any group on the road. An increasingly mobile elderly population will be sharing the road with non-elderly drivers who may be more aggressive in their driving. Intelligent transportation systems technology may offer some solutions to making this mix of drivers work.

Finally, the cultural composition of the elderly is changing. In 1995, approximately 87 percent of the elderly were White. By the middle of the next century, the Census Bureau predicts that 20 percent of older Americans will be African-American and 19 percent will be of races other than African-American or White. Over 15 percent will be of Hispanic origin. Currently, African-Americans and Hispanics travel less than Whites. As the older population becomes more diverse, will the trend toward increased travel by the elderly continue to hold?

Meeting the mobility needs of the elderly is especially complicated because many may not be able to drive. A 1990 study found that almost one in five men and one in three women older than age 75 required assistance to conduct some of their daily activities, such as bathing, dressing or eating. Between 80 and 90 percent of this kind of personal care, as well as help with household tasks—including transportation—are provided to the elderly by family members, often daughters and daughters-in-law. With the high levels of women working, there is a growing need for elderly service providers, including special transportation services designed to meet their unique needs. How our multimodal transportation system will meet the mobility needs of our expanding elderly population is a question of growing importance.

Role of Gender

Women's roles have and are continuing to change in all aspects of their lives—at home, at work, and in society at large. Changing gender roles represent the most significant influence on changes in travel behavior over the past quarter century.

Both men's and women's lives are becoming more complex as we try to balance work and family responsibilities. Women have made great strides and accomplishments in the last 20 years, but remain primarily responsible for family and shopping trips. These responsibilities stem from our attitudes toward how family needs are met. As Martin Wachs stated "travel patterns are among the most clearly 'gendered' aspects of American life."

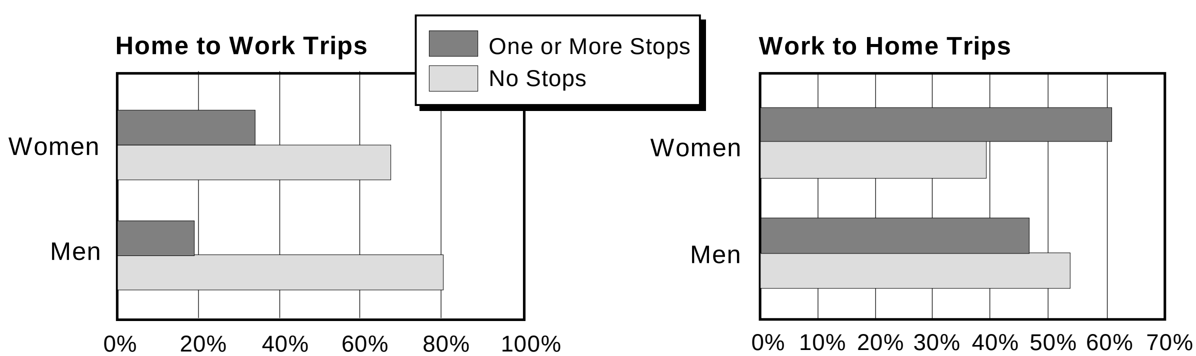
Working mothers make more trips, more often in a car, and cover more miles than at any time in the past 25 years. Dual career households buy services, such as day care, that were formerly conducted in the home. Mothers still serve as the primary "taxi" service for their children, and as they increase the number of hours worked, women link more and more stops on to the trip to and from work. This phenomenon is called "trip chaining." It is important to consider the impact of this complex travel pattern because trip chaining may increase congestion at the peak periods, and people who must link trips together have a limited ability to shift commute trips to transit or car pools.

Whereas travel by single adults of both sexes, and by men and women in households without children is rather similar, travel by men and women in households with smaller children is starkly different. Women have always made trips for sustaining the household such as shopping trips and family errands—the increase in women's participation in the labor force has pushed these trips into the non-work time periods. In addition, many employed women with children drop children at school or day-care on the way to work. Therefore, non-work related trips are being chained together between home and work. This trip-chaining behavior is especially prevalent by women in households with children under 5 years of age.

When we look at the 1995 NPTS, working adult women traveling on weekdays are more likely than men to make stops on the way to or from work, as shown in Exhibit 1-7. The majority of women (61.2 percent) make at least one stop after work, and almost thirty percent (28.3 percent) make two stops or more. Just under half (46.4 percent) of men stop on the way home from work, and only about one out of six (17.7 percent) make two stops or more. The job of running errands to support a home is exacerbated for low-income single mothers who are least likely to own or have access to an automobile.

Exhibit 1-7

Percent of Working Men and Women Who Trip Chain on the Way to or from Work



The effect of women's employment on their travel is clear. Between 1983 and 1995, the population of women 16 and older grew by 12 percent, the incidence of women in the workforce grew by 36 percent, and the average woman increased her daily person miles of travel by 49 percent. Perhaps in future years, with more women completing college, and entering more varied occupations, differences in jobs and salaries between men and women will translate into child care patterns and family responsibilities which are more evenly divided and the gap between men's and women's travel will close somewhat.

Role of Race and Hispanic Status

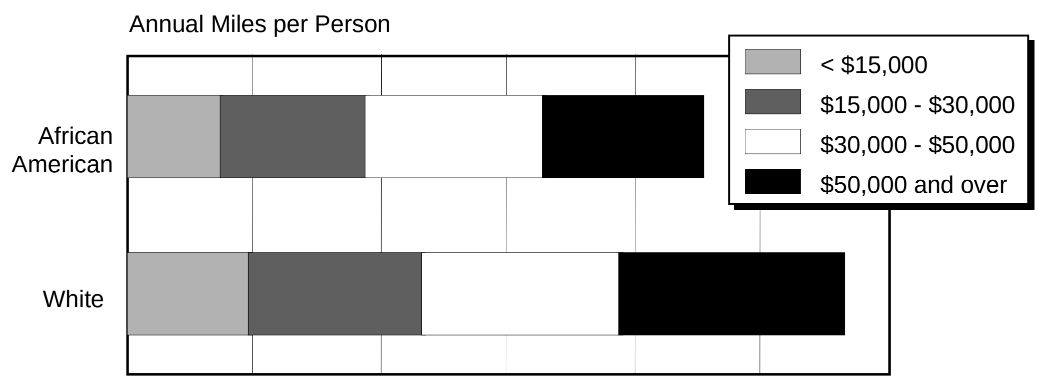
The influence of race, income and geography adds another dimension to the discussion of mobility. As Steven Polzin (University of South Florida) notes, African-Americans and Hispanics have historically spent more time at lower levels of comfort, reliability, security and safety to achieve the same level of mobility as Whites. Among Whites, 88 percent of travel is via automobile. The comparable share for Hispanics in 1995 was 83 percent and for African-Americans 76 percent. We've looked at these differences in terms of the ability to access a wide range of goods and services, and to be able to take advantage of job opportunities in a wider radius from home. How much of these differences are due to race and how much are due to the lower average household income of the African-American population?

When controlling for income, the differences are still very apparent by race as shown in Exhibit 1-8. African-Americans travel less and in a smaller area around their homes than Whites in the same income group—overall taking 15 percent fewer trips and traveling almost a quarter fewer miles per person per day.

African-Americans average 1,421 annual trips per person, or 3.9 trips a day, compared to 1,602 annual and 4.4 daily trips for Whites. As compared to Whites, African-Americans make six times the number of annual transit trips (95 vs.15) and almost twice the number of annual walk trips (131 vs. 72).

Exhibit 1-8

Travel Differences by African-Americans and Whites in the Same Income Class



Similar patterns are shown in the comparison of travel by Hispanics and non-Hispanics. Hispanics are twice as likely to use transit as non-Hispanics (48 annual trips vs. 25), and Hispanics make 50 percent more walking trips than non-Hispanics (126 vs. 80). The differences in private vehicle use are slight, with Hispanics making 83 percent of their trips by private vehicle, versus 88 percent for non-Hispanics.

The incidence of households without a vehicle is lower for Hispanics than non-Hispanics, and much lower for African-Americans than the general population (see Exhibit 1-9). While 14.9 percent of all low-income households (below $15,000) do not own a vehicle, this increases to 30.4 percent of low-income Hispanic households and 46.5 percent of low-income African-American households.

In terms of travel mode, 44 percent of transit trips are made by African-Americans, although they represent only 12.4 percent of the population. Clearly, race, income, and household location are intertwined to form a pattern of travel and mode use. Further research and data analysis may yield information that would allow for more effectively addressing the mobility needs of low-income and minority populations.

Exhibit 1-9

Percent of Households Without a Vehicle

All U.S. households without a vehicle	8.1%
Households with income below $15,000	14.9%
Hispanic households without a vehicle	12.2%
Hispanic households with income below $15,000	30.4%
African-American households without a vehicle	24.1%
African-American households with income below $15,000	46.5%

Summary

Although all elements of the population have increased their mobility over time, many challenges still exist. A transportation system that provides accessibility, efficiency and flexibility must meet mobility challenges through traditional as well as innovative means.

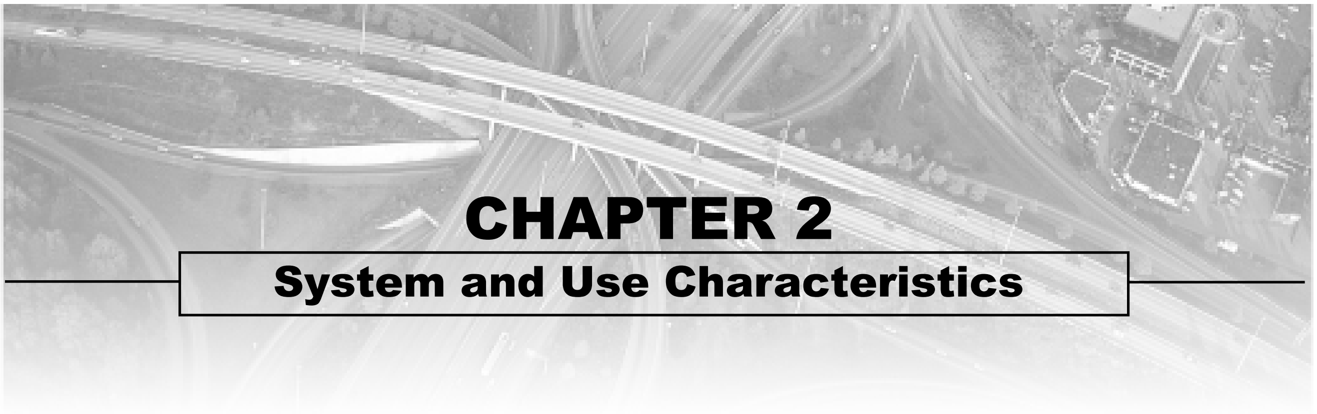
There is clearly a larger market for transit that has not yet been tapped. Currently, 84 percent of transit riders are frequent users, i.e., people who use transit two or more times a week. Demand-responsive programs to transport people to subways, trolleys and bus transfer points may increase the scope of people who consider transit as an option. Given the projected growth in the elderly population, customer oriented para-transit designed to meet the needs of older Americans may play a significant role in allowing this group to maintain their mobility.

There are a number of initiatives to promote the development of neo-traditional neighborhoods, which includes a return to higher density and mixed land use neighborhoods in which transit and walking would be viable options. The benefits of such development are found in improved air quality, residents having a full range of viable mode choices, improved health of those who walk and bike, and a greater sense of community.

Older Americans need responses that may come from new technology to insure their continued mobility and resolve some of the serious safety issues they present to themselves and others. Highway and vehicle technology can play an integral role in decreasing travel times and mitigating the impact of highway congestion.

Some researchers suggest that greater use of telecommunications and telecommuting may decrease work travel, while other researchers claim that Internet use will expand the need for geographic mobility. It is fairly certain that technology has and will continue to change travel patterns, and may result in more home-based trips and more deliveries to the home. More research is needed to help identify the major trends and assess their impact in the changing world of transportation, telecommunications and personal travel.

Having a private vehicle increases the range of goods and services available to the traveler by simply expanding the area accessible. In some areas where transit is not available, programs that provide autos may help make work viable for women on welfare. For some urban dwellers, however, an auto may be more of a liability than an asset. Innovative approaches to providing transportation services can help increase all of our ability to participate fully in our society.



CHAPTER 2

System and Use Characteristics

Introduction

This chapter describes system and use characteristics for most elements of the American surface transportation system. This network includes roads, bridges, and public transit infrastructure. As such, it provides the backbone for an economy that is increasingly hemispheric and dependent on the rapid, integrated movement of people and goods.

The chapter begins with a summary of the key points that are addressed in greater detail later in the chapter. This section includes a summary table comparing key highway and transit statistics with the values shown in the last report. This combined summary is followed by separate sections on highways, bridges, and transit characteristics and system usage.

Both vehicle miles and passenger miles of travel are distributed across functional systems, and travel by passenger vehicles, single-unit trucks, and combination trucks is shown by major highway category.

The transit section of this chapter begins with an overview of transit system operations, followed by information on the transit fleet and infrastructure. A discussion follows of transit route miles (the number of miles covered by a transit route), capacity, passenger miles of travel, and transit vehicle occupancy.

Summary

Exhibit 2-1 compares the system and use characteristics data in this report with the values shown in the 1997 C&P report. The first column shows the values from the 1997 C&P report, which were based on 1995 data. Some of the 1995 data have subsequently been revised, and this is reflected in the second column as applicable. The third column contains comparable values, based on 1997 data.

Exhibit 2-1

Comparison of System and Use Characteristics with Those in the 1997 C&P Report

	1995 data		1997 data
Statistic	1997 report	Revised	
Percentage of Total Highway Miles Controlled by Local Governments	75.1%	---	75.3%
Percentage of Total Highway Miles Controlled by State Governments	20.5%	---	20.4%
Percentage of Total Highway Miles Controlled by the Federal Government	4.4%	---	4.3%
Local Public Transit Operators in Urbanized Areas	537	---	542
Rural and Specialized Transit Services Providers	5,010	---	4,920
Total Rural Highway Miles (Population < 5,000)	3.09 million	3.10 million	3.11 million
Total Urban Highway Miles (Population >= 5,000)	0.82 million	0.82 million	0.84 million
Total Highway Miles	3.91 million	3.93 million	3.95 million
Transit Route Miles (Rail)	8,206	8,206	8,602
Transit Route Miles (Non-Rail)	158,078	158,076	156,733
Total Transit Route Miles	166,284	166,282	165,355
Total Rural Highway Lane Miles (Population < 5,000)	6.32 million	6.33 million	6.37 million
Total Urban Highway Lane Miles (Population >= 5,000)	1.84 million	1.85 million	1.89 million
Total Highway Lane Miles	8.16 million	8.19 million	8.26 million
Urban Transit Capacity-Equivalent Miles (Rail)	1.65 million	---	1.72 million
Urban Transit Capacity-Equivalent Miles (Non-Rail)	1.69 million	---	1.72 million
Urban Transit Capacity-Equivalent Miles (Total)	3.34 million	---	3.54 million
Vehicle Miles Traveled on Rural Highways (Population < 5,000)	0.93 trillion	0.94 trillion	1.00 trillion
Vehicle Miles Traveled on Urban Highways (Population >= 5,000)	1.49 trillion	1.50 trillion	1.56 trillion
Vehicle Miles Traveled on All Highways	2.42 trillion	2.44 trillion	2.57 trillion
Transit Passenger Miles (Rail)	19.7 billion	---	21.1 billion
Transit Passenger Miles (Non-Rail)	18.3 billion	---	19.0 billion
Transit Passenger Miles (Total)	38.0 billion	---	40.2 billion

Public road length as distinguished from lane-miles reached 3.95 million miles in 1997. This mileage is overwhelmingly *rural* and *local* (i.e., under local government jurisdiction). About 3.11 million miles were in rural areas in 1997, or 78.7 percent of total length on all American roads. At the same time, 2.97 million miles were under local jurisdiction in 1997, about 75.3 percent of the national road system. However, the percentage of roads owned by local governments has steadily increased since 1987, by an average of 0.4 percent annually, while the share of rural miles consistently decreased, by about 0.2 percent annually. (As defined in this report, rural areas include only those with a population under 5,000. Some areas that were formerly rural have been reclassified as urban, as their population has grown.)

Transit route miles represent the number of miles covered by a transit route. Transit route mileage fell slightly between 1995 and 1997 due to a decline in non-rail transit mileage. This largely reflects a shift from fixed route systems (such as scheduled buses) to non-fixed route modes (such as demand response and vanpools).

Total highway lane-mileage was 8.3 million in 1997, as described by Exhibit 2-7. Lane-mileage increased by an average of 0.3 percent annually between 1987 and 1997, most of which was on urban highways. Urban highway lane-miles grew by an average of 2.1 percent annually. Transit capacity-equivalent miles increased by an average of 1.8 percent annually over this 10-year period. Rail capacity-equivalent miles grew by an average of 2.0 percent annually, while non-rail capacity-equivalent miles grew by an average of 1.6 percent annually.

The number of vehicle-miles traveled (VMT) between 1987 and 1997 has actually been comparable among rural and urban communities. This is shown in Exhibit 2-11. The VMT increased annually by an average of 2.6 percent each year on rural highways and by 3.2 percent annually on urban roads. Traffic has increased in metropolitan areas, but it has also grown in rural areas where there is increased truck traffic and growing tourist travel in recreation areas.

Urban transit passenger miles grew at an average annual rate of 1.0 percent from 1987 to 1997. Passenger travel grew on rail modes more than three times faster than on non-rail modes (1.5 percent versus 0.4 percent annually). Passenger mile growth was especially pronounced between 1995 and 1997, as rail modes grew by 7.4 percent and non-rail modes by 4.1 percent. It should be noted that over 80 percent of the growth in rail PMT came from the heavy rail system of the New York City Transit Authority, which instituted a new fare structure during this period.

Highway and Bridge System and Use Characteristics

Ownership and Extent

Highways are essential to our way of life. They provide access to where we live, work, and shop. They provide a way to travel to distant places, for business or pleasure. And they provide the means for much of the goods and services we consume to be within our grasp. This chapter contains information on the ownership and extent of the highway systems that play such a large role in our lives.

Roads are commonly classified in one of two ways: *by ownership* or *by purpose*. This section describes highway and bridge system characteristics with this distinction. Jurisdictional responsibility refers to ownership of a particular road, while functional classification identifies the road by the level of service it provides. For example, arterial highways generally serve long trips; collectors disperse traffic between the arterials and lower level roads; and local roads connect neighborhoods and businesses at the most elementary level. Although this chapter presents highway miles by jurisdiction, system and use characteristics are examined by Highway Functional Classification.

> ***Q.*** **What constitutes highway jurisdiction?**
>
> ***A.*** Jurisdiction refers to governmental ownership, not necessarily responsibility. For example, some roads owned by the Federal Government are maintained by State highway authorities. Additionally, the designation of a public road as a Federal-aid highway does not alter its ownership or jurisdiction as a State or local road–only that its service value and importance have made that road eligible for Federal-aid construction and rehabilitation funds.

Ownership is divided among the Federal, State, and local governments. States own over 20 percent of the national road network. The Federal Government has responsibility for about 5 percent, primarily in national parks, forests, and Indian reservations. Over 75 percent of the road system is locally controlled, although some intergovernmental agreements may authorize States to construct and maintain locally controlled highways.

As Exhibit 2-2 demonstrates, the share of locally owned routes has grown steadily over the past decade. Public road mileage controlled by local governments increased by 1.4 percent between 1987 and 1997, or an average annual change of 0.2 percent. At the same time, State ownership of public road mileage declined slightly, by 0.2 percent annually, while miles of Federally owned roads declined by about 2.3 percent annually. The decline in Federal ownership of public roads is largely a result of Federal agencies reclassification of some of their mileage from public road to non-public road status.

Exhibit 2-2

Highway Mileage by Owner, 1987 and 1997

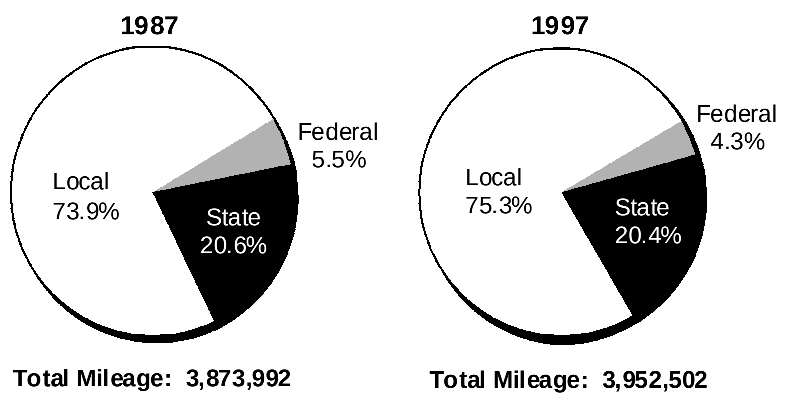


Exhibit 2-3

Highway Mileage by Owner, Selected Years 1987-1997

	1987	1989	1991	1993	1995	1997	Annual Change 1987-97
Rural Miles (population < 5000)							
Federal	211,202	177,575	176,771	179,604	170,568	167,368	-2.3%
State	703,753	707,161	702,600	690,853	692,866	694,713	-0.1%
Local	2,248,872	2,238,330	2,254,687	2,228,877	2,236,865	2,246,801	0.0%
Subtotal Rural	3,163,827	3,123,066	3,134,058	3,099,334	3,100,299	3,108,882	-0.2%
Urban Miles (population >= 5000)							
Federal	1,045	1,027	1,030	1,268	1,509	1,462	3.4%
State	95,414	96,872	95,836	109,260	113,090	113,565	1.8%
Local	613,706	655,900	652,996	695,349	711,820	728,593	1.7%
Subtotal Urban	710,165	753,799	749,862	805,877	826,419	843,620	1.7%
Total Highway Miles							
Federal	212,247	178,602	177,801	180,872	172,077	168,830	-2.3%
State	799,167	804,033	798,436	800,113	805,956	808,278	0.1%
Local	2,862,578	2,894,230	2,907,683	2,924,226	2,948,685	2,975,394	0.4%
Total	3,873,992	3,876,865	3,883,920	3,905,211	3,926,718	3,952,502	0.2%
Percent of Total Highway Miles							
Federal	5.5%	4.6%	4.6%	4.6%	4.4%	4.3%	-2.5%
State	20.6%	20.7%	20.6%	20.5%	20.5%	20.4%	-0.1%
Local	73.9%	74.7%	74.9%	74.9%	75.1%	75.3%	0.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Source: Highway Statistics Summary to 1995; June 1999 HPMS.

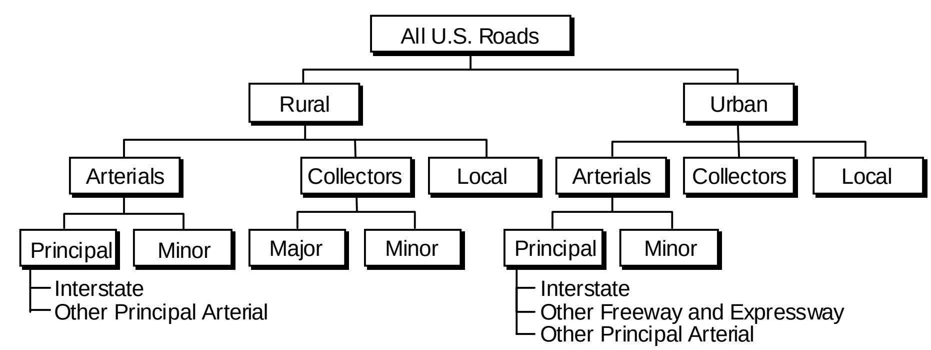
Another noticeable trend is the increase in urban highway miles. As urban areas grow throughout the United States, FHWA has expanded Federal-aid urban and urbanized area boundaries. This has led to a sharp decrease in rural miles, which dropped by an average of 0.2 percent annually between 1987 and 1997. During that same period, urban highway miles grew by an average of 1.7 percent each year.

Functional Classification

Another useful means of classifying roads is by the Highway Functional Classification System, which distinguishes among public roads by the service they provide. This is the basic organization used for the majority of this report. Exhibit 2-4 describes the hierarchy of the Highway Functional Classification System (HFCS).

Exhibit 2-4

Highway Functional Classification System



Arterials provide the highest level of mobility, at the highest speed, for long, uninterrupted travel.

The Interstate Highway System is an arterial network. Arterials generally have higher design standards than other roads, often with multiple lanes and 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. The rural principal arterial network is more significant. It serves virtually all urban areas with populations greater than 50,000 people. Additionally, most urban areas larger than 25,000 people are served by rural principal arterial highways. Rural principal arterial highways provide an integrated network without stub connections except where needed 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 1997, the rural principal arterial system accounted for about 3.3 percent of total miles in the United States. This small portion of highways carried 46.8 percent of rural traffic and 18.3 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, carrying 16.5 percent of rural traffic and 6.4 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 urban areas, and it provides continuity for all rural arterials that intercept urban boundaries. In 1997, the urban principal arterial system accounted for 1.9 percent of total miles in the United States. However, this network carried 57.8 percent of urban traffic 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 rural collector routes. In 1997, the urban minor arterial network represented 2.3 percent of total U.S. mileage. This system carried 19.5 percent of urban traffic and 12.0 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. Collectors are typically two-lane roads that collect and distribute traffic from the arterial system.

The rural collector system is stratified into two subsystems: major and minor collectors. Major collectors provide service to any county seat not on an arterial route. They also serve larger towns not accessed by higher order roads, and important industrial or agricultural centers that generate significant traffic (but are avoided by arterials). Rural major collectors accounted for 10.9 percent of total U.S. miles in 1997. They carried 20.2 percent of rural traffic and 7.9 percent of total travel in the United States.

Rural minor collectors are spaced at intervals, consistent with population density, to collect traffic from local roads and to insure that all urbanized areas are within a reasonable distance of a collector road. The rural minor collector system accounted for 6.9 percent of total U.S. mileage in 1997. These roads carried 5.3 percent of rural traffic 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 1997, the urban collector network accounted for 2.2 percent of U.S. road mileage. It carried 8.04 percent of urban traffic 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 1997, rural local roads represented 54.1 percent of total U.S. road mileage. Local roads carried only 11.5 percent of rural traffic and 4.5 percent of total travel in the United States. Urban local roads, meanwhile, accounted for 14.9 percent of total U.S. road mileage, 14.3 percent of urban traffic, and 8.7 percent of total U.S. travel.

Exhibit 2-5 summarizes the *percentage* of highway miles by functional classification. Like the jurisdictional information in Exhibit 2-2, Exhibit 2-6 shows a decrease in the percentage of miles in rural areas. However, the proportion of VMT on rural highways increased slightly between 1995 and 1997, from 38.5 percent to 39.1 percent. Accordingly, the percentage of urban highway VMT dropped slightly from 61.5 percent to 60.9 percent. Despite this slight decrease, the overwhelming majority of travel is still on urban highways in metropolitan communities.

In 1997, total public road length in the United States reached over 3.9 million route miles. About 78.7 percent of this was in rural areas, or approximately 3.1 million route miles. The remaining 21.3 percent of route mileage, or about 844,000 miles, was in urban communities. Overall route miles

Exhibit 2-5

Percentage of Highway Miles, Lane-Miles, and Vehicle-Miles Traveled by Functional System, 1997

Functional System	Miles	Lane-Miles	Vehicle-Miles Traveled
Rural Highways			
Interstate	0.8%	1.6%	9.4%
Other Principal Arterials	2.5%	3.0%	8.9%
Minor Arterial	3.5%	3.5%	6.4%
Major Collector	10.9%	10.6%	7.9%
Minor Collector	6.9%	6.6%	2.1%
Local	54.1%	51.8%	4.5%
Subtotal Rural	78.7%	77.1%	39.1%
Urban Highways			
Interstate	0.3%	0.9%	14.2%
Other Freeway & Expressway	0.2%	0.5%	6.3%
Other Principal Arterial	1.4%	2.2%	15.1%
Minor Arterial	2.3%	2.8%	11.6%
Collector	2.2%	2.3%	4.9%
Local	14.9%	14.3%	8.7%
Subtotal Urban	21.3%	22.9%	60.9%
Total Highway	100.0%	100.0%	100.0%

Source: June 1999 HPMS.

increased by an average annual rate of 0.2 percent between 1987 and 1997, decreasing by 0.1 percent in rural communities and increasing nearly 1.7 percent annually in urban areas. These statistics are described in Exhibit 2-6.

Exhibit 2-7 describes the number of highway lane-miles by functional system. Total highway lane-mileage was 8.3 million in 1997. Lane-mileage increased by an average of 0.3 percent annually

Exhibit 2-6

Highway Route Miles by Functional System, Selected Years 1987-1997

Functional System	1987	1989	1991	1993	1995	1997	Annual Rate of Change 1987-97
Rural Highway Route-Miles (population < 5000)							
Interstate	33,107	33,378	33,677	32,631	32,680	32,919	-0.1%
Other Principal Arterial	80,722	80,951	86,747	96,770	98,046	98,358	2.0%
Minor Arterial	147,252	147,327	141,795	137,577	137,444	137,791	-0.7%
Major Collector	435,409	436,184	436,746	432,222	432,482	433,500	0.0%
Minor Collector	294,793	294,424	293,511	282,182	274,764	273,042	-0.8%
Local	2,172,544	2,130,802	2,141,582	2,117,952	2,124,885	2,141,111	-0.1%
Subtotal Rural	3,163,827	3,123,066	3,134,058	3,099,334	3,100,301	3,116,721	-0.1%
Urban Highway Route-Miles (population >= 5000)							
Interstate	11,211	11,471	11,602	12,877	13,307	13,395	1.8%
Other Freeway & Expressway	7,390	7,582	7,709	8,841	9,022	9,116	2.1%
Other Principal Arterial	50,470	51,493	52,515	52,708	53,044	53,469	0.6%
Minor Arterial	74,984	74,746	74,795	86,821	89,013	89,684	1.8%
Collector	76,863	78,473	77,102	84,854	87,918	88,650	1.4%
Local	489,247	530,034	526,139	559,776	574,119	589,463	1.9%
Subtotal Urban	710,165	753,799	749,862	805,877	826,423	843,777	1.7%
Total Highway Route-Miles	**3,873,992**	**3,876,865**	**3,883,920**	**3,905,211**	**3,926,724**	**3,960,498**	**0.2%**

Source: Highway Statistics 1985-1995, Highway Statistics, 1997.

Exhibit 2-7

Highway Lane-Miles by Functional System, Selected Years 1987-1997

Functional System	1987	1989	1991	1993	1995	1997	Annual Rate of Change 1987-97
Rural Highway Lane-Miles (population < 5000)							
Interstate	133,452	134,960	136,503	132,138	132,344	133,574	0.1%
Other Principal Arterial	203,535	205,654	220,796	240,574	245,095	248,921	2.1%
Minor Arterial	308,939	308,308	297,017	285,332	286,433	288,742	-0.6%
Major Collector	878,187	880,182	880,539	870,109	870,855	874,969	0.0%
Minor Collector	589,586	588,848	587,022	564,364	549,528	546,084	-0.8%
Local	4,345,088	4,261,604	4,283,164	4,235,904	4,249,770	4,282,222	-0.2%
Subtotal Rural	6,458,787	6,379,556	6,405,041	6,328,421	6,334,025	6,374,512	-0.1%
Urban Highway Lane-Miles (population >= 5000)							
Interstate	59,835	61,786	62,826	69,184	72,078	72,967	2.4%
Other Freeway & Expressway	32,546	33,460	34,736	39,588	40,533	41,402	2.7%
Other Principal Arterial	166,762	170,423	176,536	176,261	180,637	184,203	1.5%
Minor Arterial	190,230	189,113	191,088	219,537	226,737	229,631	2.4%
Collector	164,361	168,546	165,288	179,653	186,317	189,476	1.6%
Local	978,494	1,060,068	1,052,278	1,119,552	1,148,234	1,178,926	2.2%
Subtotal Urban	1,592,228	1,683,396	1,682,752	1,803,775	1,854,536	1,896,605	2.1%
Total Highway Lane-Miles	8,051,015	8,062,952	8,087,793	8,132,196	8,188,561	8,271,117	0.3%

Source: Highway Statistics 1985-1995, updated as of 10/97. June 1999 HPMS.

between 1987 and 1997, most of which was on urban highways. Urban highway lane-miles grew by an average of 2.1 percent annually, while rural highway lane-miles dropped by about 0.1 percent each year.

Bridges

Exhibit 2-8 describes bridges by jurisdiction. The number of privately-owned bridges and those in rural communities declined from 1996 to 1998, but there was an increase in bridges on Federal and state property. Exhibit 2-9 relates bridge data by functional classification. The number of urban bridges—and those on arterial systems—increased between 1996 and 1998. This resulted from more aggressive reporting efforts for the National Bridge Inventory (NBI). It also occurred because many roads that included bridges were reclassified from rural to urban. Exhibit 2-10 illustrates the functional system data presented in Exhibit 2-9.

Exhibit 2-8

Bridges by Owner, 1996 and 1998

	Number of Bridges	
Owner	1996	1998
Federal	6,171	7,448
State	273,198	273,897
Local	299,078	298,222
Private	2,378	2,278
Unknown/Unclassified	1,037	1,131
	581,862	582,976

Source: National Bridge Inventory, 1999.

Exhibit 2-9

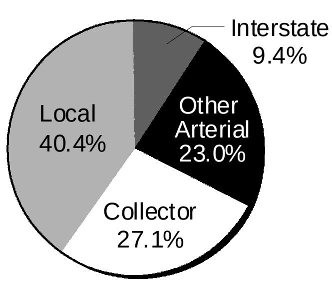
Bridges by Functional System, 1996 and 1998

	Number of Bridges	
Functional System	1996	1998
Rural Bridge		
Interstate	28,638	27,530
Other Arterial	72,970	73,324
Collector	144,246	143,140
Local	211,059	210,670
Subtotal Rural	456,913	454,664
Urban Bridge		
Interstate	26,596	27,480
Other Arterial	59,064	60,901
Collector	14,848	14,962
Local	24,441	24,969
Subtotal Urban	124,949	128,312
Bridge Total	581,862	582,976

Source: National Bridge Inventory, 1999.

Exhibit 2-10

Distribution of Bridges by Function, 1998



Use Characteristics

This section describes highway infrastructure use. Highway use is defined by VMT. Total highway VMT grew to 2.6 trillion in 1997. While Exhibit 2-11 shows increases for both urban and rural systems, perhaps the most interesting change is the growth in VMT on rural highways. Rural highway VMT climbed from 937 billion in 1995 to over 1.0 trillion in 1997, a 7.2 percent increase. During this time, urban highway vehicle-miles increased by 4.1 percent, from 1.50 trillion to about 1.56 trillion.

Exhibits 2-12 and 2-13 describe highway travel by functional classification and vehicle type, expanding on the information in Exhibit 2-11. In these exhibits there are three types of vehicles. Passenger vehicles (PV) include buses and 2-axle, 4-tire vehicles; single unit trucks (SU) have 6 or more tires; and combination trucks (Combo) include trailers and semi-trailers.

As Exhibits 2-12 and 2-13 show, travel grew the fastest on rural and urban interstates, particularly among combination trucks. For example, the average annual growth rate between 1987 and 1997 was 4.4 percent for combination trucks on rural interstates and 3.9 percent on urban interstates. Overall, passenger vehicle travel grew by an average of 2.8 percent annually between 1987 and 1997. Single unit truck travel grew by about 3.4 percent each year, and combination truck travel increased by an average of 3.8 percent annually.

Exhibit 2-11

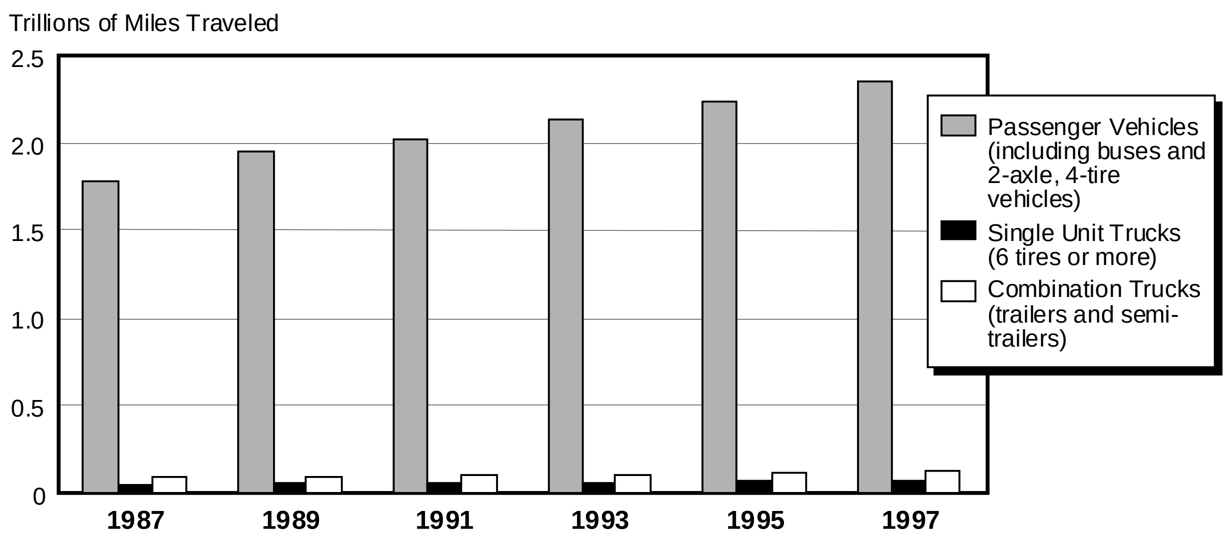
Highway Vehicle (VMT) and Passenger Miles of Travel (PMT), 1987-1997 (Millions of Miles)

Functional System	1987	1989	1993	1995	1997	Annual Rate of Change 1987-97
Rural Highway Vehicle-Miles (population < 5000)						
Interstate	170,493	191,085	208,308	224,435	241,451	3.5%
Other Principal Arterial	155,446	165,859	203,113	215,941	229,133	4.0%
Minor Arterial	146,543	156,646	146,454	153,824	163,999	1.1%
Major Collector	174,301	187,195	178,170	186,904	201,926	1.5%
Minor Collector	44,535	48,714	48,126	50,389	53,076	1.8%
Local	89,132	97,726	102,535	105,826	115,058	2.6%
Subtotal Rural	780,450	847,225	886,706	937,319	1,004,643	2.6%
Urban Highway Vehicle-Miles (population >= 5000)						
Interstate	244,836	270,735	317,399	344,602	364,769	4.1%
Other Freeway & Expressway	109,961	122,024	142,063	152,377	160,482	3.9%
Other Principal Arterial	304,684	327,173	354,976	372,995	387,808	2.4%
Minor Arterial	224,144	234,769	276,939	295,355	298,954	2.9%
Collector	95,970	101,871	117,887	128,362	126,718	2.8%
Local	161,159	192,690	200,408	207,361	223,584	3.3%
Subtotal Urban	1,140,754	1,249,262	1,409,672	1,501,052	1,562,315	3.2%
Total Highway Vehicle Miles	**1,921,204**	**2,096,487**	**2,296,378**	**2,438,371**	**2,566,958**	**2.9%**
Total Highway Passenger Miles	**3,088,227**	**3,231,369**	**3,825,052**	**4,017,442**	**4,087,217**	**2.8%**

Source: Highway Statistics, Summary to 1995, Tables VM-202 and VM-201, June 1997 HPMS. June 1999 HPMS.

Exhibit 2-12

Highway Travel by Vehicle Type, 1987-1997



Source: Highway Statistics, Summary to 1995, Table VM-201; Highway Statistics, 1997, Table VM-1.

Exhibit 2-13

Highway Travel by System and Vehicle Type, 1987-1997
(Millions of Vehicle-Miles Traveled)

Functional System Vehicle Type	1987	1989	1991	1993	1995	1997	Rate of Change 1987-97
Rural Interstate							
PV	138,323	156,503	168,361	169,500	180,031	188,969	3.2%
SU	5,060	5,485	5,822	5,982	6,708	7,667	4.2%
Combo	27,110	29,097	30,829	32,826	36,644	41,642	4.4%
Other Arterials							
PV	272,816	291,874	302,889	314,469	331,539	349,555	2.5%
SU	10,078	10,549	10,866	11,374	12,980	13,668	3.1%
Combo	19,095	20,082	21,000	23,724	24,076	25,467	2.9%
Other Rural							
PV	287,100	311,532	320,913	304,389	315,687	338,590	1.7%
SU	11,154	11,690	11,960	12,505	12,948	13,671	2.1%
Combo	9,714	10,413	10,914	11,936	12,676	12,447	2.5%
Total Rural							
PV	698,239	759,909	792,163	788,358	827,257	877,114	2.3%
SU	26,292	27,724	28,648	29,861	32,636	35,006	2.9%
Combo	55,919	59,592	62,743	68,486	73,396	79,556	3.6%
Urban Interstate							
PV	225,307	249,144	262,400	294,703	315,888	330,668	3.9%
SU	5,395	5,970	6,384	6,513	7,148	7,906	3.9%
Combo	14,135	15,622	16,540	16,183	18,492	20,641	3.9%
Other Urban							
PV	864,141	944,685	967,945	1,053,429	1,101,516	1,144,334	2.8%
SU	16,335	17,176	17,866	20,398	22,923	23,933	3.9%
Combo	15,442	16,665	17,361	18,446	23,567	24,303	4.6%
Total Urban							
PV	1,089,448	1,193,829	1,230,345	1,348,132	1,417,404	1,475,002	3.1%
SU	21,730	23,146	24,250	26,911	30,071	31,839	3.9%
Combo	29,577	32,287	33,901	34,629	42,059	44,944	4.3%
Total							
PV	1,787,687	1,953,738	2,022,508	2,136,490	2,244,661	2,352,116	2.8%
SU	48,022	50,870	52,898	56,772	62,707	66,845	3.4%
Combo	85,496	91,879	96,644	103,115	115,455	124,500	3.8%

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, 1997, Table VM-1.

Transit System Characteristics

The Role of Mass Transit

Public transit in the United States performs several services for transit passengers and local taxpayers. These can be summarized by three public policy functions:

- Transit provides *basic mobility* for those who cannot operate a motor vehicle because of low income, disability, youth, old age, or other reasons. These users benefit from a transit system that provides regular access to multiple destinations at a low cost.
- Transit encourages household *location efficiency.* A well-developed transit system encourages dense, multiple-purpose, pedestrian-oriented urban development in the vicinity of transit corridors and stations. This pattern of development allows households to reduce their ownership and use of motor vehicles while continuing to enjoy the benefits of accessibility to activity destinations.
- Transit assists in *congestion relief*. If transit service consistently provides door-to-door travel times that are competitive with those of private automobile trips, then transit will provide a meaningful substitute for autos as the travel mode of choice. In doing so, transit can effectively reduce roadway congestion. This function is especially important for commuting trips, which are often made during times of peak-period congestion on the urban road system. This function is best served by transit modes with a separate right-of-way and grade from the highway system, such as bus rapid transit and heavy rail systems.

These three public policy functions, while distinct in purpose, will obviously overlap with and support each other. For example, a transit vehicle may primarily serve as a congestion relief tool during peak travel periods while supporting basic mobility in off-peak hours. An individual may choose a housing location near a transit station in order to both avoid rush-hour congestion and to access diverse shopping and entertainment activities in the evening. For illustration purposes, however, it is often useful to assign transit trips to a particular functional category. Exhibit 2-14 describes such a classification system for transit trips in the 1995 Nationwide Passenger Transportation Survey.

Exhibit 2-14

Classification of Transit Trips by Public Policy Function

	Poverty	Vehicle Ownership	Age
Basic Mobility	Below	None or More	Not 16 - 74
Location Efficiency	Above	No Autos Owned	16 to 74
Congestion Relief	Above	One or More	16 to 74

Source: 1995 NPTS.

Using these definitions, Exhibit 2-15 indicates that basic mobility accounted for 40.1 percent of total transit passengers in 1995. Location efficiency accounted for 25.3 percent of total patronage, while congestion relief represented 34.7 percent of transit patronage.

Exhibit 2-15

Passenger Trips by Public Policy Function

	Percent
Basic Mobility	40.1%
Location Efficiency	25.3%
Congestion Relief	34.7%
Total	100.0%

Source: 1995 NPTS.

Exhibit 2-16 illustrates the distinct market niche that each of the three policy functions serves. Only 20 percent of the transit trips made by the basic mobility group were for work

Exhibit 2-16

Trip Characteristics of Transit's Primary Market Niches

	Percent Work Trips	Average Trip Distance (miles)	Percent by Bus
Basic Mobility	20.0%	10.2	82.9%
Location Efficiency	38.8%	6.9	60.1%
Congestion Relief	58.6%	21.0	57.3%

Source: 1995 NPTS.

trips, compared with 38.8 percent of the trips made by the location efficient group and 58.6 percent for the congestion relief group. For basic mobility, transit serves a wide variety of purposes, as users in this niche depend on transit for most of their mobility needs. Transit usage in the location efficiency niche serves fewer mobility purposes, as more of these purposes are served by neighborhood walking trips. Work trips dominate for congestion relief, when non-discretionary travel needs during peak congestion periods make rapid transit an appealing alternative to the private automobile.

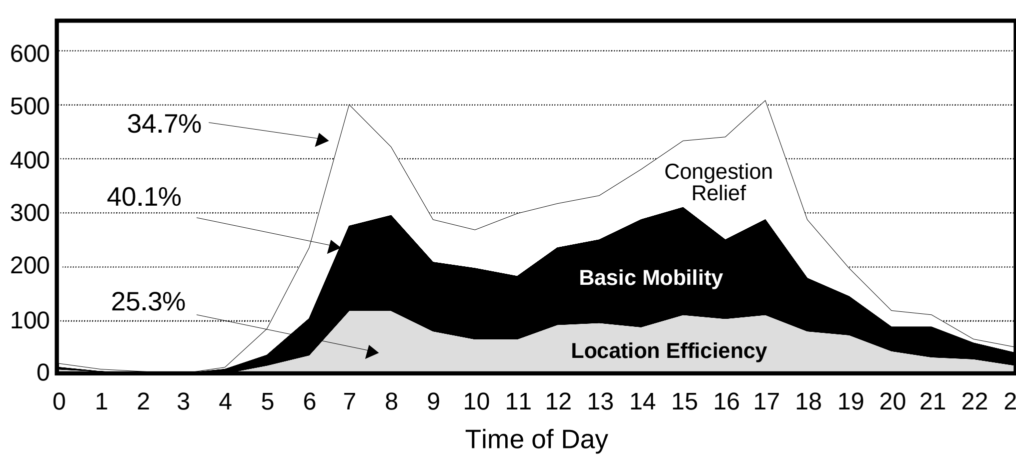
The average trip distance for basic mobility, 10.2 miles, is similar to the average automobile trip distance in the United States. The average trip distance for those wishing to bypass congestion is twice as long, reflecting the particular appeal of rapid transit for lengthy, congested work trips. Transit trips are shortest for those interested in location efficiency, reflecting transit's role in distributing passengers across central neighborhoods and commercial centers.

The relatively high share of basic mobility trips (82.9 percent) on buses as compared to location efficiency and congestion relief (60.1 and 57.3 percent, respectively) reflects two important characteristics of mass transit and its ridership. First, it reflects the preference of transit users in these two latter niches (who generally have higher incomes than those of basic mobility users) for faster modes of transportation, such as rail transit. Second, the greater dependence of the basic mobility group on bus transit also reflects the greater coverage provided by bus routes relative to rail routes, an especially important feature to individuals with limited mobility, such as the elderly and disabled.

Exhibit 2-17 shows how transit usage by the three market niches varies by time of day. Trips made by the location efficient group, *above-poverty households without cars*, tend to be evenly distributed throughout the day, with a very mild peaking in the morning and afternoon. Trips made by people from below poverty households tend to be slightly more peaked during the commuting hours. Transit use by above poverty households with cars contributes the most to the peaking of travel demand.

Exhibit 2-17

Transit Trips by Function and Time of Day, 1995



System Operations and Infrastructure

While State and Federal governments provide much of the funding for public transit in the United States, actual operations remain primarily a local responsibility. As local governments come to realize the regional nature of transportation problems, metropolitan planning organizations are playing an increasing role in formulating transit policy. Regional planning allows local officials to consider the effects of the transportation system on other characteristics of the urban environment as well, including land use, employment creation and location, and accessibility.

While most mass transit usage continues to occur in major metropolitan areas, it is becoming increasingly important in small urban areas and rural areas. In 1997 there were 556 local public transit operators serving 319 urbanized areas. There were also 1,260 operators providing service in rural areas, and 3,660 providers of specialized service to the elderly and disabled.

The urban transit system continues to grow in the United States. In 1997, transit systems in the U.S. operated 149,468 vehicles (Exhibit 2-18). Rail operators controlled over 9,922 miles of track and served 2,681 stations. There were also 1,179 maintenance facilities for transit vehicles in use. Between 1995 and 1997, the number of vehicles increased by 10.3 percent, track mileage grew by 3.6 percent, the number of stations increased by 2.3 percent, and the number of maintenance facilities grew by 1.2 percent.

Route Miles

Another indicator of the extent of transit service is route mileage. This represents the mileage covered by a transit route, independent of the number of vehicles that serve that route. The routes may be along fixed guideways (as in the case of rail modes) or may share city streets with other vehicles (as for most bus routes). When routes overlap, the mileage is counted separately for each route. Route miles are also called directional route miles, meaning that they are counted for vehicles traveling in a particular direction. This accounts for such transit route features as one-way loops.

Exhibit 2-19 shows transit route mileage from 1987 to 1997. In 1997, there were 8,602 rail route miles and 156,733 non-rail route miles operated by mass transit systems. While overall mileage increased at an annual rate of 1.1 percent during that period, it actually fell slightly between 1995 and 1997. This was due to a decline in non-rail transit mileage, reflecting a shift from fixed route systems (such as scheduled buses) to non-fixed route modes (such as demand response and vanpools). While rail systems continue to represent only 5.0 percent of transit route mileage, they are growing significantly. Rail route miles have increased at an annual rate of 3.7 percent since 1987, reflecting the new-start rail systems and extensions that have come online during that period.

System Capacity

Transit service capacity is measured by vehicle revenue miles (VRM), which incorporate the distance traveled by a transit vehicle (e.g., a bus or train car) in passenger-carrying revenue service. Vehicle revenue miles can be adjusted to reflect differences in the carrying capacity of different kinds of transit vehicles, using the typical bus as the reference point. The resulting measure, Transit Capacity-Equivalent Miles, is shown in Exhibit 2-20.

In 1997, transit operators supplied 3.44 billion capacity-equivalent miles of service in the United States. Of this total, 1.72 billion capacity-equivalent miles came from rail modes, a 2.0 percent annual increase since 1987, and 1.72 billion came from non-rail modes, representing an annual rate of increase of 1.6 percent over the same time period.

Exhibit 2-18

Urban Mass Transit Active Fleet and Infrastructure, 1997

	Urbanized Areas over 1 million	Urbanized Areas under 1 million	Total
Vehicles			
Buses	43,169	20,088	63,257
Heavy Rail	10,273	0	10,273
Light Rail	1,216	46	1,262
Self-Propelled Commuter Rail	2,520	0	2,520
Commuter Rail Trailers	2,757	0	2,757
Commuter Rail Locomotives	624	0	624
Vans	12,620	8,662	21,282
Other (including Ferryboats)	145	138	283
Rural Service Vehicles	0	17,879	17,879
Special Service Vehicles	4,400	24,931	29,331
Total Active Vehicles	**77,723**	**71,745**	**149,468**
Infrastructure			
Track Mileage			
Heavy Rail	2,148	0	2,148
Commuter Rail	6,845	104	6,949
Light Rail	780	23	803
Other Rail	21	2	23
Total Track Mileage	**9,794**	**129**	**9,922**
Stations			
Heavy Rail	997	0	997
Commuter Rail	1,103	8	1,111
Light Rail	493	37	530
Other Rail	36	7	43
Total Transit Rail Stations	**2,629**	**52**	**2,681**
Maintenance Facilities			
Heavy Rail	53	0	53
Light Rail	23	3	26
Commuter Rail	41	0	41
Ferryboat	6	1	7
Buses	272	235	507
Demand Response	28	55	83
Other	9	3	12
Rural Transit Maintenance Facilities	0	450	450
Total Maintenance Facilities	**433**	**746**	**1,179**

Exhibit 2-19

Urban Transit Route Miles, 1987-1997

	1987	1989	1991	1993	1995	1997	Annual Rate of Change
Rail	5,966	6,754	7,003	7,334	8,206	8,602	3.7%
Non-Rail	141,915	146,589	149,332	158,779	158,076	156,733	1.0%
Total	**149,868**	**155,332**	**158,326**	**168,106**	**168,277**	**167,332**	**1.1%**
Percent Rail	*4.0%*	*4.3%*	*4.4%*	*4.4%*	*4.9%*	*5.1%*	

Source: National Transit Database.

Exhibit 2-20

Transit Capacity, 1987-1997
(Millions of Urban Transit Capacity-Equivalent Vehicle Revenue Miles)

	1987	1989	1991	1993	1995	1997	Annual Rate of Change
Rail	1,406	1,539	1,558	1,564	1,646	1,722	2.0%
Non-Rail	1,468	1,562	1,619	1,659	1,689	1,718	1.6%
Total	**2,873**	**3,100**	**3,178**	**3,223**	**3,335**	**3,440**	**1.8%**
Percent Rail	*48.9%*	*49.6%*	*49.0%*	*48.5%*	*49.4%*	*50.0%*	

Source: National Transit Database.

Passenger Travel

Transit travel is measured by passenger miles traveled (PMT), the total number of miles traveled by passengers in transit vehicles. Transit PMT is described in Exhibit 2-21. Urban transit passenger miles grew at an annual rate of 1.0 percent from 1987 to 1997. Passenger travel growth on rail modes was more than three times higher than on non-rail modes (1.5 percent versus 0.4 percent annually). In 1997, rail travel was 21.1 billion PMT, which accounted for nearly 53.0 percent of transit passenger miles (while serving just 5.1 percent of route miles, as noted above). Passenger mile growth was especially significant between 1995 and 1997, as rail modes grew by 7.4 percent and non-rail modes by 4.1 percent during that two-year span. This difference again reflects the recent expansion of rail transit in the U.S.

Exhibit 2-21

Urban Transit Passenger Miles, 1987-1997 (Millions of Miles)

	1987	1989	1991	1993	1995	1997	Annual Rate of Change
Rail	18,131	19,766	18,551	17,867	19,682	21,138	1.5%
Non-Rail	18,241	18,455	18,921	18,353	18,289	19,043	0.4%
Total	**36,372**	**38,221**	**37,472**	**36,220**	**37,971**	**40,180**	**1.0%**
Percent Rail	*49.8%*	*51.7%*	*49.5%*	*49.3%*	*51.8%*	*52.6%*	

Source: National Transit Database.

Vehicle Occupancy

Transit vehicle occupancy is calculated as passenger miles traveled divided by capacity-equivalent vehicle revenue miles. This measure relates transit service consumed by passengers to the transit service supplied by the operators of vehicles. In 1997, vehicle occupancy was 11.7 passengers for all transit services, 12.3 passengers per capacity-equivalent vehicle for rail modes, and 11.1 passengers per vehicle for non-rail modes (Exhibit 2-22). While these figures reflect a decline relative to 1987 for both rail and non-rail modes, they have been increasing since 1993 for rail and 1995 for non-rail modes.

Q. **Are there any major changes that might explain the recent growth in rail passenger mileage?**

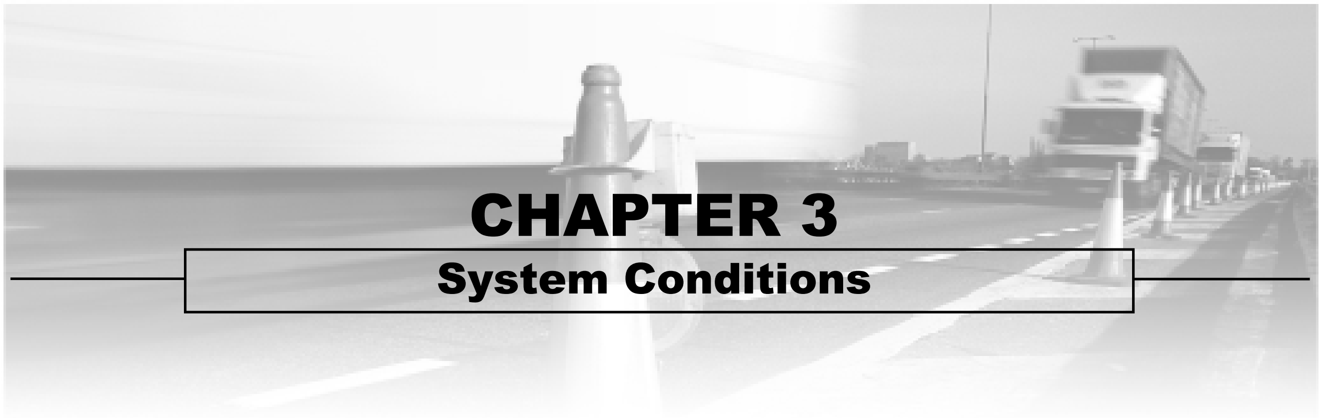
A. Over 80 percent of the nationwide growth in rail PMT between 1995 and 1997 occurred on the heavy rail system of the New York City Transit Authority. Much of the increase in that city can be attributed to the change in fare structure that occurred with the introduction of the Metrocard system.

Exhibit 2-22

Transit Vehicle Occupancy (Passengers per Capacity-Equivalent Vehicle)

	1987	1989	1991	1993	1995	1997
Rail	12.9	12.8	11.9	11.4	12.0	12.3
Non-Rail	12.4	11.8	11.7	11.1	10.8	11.1
Total	**12.7**	**12.3**	**11.8**	**11.2**	**11.4**	**11.7**

Source: National Transit Database.



CHAPTER 3

System Conditions

Introduction

The surface transportation system consists of a highway component and transit component. The condition of these two components is addressed in this chapter. The highway system assessment includes the status of roads and bridges. The transit system condition is based on the status of transit vehicles and facilities. Each element presented influences the overall condition of our transportation system. The data in this chapter will not only provide an evaluation of the transportation system, but can also help identify the future rehabilitation and replacement needs.

This chapter begins with a summary table comparing key highway and transit statistics with the values shown in the last report. This table is followed by a summary of the key points addressed in more depth later in the chapter.

The road conditions section of this chapter reviews pavement condition, alignment adequacy and lane widths. The pavement condition segment describes the measurement used, presents the overall pavement condition, and breaks down pavement conditions by location (rural/urban) and functional system. The alignment segment explains horizontal and vertical alignment, presents the rating system and evaluates the alignment adequacy in rural areas by functional system. The lane width segment describes current Interstate lane width requirements and presents lane widths by location and functional system. Where possible historical trends are illustrated.

The section of this chapter dealing with bridges includes bridge ratings and number of deficient bridges. Next, the number of deficient bridges is broken down by jurisdiction, location and functional system. The section concludes with a historical view of bridges on Interstates, other arterials, collectors and local functional systems.

The transit conditions section begins with a brief discussion of how transit conditions are measured; a more detailed discussion of the methodology is found in Appendix I. The section is broken down into three segments: urban bus conditions, rail conditions, and rural and specialized transit conditions. In the bus segment, information on the condition of bus vehicles is presented for different types of buses. Urban bus maintenance facility ages and conditions are also shown. In the rail segment, conditions for different types of vehicles are presented, followed by the conditions of different types of rail infrastructure. The rural and specialized transit segment contains information that is carried over from the previous report.

The data sources for the condition analysis include the Highway Performance Monitoring System (HPMS), the Nationwide Personal Travel Survey (NPTS), the National Bridge Inventory (NBI), the Transit Economic Requirements Model (TERM), the National Transit Database (NTD), the National Bus Condition Assessment (NBCA), and data provided by the Community Transportation Association of America (CTAA). The NBI covers all bridges on public roads and is collected biannually.

Summary

Exhibit 3-1 highlights the key highway and transit statistics discussed in this chapter, and compares them with the values from the last report. The first data column contains the values reported in the 1997 C&P report, which were based on 1995 data. Where the 1995 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 1997 data.

Exhibit 3-1

Comparison of the System Conditions Statistics with Those in the 1997 C&P Report

Statistic	1995 Data		1997 Data
	1997 Report	Revised	
Pavement in Good or Very Good Condition	42.2%	---	41.3%
Pavement in Fair Condition	38.9%	39.0%	41.6%
Pavement in Poor Condition	6.4%	---	6.6%
Poor Pavement on Rural Interstates	5.3%	---	3.7%
Poor Pavement on Urban Interstates	9.8%	---	9.2%
Deficient Bridges	31.4%	---	29.6%
Deficient Bridges on Interstates	24.7%	---	21.6%
Deficient Bridges on Other Arterials	27.6%	---	25.8%
Average urban bus condition rating	3.8	3.0	3.1
Average rail vehicle condition rating	4.2	---	4.0
Poor/substandard urban bus maintenance facilities	19%	---	23%
Good/excellent rail track mileage	73%	---	73%
Good/excellent rail maintenance facilities	64%	---	60%
Average small rural bus age	4.9 yrs	---	4.9 yrs

The pavement conditions reported in this chapter include all functional systems except rural minor collectors and local roads. The overall pavement conditions are presented based on the qualitative condition terms “very good,” “good,” “fair,” “mediocre” and “poor.” These ratings are derived from one of two measures: International Roughness Index (IRI) or Present Serviceability Rating (PSR). The definitions for IRI and PSR and the relationship between these two measures are discussed later in the chapter.

In 1997, 41.3 percent of measured roads were in “very good” or “good” condition, 52.1 percent were in “fair” or “mediocre” condition and 6.6 percent were in “poor” condition. Since 1995, there was a slight decrease in the percentage of miles rated “very good” or “good” and a slight increase in the percentage of miles rated “fair” or “mediocre” and “poor.” Pavement condition on the Interstate system improved since 1995. The percentage of “poor” pavement on rural and urban Interstates decreased while the percentage of “very good” or “good” pavement on both rural and urban Interstates increased. Based on the NHS “acceptable ride quality” standard, Interstate pavement condition improved in both rural and urban areas.

The common indicator used to evaluate the condition of our Nation's bridges is the number of deficient bridges. There are two types of deficient bridges: structurally deficient and functionally obsolete. In 1998, 29.6 percent of our Nation's bridges were deficient. Of the total number of bridges, 16.0 percent were structurally deficient while 13.6 percent were functionally obsolete. In urban areas, 32.5 percent of bridges were deficient, while in rural areas 28.8 percent were deficient. Over half of the deficient bridges are owned by local governments.

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.

Pavement Terminology & Measurements

Pavement condition affects travel cost 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 the surface condition 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 cracks and spalling.
2.0 - 3.0	The riding qualities of pavements in this category are noticeably inferior to those of 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 in this group 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 speeds and considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.

States are now expected to report IRI data for the Interstate system, other principal arterials, and rural minor arterials. IRI reporting is recommended for all other functional systems, but the majority of the data reported on rural major collectors, urban minor arterials, and urban collectors still uses PSR ratings. The FHWA adopted the IRI for the higher functional systems because this index uses a standardized procedure, is consistent across jurisdictions, is an objective measurement, and is accepted as a worldwide pavement roughness measurement. The IRI system results in more consistent data for trend analyses and across jurisdictions.

Exhibit 3-3 contains a qualitative pavement condition term and corresponding quantitative PSR and IRI values. Interstate mileage has stricter guidelines than all other functional systems under both PSR and IRI. The translation between PSR and IRI is not exact. The IRI values are based on objective measurements of pavement roughness, while PSR is a more 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 2.5 on the PSR scale. Such a section would be rated as "Mediocre" based on its IRI, but would have been rated as "Poor" 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.

Exhibit 3-3

Relationship Between IRI and PSR

Condition Term	PSR Rating		IRI Rating (inches/mile)		Interstate & NHS Ride Quality
Categories	Interstate	Other	Interstate	Other	
Very Good	≥4.0	≥4.0	< 60	< 60	
Good	3.5 - 3.9	3.5 - 3.9	60 - 94	60 - 94	Acceptable 0 - 170
Fair	3.1 - 3.4	2.6 - 3.4	95 - 119	95 - 170	
Mediocre	2.6 - 3.0	2.1 - 2.5	120 - 170	171 - 220	Less than Acceptable > 170
Poor	≤2.5	≤2.0	> 170	> 220	

The *Federal Highway Administration 1998 National Strategic Plan* introduced a new descriptive term for pavement condition, "acceptable ride quality." The *Strategic Plan* stated that by 2008, 93 percent of the National Highway System (NHS) mileage should meet pavement standards for "acceptable ride quality." This goal is discussed in greater detail in Appendix B. In order to be rated "acceptable" pavement performance must have an IRI value of less than or equal to 170 inches per mile. The FHWA Strategic 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, so the PSR data are not used to determine "acceptable ride quality" in the *Strategic Plan* or related annual reports. This report uses the term "less than acceptable" (< Acceptable) to describe mileage that does not meet the "acceptable" threshold on the Interstate system.

In this chapter, overall pavement condition is presented based on the qualitative condition terms "very good," "good," "fair," "mediocre" and "poor" associated with the IRI or PSR system. Pavement conditions specific to the NHS are discussed in Appendix B.

Overall Pavement Condition

The highway systems covered in this chapter includes all mileage except rural minor collectors and local functional systems. Currently, 16.0 percent of our roads are in "very

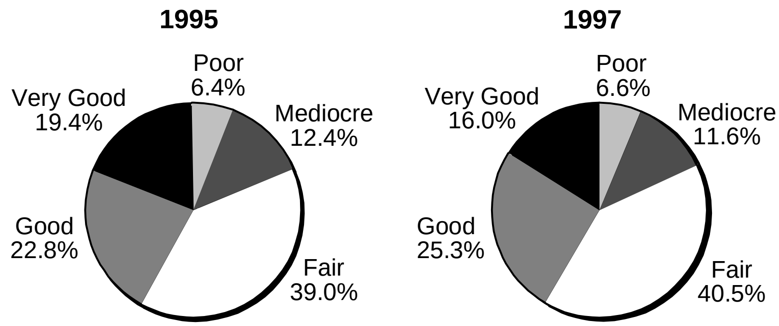
Q. **Do other measures of pavement condition exist?**

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 system. In order to continue to improve our pavement evaluation, FHWA has been working with AASHTO and the States to establish standards for measuring roughness, cracking, rutting and faulting.

good" condition and 25.3 percent are in "good" condition. Since 1995, the percentage of mileage in "very good" condition fell 3.4 percentage points while the percentage of mileage in "good" condition rose 3.0 percentage points. The percentage of "fair" pavement and "mediocre" pavement had a similar up and down trend. The percentage of "fair" pavement increased from 39.0 percent to 40.5 percent while the percentage of "mediocre" pavement decreased from 12.4 percent to 11.6 percent. Finally, the percentage of "poor" pavement increased from 6.4 percent to 6.6 percent since 1995 [*See Exhibit 3-4*].

Exhibit 3-4

Pavement Condition, by Total Percent Miles, 1995 and 1997

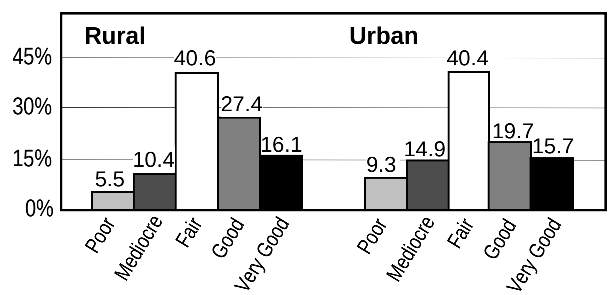


Rural and Urban Pavement Conditions

When discussing pavement conditions, it is important to note the different travel characteristics between rural and urban areas. As mentioned in Chapter 2, rural areas contain 78.7 percent of road miles, but only 39.1 percent of annual VMT. In other words, although rural areas have a larger percentage of road miles, the majority of travel is occurring in the urban areas. According to 1997 data, pavement conditions in rural areas are slightly better than in urban areas. Only 5.5 percent of road miles in rural areas are rated "poor," while 9.3 percent of road miles in urban areas are rated "poor." Rural areas also have a larger percentage of "very good" and "good" roads. [*See Exhibit 3-5*]. When evaluating these percentages, please note that rural minor collectors and local functional system mileage are not included.

Exhibit 3-5

Rural & Urban Pavement Conditions, 1997

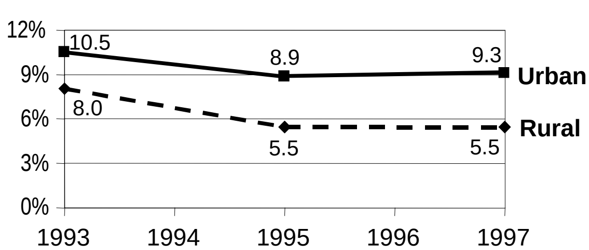


Source: June 1999 HPMS.

Pavement conditions in both rural and urban areas have generally been improving over time. Since 1993, the percentage of road miles in poor condition has decreased from 8.0 percent to 5.5 percent in rural areas and from 10.5 percent to 9.3 percent in urban areas. However, since 1995, the percent of urban miles in poor condition has increased. [*See Exhibit 3-6*].

Exhibit 3-6

Poor Pavement - Percent Miles, 1993-1997



Source: June 1999 HPMS.

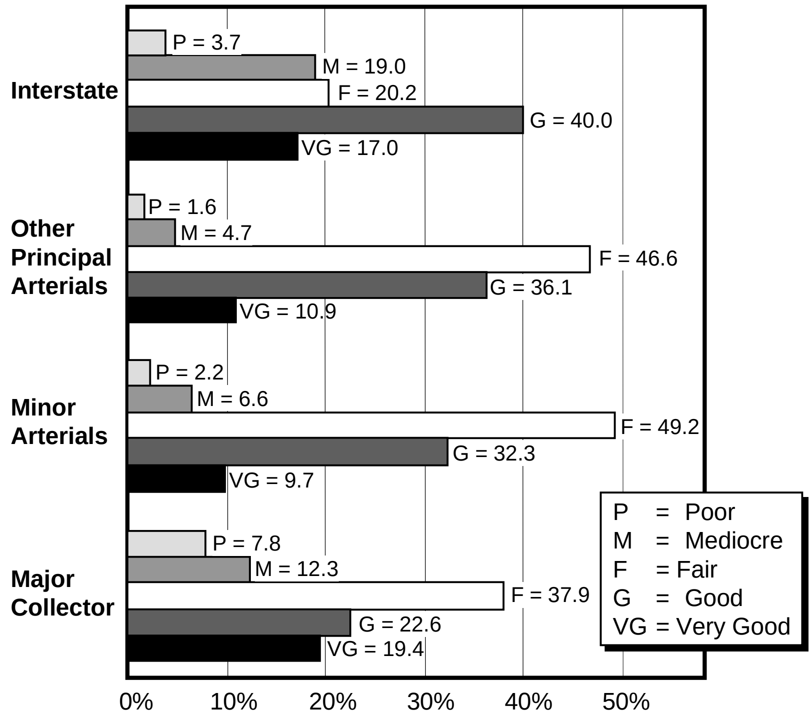
Pavement Condition by Functional System

As was mentioned in Chapter 2, the functional system for approximately 68.9 percent of total mileage is "local." Nevertheless, roads classified as "Interstate" have the largest percentage of VMT, followed by minor arterials and major collectors. Therefore, ride quality on Interstate routes affects more users than ride quality on lower functional systems. Interstate mileage in rural areas is 57.0 percent "very good" or "good," 39.2 percent "mediocre" or "fair" and 3.7 percent "poor." In urban areas on the other hand, Interstate mileage is 40.5 percent "very good" or "good," 50.3 percent "mediocre" or "fair" and 9.2 percent "poor." Regarding minor arterials, rural areas have a slightly lower percentage of "poor" roads and a slightly higher percentage of "mediocre" or "fair" roads compared to urban areas. The urban areas also have a higher percentage of collector roads in "poor" condition and a lower percentage of collector roads in "very good" or "good" condition compared to rural areas. Exhibits 3-7 & 3-8 contain the portion of rural and urban pavement in the various condition categories, respectively.

A historical view helps clarify where pavement improvements are

Exhibit 3-7

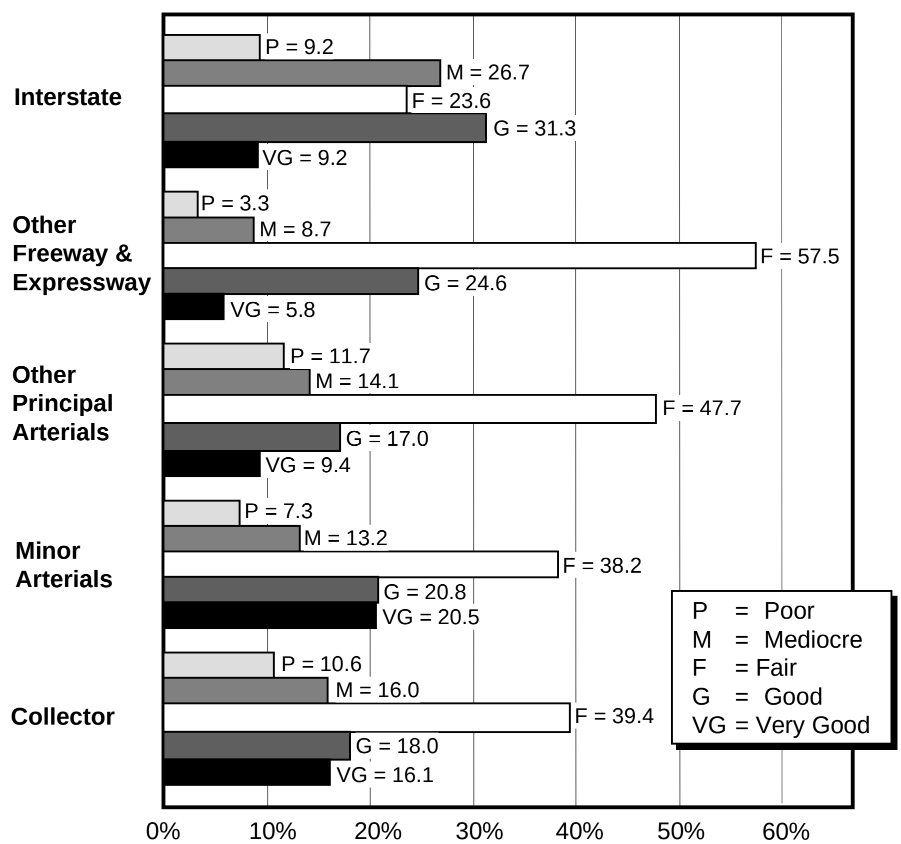
Rural Pavement Condition, by Functional System, 1997



Source: June 1999 HPMS.

Exhibit 3-8

Urban Pavement Condition, by Functional System, 1997

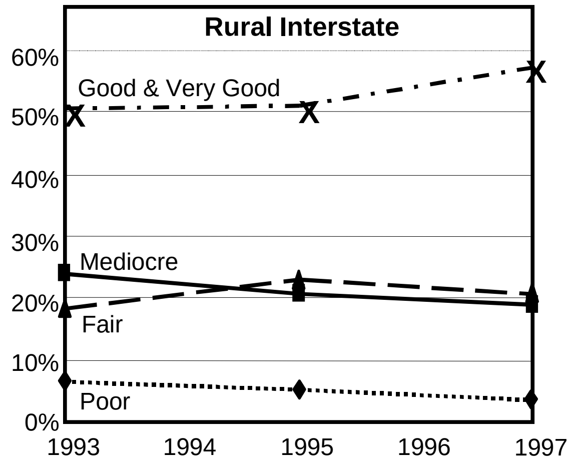


Source: June 1999 HPMS.

occurring and at what rate. Exhibits 3-9 and 3-10 list the pavement condition by category, functional system and location from 1993 to 1997. The data table and graphs illustrate that pavement conditions

Exhibit 3-9

Rural Pavement Condition by Functional System, 1993-1997



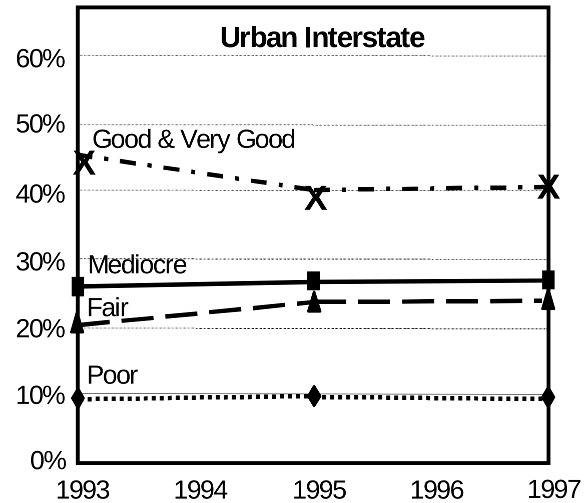
Rural

	1993	1995	1997
Interstate			
*(Acceptable)**	*93.1%*	*94.7%*	*96.2%*
Good & Very Good	50.7%	51.3%	57.0%
Fair	18.4%	22.8%	20.2%
Mediocre	24.0%	20.6%	19.0%
Poor	6.9%	5.3%	3.7%
Other Principal Arterials			
Good & Very Good	40.3%	37.9%	47.0%
Fair	23.8%	53.2%	46.6%
Mediocre	26.5%	7.0%	4.7%
Poor	9.3%	1.9%	1.6%
Minor Arterials			
Good & Very Good	37.9%	35.3%	42.0%
Fair	29.1%	53.3%	49.2%
Mediocre	22.0%	8.9%	6.6%
Poor	11.0%	2.6%	2.2%
Collectors			
Good & Very Good	32.2%	48.2%	42.0%
Fair	37.7%	31.9%	37.9%
Mediocre	12.4%	12.7%	12.3%
Poor	6.8%	7.3%	7.8%

*Acceptable: IRI<=170

Exhibit 3-10

Urban Pavement Condition by Functional System, 1993-1997



Urban

	1993	1995	1997
Interstate			
*(Acceptable)**	*90.5%*	*90.2%*	*90.8%*
Good & Very Good	45.3%	40.0%	40.5%
Fair	20.3%	23.7%	23.6%
Mediocre	24.9%	26.5%	26.7%
Poor	9.5%	9.8%	9.2%
Other Freeway & Expressway			
Good & Very Good	37.9%	31.6%	30.4%
Fair	21.9%	54.8%	57.5%
Mediocre	30.2%	9.2%	8.7%
Poor	9.9%	4.3%	3.3%
Other Principal Arterials			
Good & Very Good	35.2%	25.9%	26.4%
Fair	23.5%	47.8%	47.7%
Mediocre	26.4%	14.5%	14.1%
Poor	15.0%	11.8%	11.7%
Minor Arterials			
Good & Very Good	37.8%	43.3%	41.3%
Fair	40.2%	36.3%	38.2%
Mediocre	13.8%	13.6%	13.2%
Poor	7.9%	6.7%	7.3%
Collectors			
Good & Very Good	31.6%	34.8%	34.1%
Fair	40.0%	38.6%	39.4%
Mediocre	16.8%	16.8%	16.0%
Poor	10.6%	9.7%	10.6%

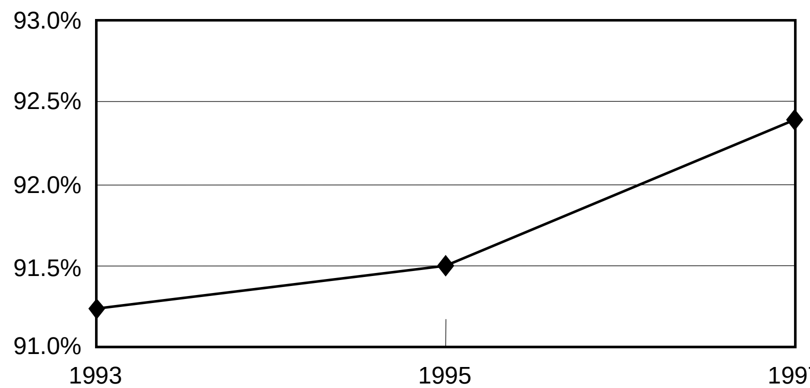
*Acceptable: IRI<=170

have changed in a variety of ways. For example, since 1993, the percentage of Interstate miles in rural areas characterized as "very good" and "good" has increased from 50.7 percent to 57.0 percent while the percentage characterized as "poor" has decreased from 6.9 percent to 3.7 percent. On the other hand, the percentage of Interstate miles in urban areas characterized as "very good" and "good" has decreased from 45.3 percent to 40.5 percent while the percentage characterized as "poor" has only slightly decreased from 9.5 percent to 9.2 percent. One consistent trend is the faster rate of pavement condition improvement in rural areas versus urban areas. For example, since 1993, the percentage of minor arterial miles in rural areas characterized as "poor" fell from 11.0 percent to 2.2 percent while the percentage in urban areas only fell from 7.9 percent to 7.3 percent. Exhibits 3-9 and 3-10 also identify the portion of Interstate pavements that meet the FHWA Strategic Plan standard for "acceptable ride quality" on the NHS.

Combining the rural and urban Interstate data illustrates that overall our Interstate pavement performance has improved since 1993. Exhibit 3-11 traces the percentage of Interstate miles in "acceptable ride quality." The percentage of all Interstate mileage with "acceptable ride quality" increased from 91.2 percent in 1993 to 92.4 percent in 1997.

Exhibit 3-11

Percentage of Interstate Miles with Acceptable Ride Quality, 1997



Roadway Alignment

Alignment adequacy affects the level of service and safety of the highway system. There are two types: horizontal and vertical. Horizontal alignment affects speed and sight distance, while vertical alignment affects principally sight distance. Inadequate alignment may result in speed reductions (especially for trucks) as well as impaired sight distance. Alignment adequacy is evaluated on a scale from Code 1 (best) to Code 4 (worst). Exhibit 3-12 explains the alignment rating system.

Exhibit 3-12

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 speeds 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 3-13 and 3-14 illustrate that more than 90 percent of the rural Interstate miles are classified as Code 1 for both vertical and horizontal alignment. A small portion of all roads is rated Code 4 (9.1 percent for horizontal alignment and 4.6 percent for vertical alignment). Roadway alignment continues to improve gradually as sections with poor alignment are reconstructed.

Exhibit 3-13

Rural Horizontal Alignment Adequacy, 1997

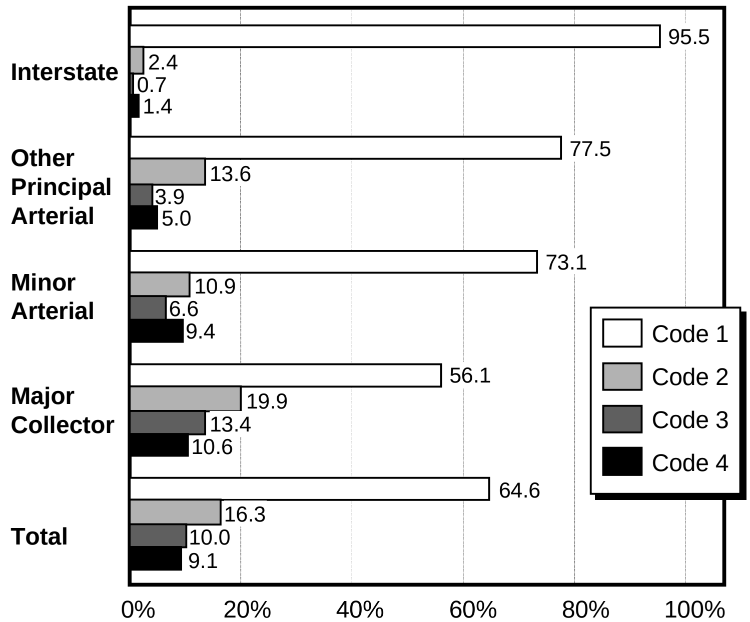
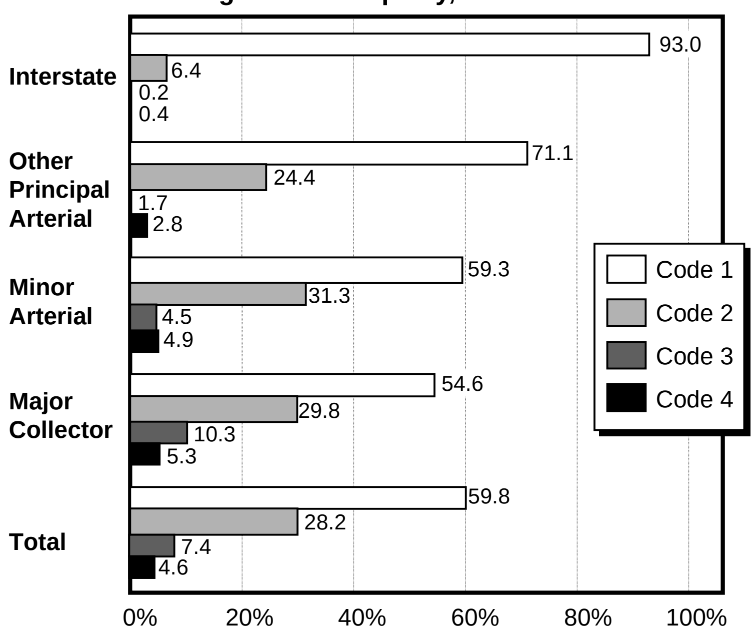


Exhibit 3-14

Rural Vertical Alignment Adequacy, 1997



Lane Width

Lane width affects capacity and safety. For example, narrow lanes prevent a road from operating at capacity. As with roadway alignment, lane width is more crucial on functional systems with the higher travel volumes. Currently, high-type facilities (e.g. Interstates) are expected to have 12-foot lanes. Exhibits 3-15 and 3-16 illustrate that over 99 percent of the all Interstate miles meet the 12-foot standard. The percentage of 12+ foot lane widths decreases as the travel volume decreases. This relationship is seen on urban collectors and major rural collectors which have 51 percent and 36.8 percent respectively of 12+ foot lanes. The lanes that are less than 9 feet are mainly concentrated on the collector roads.

Exhibit 3-15

Rural Lane Width, by Functional System, 1997

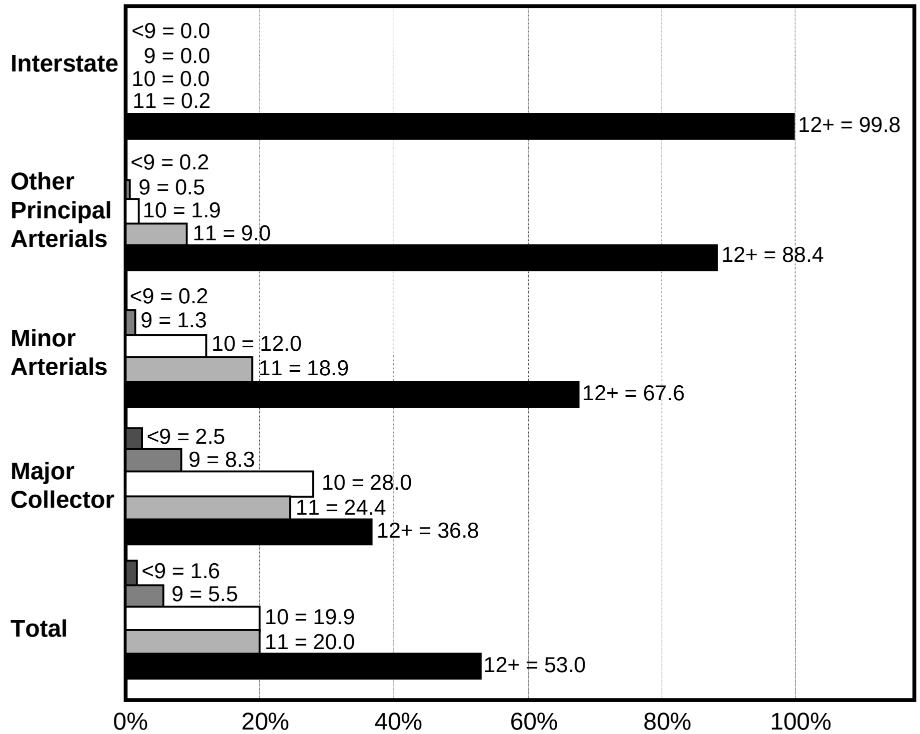
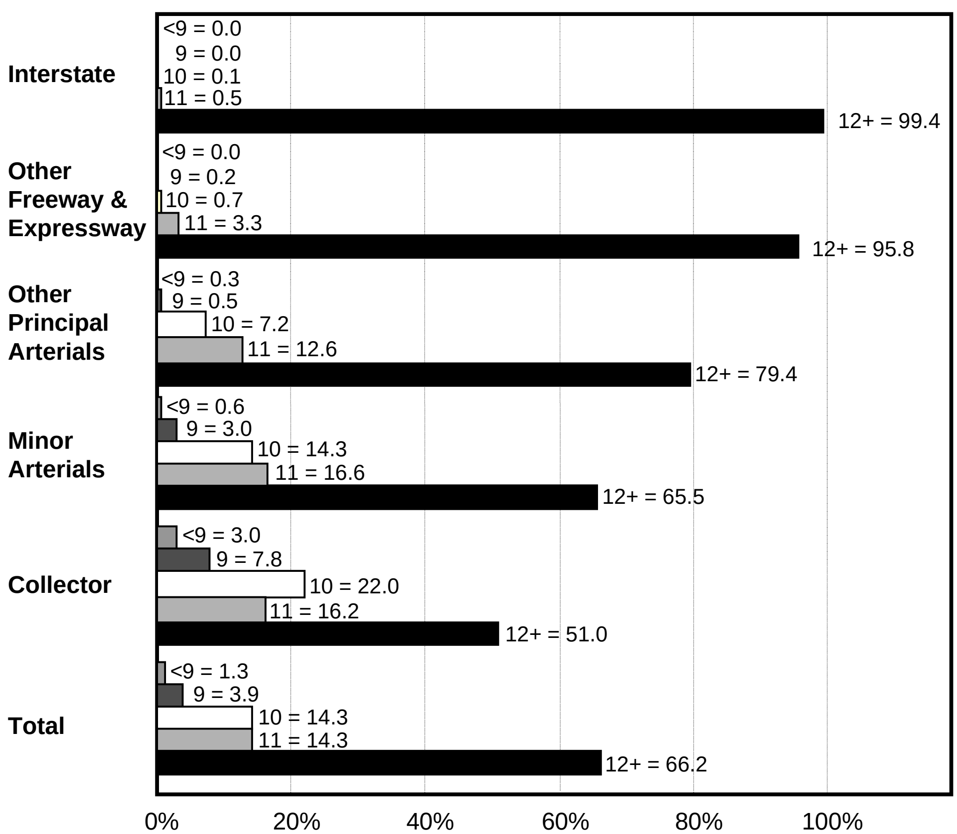


Exhibit 3-16

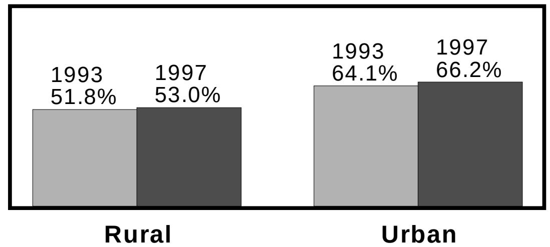
Urban Lane Width, by Functional System, 1997



Lanes have been widened over time through new construction, reconstruction, and widening projects. Since 1993, the rural mileage with lane width greater than or equal to 12 feet increased from 51.8 percent to 53.0 percent while the urban mileage with 12 foot+ lanes increased from 64.1 percent to 66.2 percent [*see Exhibit 3-17*].

Exhibit 3-17

12+ Foot Lanes, Rural and Urban, 1993 and 1997



Bridge Conditions

This section uses two measures of bridge conditions: bridge component ratings, and the number of deficient bridges. The bridge component ratings provide a broader perspective on conditions, but the quantity of deficient bridges is a more widely used indicator. The bridge investment requirement analysis described later in this report focuses on bridge deficiencies. In addition, the *Federal Highway Administration 1998 National Strategic Plan* includes two goals related to percentage of deficient bridge. The target for NHS bridges is discussed in Appendix B. The target for all bridges is discussed later in this chapter.

Bridge Component Ratings

The National Bridge Inventory (NBI) contains ratings on the conditions of three major bridge components: deck, superstructure, and substructure. Exhibit 3-18 contains a description of this rating system.

Exhibit 3-18

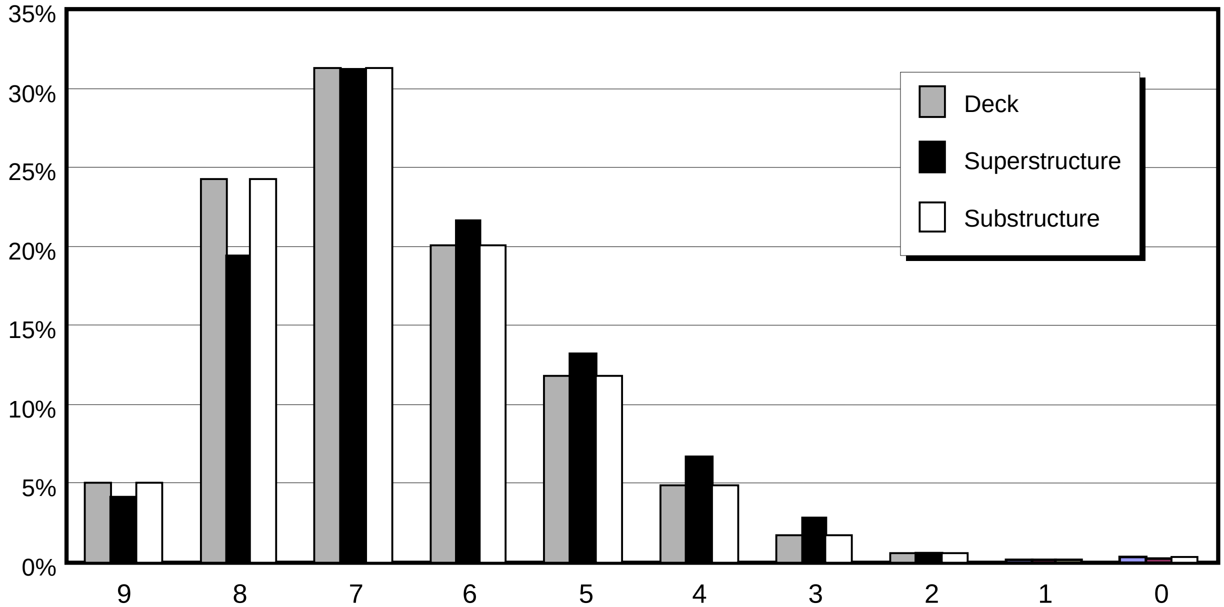
Bridge Component Ratings

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. Fatique 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.

Exhibit 3-19 illustrates the distribution of bridge component ratings. The majority of bridge components are rated 7 or higher, indicating that they are in good, very good, or excellent condition. Approximately one-third are rated 5 or 6, indicating that they are considered fair or satisfactory. The remainder of bridge components are rated 4 or lower, indicating that they are in poor or worse condition. A component rating does not translate directly into an overall rating of a bridge's condition.

Exhibit 3-19

Bridge Component Conditions, 1998



Bridge Deficiencies

The more common indicator used to evaluate the condition of our Nation's bridges is the number of deficient bridges. There are two types of deficient bridges: structurally deficient and functionally obsolete.

Exhibit 3-20 shows that in 1998 29.6 percent of our Nation's bridges were deficient. Of these deficient bridges, 16.0 percent of bridges were structurally deficient while 13.6 percent were functionally obsolete.

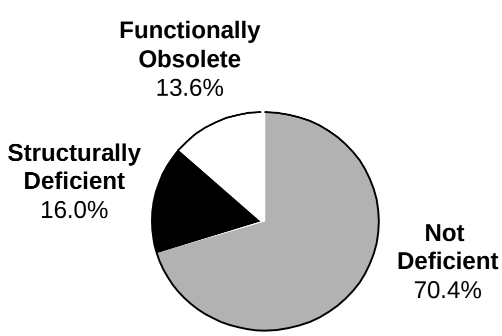
Q. **How are "structurally deficient" and "functionally obsolete" bridges defined?**

A. Bridges are structurally deficient if they have been restricted to light vehicles, require immediate rehabilitation to remain open, or are closed.

Bridges are functionally obsolete if they have deck geometry, load carrying capacity, clearance or approach roadway alignment that no longer meet the criteria for the system of which the bridge is a part.

Exhibit 3-20

Deficiencies, All Bridges, 1998



Q. **Are all deficient bridges unsafe to cross?**

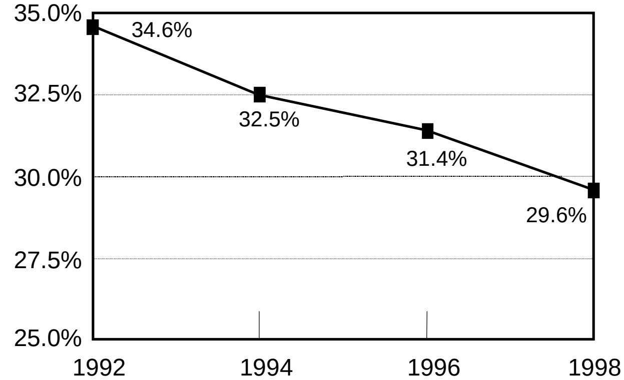
A. No. A deficient bridge is not necessarily unsafe or one that requires special posting for speed or weight limitations. It does require significant maintenance, rehabilitation, or sometimes replacement. Some of these bridges are posted and may require trucks over a certain weight to take a longer route. For further information on the status of bridges, please refer to *The Status of the Nation's Highway Bridges: Highway Bridge Replacement and Rehabilitation Program and National Bridge Inventory*, Report to Congress dated May 1997.

Q. How do recent deficient bridge data compare with the FHWA Strategic Plan target for deficient bridges in 2008?

A. The Federal Highway Administration 1998 Strategic Plan stated that by 2008, less than 25 percent of our bridges should be classified as deficient. As Exhibit 3-21 illustrates, the percent of deficient bridges has been declining in recent years, from 34.6 percent in 1992 to 29.6 percent in 1998. The Strategic Plan also established a target for bridges on the NHS which is discussed in further detail in Appendix B.

Exhibit 3-21

Percentage of Deficient Bridges, 1992-1998



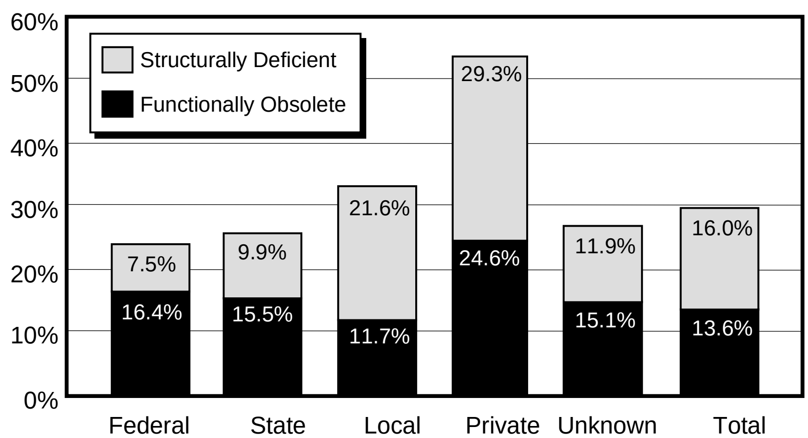
Bridge Deficiencies by Jurisdiction

As Chapter 2 explained, ownership of bridges is divided among Federal, State, and local governments and private companies (including railroads). State and local governments own the majority of bridges, 46.9 percent and 51.2 percent respectively. The remaining 1.9 percent includes bridges owned by the Federal Government or private companies, and bridges for which ownership is unknown or not coded in the NBI.

Exhibit 3-22 shows there are significant differences in bridge deficiencies by level of government. Of the 298,222 bridges owned by local governments, 99,503 (33.4 percent) are deficient. This represents 57.7 percent of the total number of deficient bridges, 172,572. Although private companies own only

Exhibit 3-22

Bridges: Percent Deficient, by Ownership, 1998



	Federal	State	Local	Private	Unknown	Total
Total Bridges	7,448	273,897	298,222	2,278	1,131	582,976
Total Deficient	1,774	69,762	99,503	1,227	306	172,572
Structurally Deficient	555	27,196	64,519	667	135	93,072
Functionally Obsolete	1,219	42,566	34,984	560	171	79,500
Percent Deficent	23.8%	25.5%	33.4%	53.9%	27.1%	29.6%
Percent Structurally Deficent	7.5%	9.9%	21.6%	29.3%	11.9%	16.0%
Percent Functionally Obsolete	16.4%	15.5%	11.7%	24.6%	15.1%	13.6%

Source: National Bridge Inventory.

2,278 bridges, 0.4 percent of the total, 53.9 percent of these bridges are deficient. Of federally owned bridges, only 23.8 percent are deficient.

Exhibit 3-22 also shows that the majority of deficiencies on bridges owned by local governments are structural. However, for State and federally owned bridges, the majority of the deficiencies are functional. Exhibits 3-23 and 3-24 clarify this difference. Local governments own 69.3 percent of structurally deficient bridges, but only 44.0 percent of functionally obsolete bridges. State governments own the majority (53.6 percent) of functionally obsolete bridges.

Exhibit 3-23

Ownership of Structurally Deficient Bridges, 1998

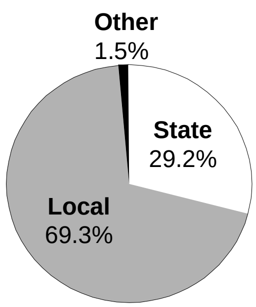
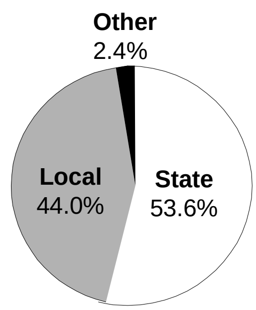


Exhibit 3-24

Ownership of Functionally Obsolete Bridges, 1998



Rural and Urban Bridges

As indicated in Chapter 2, 78.0 percent of all bridges are located in rural areas. In 1998, 130,911 of the total 454,664 rural bridges (28.8 percent) were deficient. Bridges in urban areas are more likely to be deficient than those in rural areas. In 1998, 41,661 of the total 128,312 urban bridges (32.5 percent) were deficient. Exhibit 3-25 shows that deficient rural bridges are more likely to be structurally deficient, while deficient urban bridges are more likely to be functionally obsolete.

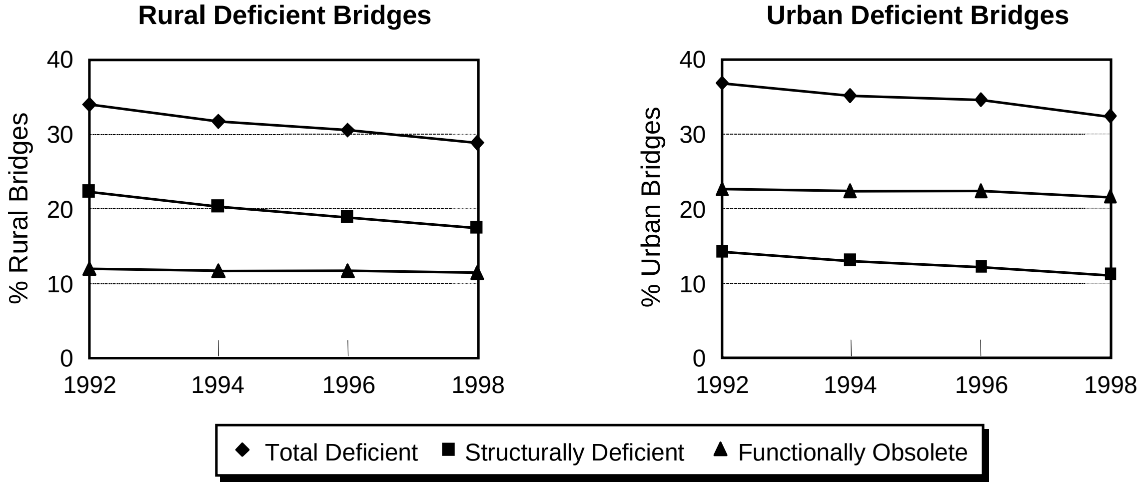
Bridge condition in both urban and rural areas has been improving in recent years. Exhibit 3-25 shows that the number of deficient rural bridges has declined from 156,863 (34.1 percent of the total) in 1992 to 130,911 (28.8 percent). The number of deficient urban bridges has declined from 42,489 (36.8 percent) in 1992 to 41,661 (32.5 percent) in 1998. The percentage of rural bridges that are structurally deficient has declined from 22.2 percent in 1992, to 17.4 percent in 1998, while the percentage of urban bridges that are structurally deficient declined from 14.1 percent to 11.0 percent over the same period. The number of urban bridges that are functionally obsolete grew from 26,228 to 27,588 over this 6-year period, though this represented a decline in percentage terms, from 22.7 percent to 21.5 percent. In summary, since 1992, the reduction in the number of structurally deficient bridges has been much more pronounced (20.6 percent to 16.0 percent) than the reduction in functionally obsolete bridges (14.0 percent to 13.6 percent).

Bridges by Functional System

The general trend described in the previous section, where bridges in urban areas are more likely to be deficient, can also be seen in Exhibit 3-26. Bridges found on urban Interstates, urban other principal arterials and urban minor arterials have a higher percentage of deficient bridges than those on comparable rural functional systems. However, a larger percentage of bridges on local roads in rural areas are deficient (36.5 percent) compared to those in urban areas (32.6 percent).

Exhibit 3-25

Rural and Urban Bridge Deficiencies, 1992-1998



	1992		1994		1996		1998	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	460,219		455,319		456,913		454,664	
Deficient Bridges	156,863	34.1%	144,799	31.8%	139,545	30.5%	130,911	28.8%
Structural	102,292	22.2%	91,991	20.2%	86,424	18.9%	78,999	17.4%
Functional	54,571	11.9%	52,808	11.6%	53,121	11.6%	51,912	11.4%
Urban Bridges	115,364		121,141		124,949		128,312	
Deficient Bridges	42,489	36.8%	42,716	35.3%	43,181	34.6%	41,661	32.5%
Structural	16,261	14.1%	15,692	13.0%	15,094	12.1%	14,073	11.0%
Functional	26,228	22.7%	27,024	22.3%	28,087	22.5%	27,588	21.5%
Total Bridges	575,583		576,460		581,862		582,976	
Deficient Bridges	199,352	34.6%	187,515	32.5%	182,726	31.4%	172,572	29.6%
Structural	118,553	20.6%	107,683	18.7%	101,518	17.4%	93,072	16.0%
Functional	80,799	14.0%	79,832	13.8%	81,208	14.0%	79,500	13.6%

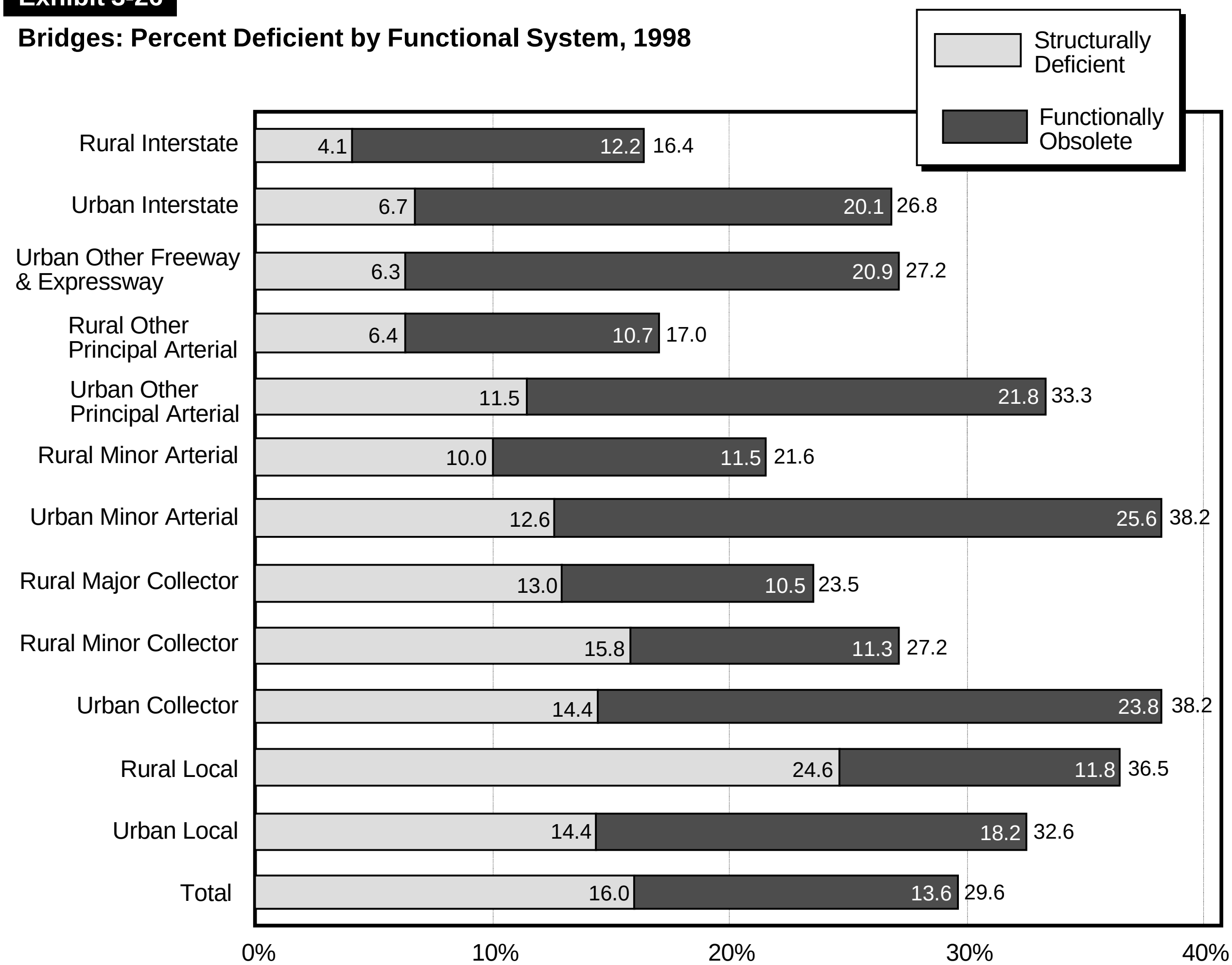
Source: National Bridge Inventory.

The proportion of structurally deficient and functionally obsolete bridges varies by functional system. Exhibit 3-26 highlights some of these differences. For the most part, the percentage of bridges that are deficient increases on lower functional systems. Bridges on the Interstate have the lowest percentage of deficient bridges (16.4 percent in rural areas and 26.8 percent in urban areas). The rural Interstate bridges also have the lowest percentage of structurally deficient bridges, 4.1 percent, of all functional systems in both areas. Other principal arterials, which like Interstates account for a large share of VMT, have a relatively small percentage of deficient bridges (17.0 percent in rural areas and 33.3 percent in urban areas).

Minor arterials have a larger percentage of deficient bridges than the higher functional systems. In urban areas, minor arterials are tied with collector roads for the highest percentage of deficient bridges (38.2 percent). This is the highest percentage of deficient bridges among all functional systems. Functionally obsolete bridges make up the largest portion of this percentage.

Exhibit 3-26

Bridges: Percent Deficient by Functional System, 1998



Functional Class	Total Bridges	Bridge Deficiencies			Percent Deficient		
		Structural	Functional	Total	Structural	Functional	Total
Rural							
Interstate	27,530	1,135	3,369	4,504	4.1%	12.2%	16.4%
Other Principal Arterial	35,302	2,252	3,765	6,017	6.4%	10.7%	17.0%
Minor Arterial	38,022	3,808	4,391	8,199	10.0%	11.5%	21.6%
Major Collector	95,830	12,426	10,097	22,523	13.0%	10.5%	23.5%
Minor Collector	47,310	7,493	5,352	12,845	15.8%	11.3%	27.2%
Local	210,670	51,885	24,938	76,823	24.6%	11.8%	36.5%
Total Rural	**454,664**	**78,999**	**51,912**	**130,911**	**17.4%**	**11.4%**	**28.8%**
Urban							
Interstate	27,480	1,850	5,526	7,376	6.7%	20.1%	26.8%
Other Freeway & Expressway	15,221	960	3,177	4,137	6.3%	20.9%	27.2%
Other Principal Arterial	23,463	2,699	5,113	7,812	11.5%	21.8%	33.3%
Minor Arterial	22,217	2,808	5,678	8,486	12.6%	25.6%	38.2%
Collector	14,962	2,158	3,560	5,718	14.4%	23.8%	38.2%
Local	24,969	3,598	4,534	8,132	14.4%	18.2%	32.6%
Total Urban	**128,312**	**14,073**	**27,588**	**41,661**	**11.0%**	**21.5%**	**32.5%**
Total, Rural and Urban	**582,976**	**93,072**	**79,500**	**172,572**	**16.0%**	**13.6%**	**29.6%**

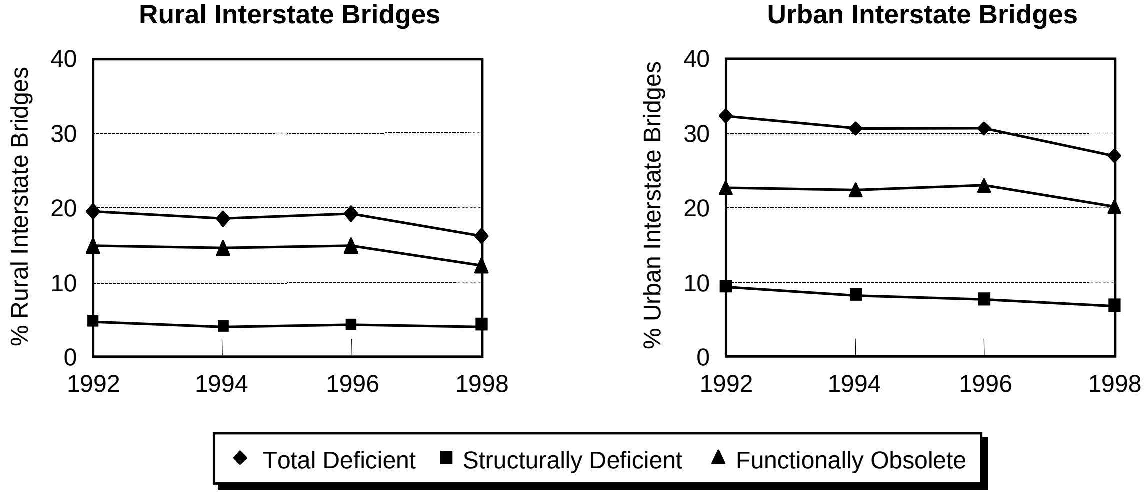
Source: National Bridge Inventory.

A high percentage of bridges functionally classified as local are deficient. In urban areas the percentage is 32.6 percent and in rural areas the percentage is 36.5 percent. The high percentage in rural areas is particularly significant because 36.1 percent of all bridges are on local rural roads. In addition, a large portion of the deficient bridges are structurally deficient.

Exhibit 3-27 through Exhibit 3-30 provide a historical perspective on bridge improvements. Since 1992, the percentage of deficient bridges on Interstates, other principal arterials, collectors and local roads have decreased in both rural and urban areas. However, there was an increase in the percentage of functionally deficient bridges from 1994 to 1996. This occurred on Interstates, other arterials and collectors in both rural and urban areas. In most cases, the increase was very small. The history of local functional system roads is mixed. Even though the percentage of total deficient bridges has decreased since 1992 there was a slight increase (up .4 percentage points) between 1996 and 1998.

Exhibit 3-27

Interstate Bridge Deficiencies, 1992-1998

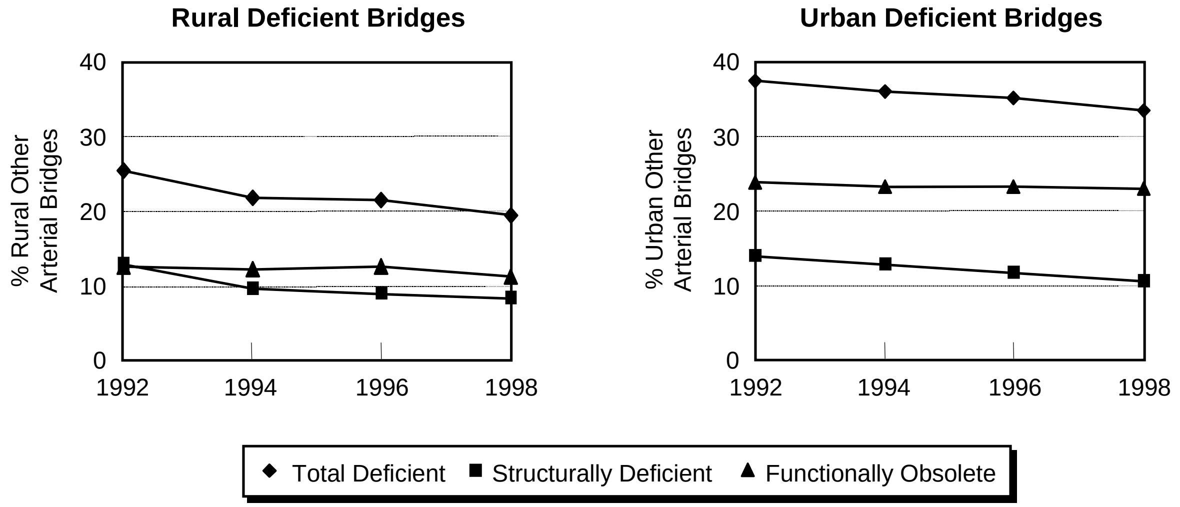


	1992		1994		1996		1998	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	29,148		28,865		28,638		27,530	
Deficient Bridges	5,659	19.4%	5,342	18.5%	5,479	19.1%	4,504	16.4%
Structural	1,330	4.6%	1,162	4.0%	1,249	4.4%	1,135	4.1%
Functional	4,329	14.9%	4,180	14.5%	4,230	14.8%	3,369	12.2%
Urban Bridges	25,013		25,861		26,596		27,480	
Deficient Bridges	8,066	32.2%	7,920	30.6%	8,181	30.8%	7,376	26.8%
Structural	2,367	9.5%	2,141	8.3%	2,070	7.8%	1,850	6.7%
Functional	5,699	22.8%	5,779	22.3%	6,111	23.0%	5,526	20.1%
Total Bridges	54,161		54,726		55,234		55,010	
Deficient Bridges	13,725	25.3%	13,262	24.2%	13,660	24.7%	11,880	21.6%
Structural	3,697	6.8%	3,303	6.0%	3,319	6.0%	2,985	5.4%
Functional	10,028	18.5%	9,959	18.2%	10,341	18.7%	8,895	16.2%

Source: National Bridge Inventory.

Exhibit 3-28

Other Arterial Bridge Deficiencies, 1992-1998

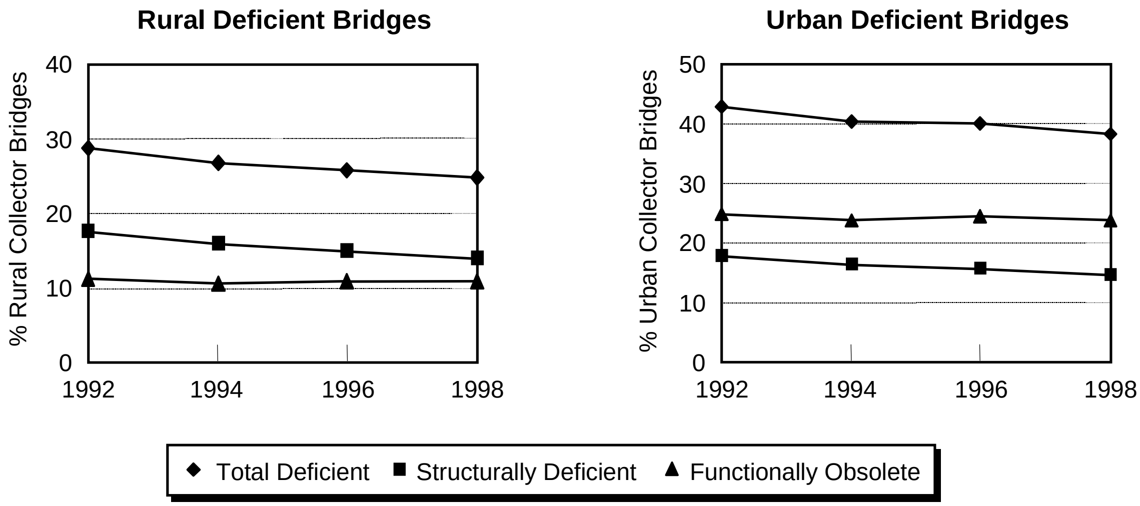


	1992		1994		1996		1998	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	78,123		72,453		72,970		73,324	
Deficient Bridges	19,884	25.5%	15,693	21.7%	15,693	21.5%	14,216	19.4%
Structural	9,965	12.8%	6,914	9.5%	6,622	9.1%	6,060	8.3%
Functional	9,919	12.7%	8,779	12.1%	9,071	12.4%	8,156	11.1%
Urban Bridges	54,589		57,012		59,064		60,901	
Deficient Bridges	20,481	37.5%	20,506	36.0%	20,710	35.1%	20,435	33.6%
Structural	7,544	13.8%	7,247	12.7%	6,902	11.7%	6,467	10.6%
Functional	12,937	23.7%	13,259	23.3%	13,808	23.4%	13,968	22.9%
Total Bridges	132,712		129,465		132,034		134,225	
Deficient Bridges	40,365	30.4%	36,199	28.0%	36,403	27.6%	34,651	25.8%
Structural	17,509	13.2%	14,161	10.9%	13,524	10.2%	12,527	9.3%
Functional	22,856	17.2%	22,038	17.0%	22,879	17.3%	22,124	16.5%

Source: National Bridge Inventory.

Exhibit 3-29

Collector Bridge Deficiencies, 1992-1998

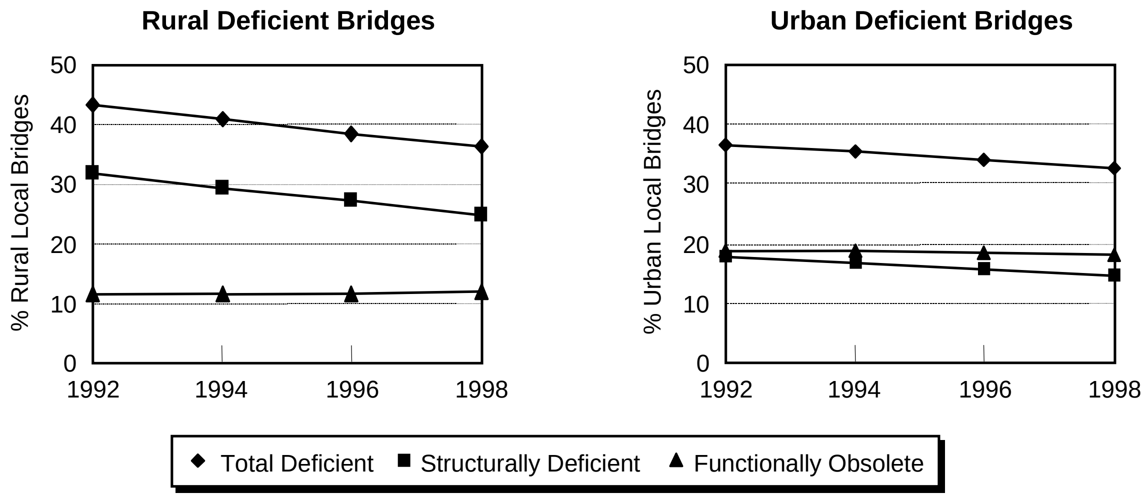


	1992		1994		1996		1998	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	147,148		147,612		144,246		143,140	
Deficient Bridges	42,270	28.7%	39,398	26.7%	37,158	25.8%	35,368	24.7%
Structural	25,933	17.6%	23,645	16.0%	21,375	14.8%	19,919	13.9%
Functional	16,337	11.1%	15,753	10.7%	15,783	10.9%	15,449	10.8%
Urban Bridges	13,647		14,702		14,848		14,962	
Deficient Bridges	5,847	42.8%	5,932	40.3%	5,976	40.2%	5,718	38.2%
Structural	2,440	17.9%	2,415	16.4%	2,337	15.7%	2,158	14.4%
Functional	3,407	25.0%	3,517	23.9%	3,639	24.5%	3,560	23.8%
Total Bridges	160,795		162,314		159,094		158,102	
Deficient Bridges	48,117	29.9%	45,330	27.9%	43,134	27.1%	41,086	26.0%
Structural	28,373	17.6%	26,060	16.1%	23,712	14.9%	22,077	14.0%
Functional	19,744	12.3%	19,270	11.9%	19,422	12.2%	19,009	12.0%

Source: National Bridge Inventory.

Exhibit 3-30

Local Bridge Deficiencies, 1992-1998



	1992		1994		1996		1998	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rural Bridges	205,800		206,389		211,059		210,670	
Deficient Bridges	89,050	43.3%	84,366	40.9%	81,215	38.5%	76,823	36.5%
Structural	65,064	31.6%	60,270	29.2%	57,178	27.1%	51,885	24.6%
Functional	23,986	11.7%	24,096	11.7%	24,037	11.4%	24,938	11.8%
Urban Bridges	22,115		23,566		24,441		24,969	
Deficient Bridges	8,095	36.6%	8,358	35.5%	8,314	34.0%	8,132	32.6%
Structural	3,910	17.7%	3,889	16.5%	3,785	15.5%	3,598	14.4%
Functional	4,185	18.9%	4,469	19.0%	4,529	18.5%	4,534	18.2%
Total Bridges	227,915		229,955		235,500		235,639	
Deficient Bridges	97,145	42.6%	92,724	40.3%	89,529	38.0%	84,955	36.1%
Structural	68,974	30.3%	64,159	27.9%	60,963	25.9%	55,483	23.5%
Functional	28,171	12.4%	28,565	12.4%	28,566	12.1%	29,472	12.5%

Source: National Bridge Inventory.

Transit System Conditions

This report represents another step in a series of improvements that have been made in recent years to the calculation of public transit asset conditions, particularly in relating the age of assets to their actual physical condition. In particular, the data presented here on bus vehicle and maintenance facility conditions have been improved by input from the 1999 National Bus Condition Assessment. Such improvements are expected to continue in the future, as more data on conditions is collected and analyzed. For more information on the National Bus Condition Assessment and the methodology used to calculate conditions, see Appendix I.

Urban Bus Fleet

Vehicle condition ratings are based on a scale from 1 (poor) to 5 (excellent) (Exhibit 3-31). The aging of the fleet can be described both by the average vehicle age and by the percentage of vehicles which are considered "overage," meaning that the vehicle's age exceeds FTA's minimum useful-life guidelines (Exhibit 3-32). Exhibit 3-33 shows the average ratings on this scale for different sizes of bus and demand response vehicles, as well as the average age and the overage percentage for each type of vehicle.

Exhibit 3-31

Bus Fleet Condition Ratings Description

Rating	Condition Definition
5.0	Excellent
4.0	Good
3.0	Adequate
2.0	Substandard
1.0	Poor

Source: Transit Economic Requirements Model (TERM).

The ratings shown here differ from those found in the 1997 Report in two significant ways:

- Estimated conditions are uniformly lower than reported in prior reports
- Average conditions for each asset type do not change as significantly over time

Exhibit 3-32

FTA Minimum-Useful Life Guidelines

Vehicle Type	Age (years)
Full-Size Bus	12
Medium-Size Bus	10
Small Bus	7
Rail Vehicles	25

Both of these features are primarily due to the updated relationship between bus vehicle condition and age determined by the National Bus Condition Assessment (Appendix I). The lower ratings result from the more rapid decline in asset condition that is exhibited by the new curves, and the more stable time series reflects in part the long period of slow decay.

The estimated average condition of the urban bus fleet in 1997 is 3.1, or adequate. This represents a slight improvement over the level of 3.0, which was attained in each of the previous 9 years. Conditions for large, articulated buses have declined over the previous decade, from 3.1 to 2.7, while conditions of vans have increased from 3.2 to 3.5.

This improvement in conditions reflects the slight change in average vehicle age over the decade from 7.5 years to 6.6 years. Decreases in the average ages of vans and small and mid-sized buses have been partially offset by the significant aging of the articulated bus fleet, where the average age has increased from 4.9 to 11.8 years, and over 60 percent of these vehicles can be considered overage.

Exhibit 3-33

Urban Transit Bus Fleet Count, Age and Condition, 1987-1997

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Articulated Buses											
Total Fleet	1,712	1,751	1,730	1,717	1,764	1,698	1,807	1,613	1,716	1,652	1,523
Percent Overage Vehicles	0%	0%	0%	0%	13%	18%	16%	17%	33%	47%	61%
Average Age	4.9	5.9	6.7	7.6	8.2	9.1	9.5	10.1	10.7	10.6	11.8
Average Condition	3.1	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.8	2.7
Full-Size Buses											
Total Fleet	46,231	46,164	46,446	46,553	46,660	46,757	46,824	46,987	46,335	47,898	47,149
Percent Overage Vehicles	21%	23%	22%	19%	17%	18%	20%	24%	23%	23%	25%
Average Age	8.2	8.2	8.4	8.2	8.0	8.3	8.5	8.7	8.6	8.3	8.2
Average Condition	3.0	3.0	2.9	3.0	3.0	2.9	2.9	2.9	2.9	2.9	3.0
Mid-Size Buses											
Total Fleet	2,821	3,002	2,928	3,106	3,268	3,204	3,598	3,693	3,879	4,434	5,328
Percent Overage Vehicles	10%	14%	14%	18%	23%	26%	24%	24%	23%	20%	18%
Average Age	5.9	6.5	6.5	6.6	6.7	6.8	6.4	6.9	6.8	6.0	5.6
Average Condition	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.0	3.0
Small Buses											
Total Fleet	2,127	2,116	2,428	2,684	3,415	3,716	4,064	4,738	5,447	6,261	7,081
Percent Overage Vehicles	11%	14%	15%	11%	14%	14%	13%	15%	13%	13%	13%
Average Age	3.9	4.2	4.1	3.9	4.0	4.1	4.0	4.1	4.0	3.8	3.7
Average Condition	3.3	3.0	3.0	3.3	3.0	3.0	3.0	3.0	3.0	3.3	3.4
Vans											
Total Fleet	3,241	3,243	3,288	3,778	6,261	7,028	8,353	10,785	11,969	12,317	13,796
Percent Overage Vehicles	30%	29%	21%	22%	22%	15%	22%	19%	21%	23%	22%
Average Age	3.1	3.6	2.9	2.8	3.0	3.1	3.1	3.0	3.2	2.9	2.3
Average Condition	3.2	2.9	3.2	3.3	3.2	3.2	3.2	3.2	3.1	3.2	3.5
Weighted Average Condition	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.1
Weighted Average Age	7.5	7.6	7.7	7.5	7.2	7.4	7.4	7.4	7.3	6.9	6.6

Source: Transit Economic Requirements Model, National Transit Database.

Note that the corresponding decay has not been nearly as dramatic, however, due to the relatively flat decay curve in the range from 5 to 12 years.

The average age of full-size buses, by far the most numerous bus type, is the same as it was in 1987 (8.2 years), but has decreased since 1994. Accordingly, the average condition of this predominant type remains at 3.0.

Q. **Why was the average bus condition level for 1995 and prior years revised downward?**

A. The revision reflects the improvement in the modeling of bus conditions that resulted from the 1999 National Bus Condition Assessment. See Appendix I for a description of this change in modeling procedure.

Urban Bus Maintenance Facilities

Estimates of the condition of urban bus maintenance facilities come from the National Bus Condition Assessment. Exhibit 3-34 shows the age range of these facilities. Fifty-six percent of bus maintenance facilities are less than 20 years old, with most of these in the older half of that range. Nearly one-third of the facilities are over 30 years old.

Exhibit 3-35 shows the condition of bus maintenance facilities. A majority of the facilities (57 percent) are found to be in adequate, middle-range condition. A slightly higher percentage of facilities are substandard/ poor (23 percent) than are good/excellent (20 percent). Less than 8 percent of facilities are in either extreme range (poor or excellent). Definitions of these condition levels are found in Exhibit 3-36.

Exhibit 3-34

Age of Urban Bus Facilities, 1997

Age (years)	Number	Percent
0-10	73	14%
11-20	212	42%
21-30	53	11%
31+	165	33%
Total	**503**	100%

Source: National Bus Condition Assessment.

Exhibit 3-35

Condition of Urban Bus Maintenance Facilities, 1997

Age (years)	Number	Percent
Excellent	13	3%
Good	86	17%
Adequate	285	57%
Substandard	93	18%
Poor	26	5%
Total	**503**	100%

Source: National Bus Condition Assessment.

Exhibit 3-36

Definitions of Urban Bus Maintenance Facility Conditions

Condition	Description
Excellent	The facility meets or exceeds most reasonable requirements of a transit bus maintenance program.
Good	The facility meets most reasonable requirements of a transit bus maintenance program but may have some less than optimum characteristics.
Adequate	The facility has shortcomings in its ability to support a transit bus maintenance program. While these shortcomings hinder the department's effectiveness or efficiency, they are not deemed to significantly impact performance.
Substandard	The facility has shortcomings in its ability to support a transit bus maintenance program, and these shortcomings are deemed to be below industry standards. The deficiencies adversely affect the efficiency and/or effectiveness of the operation.
Poor	The facility has significant shortcomings in its ability to support a transit bus maintenance program.

Source: Transit Economic Requirements Model (TERM).

Rail Vehicles

Conditions of the Nation's rail vehicle fleet are shown in Exhibit 3-37. While the ratings are based on the same 1 to 5 scale as was used for buses, the decay curves used to estimate conditions are of the logistic form discussed above, rather than the updated form used for buses.

Exhibit 3-37

Rail Transit Vehicle Fleet Count, Age and Condition, 1987-1997

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Locomotives											
Total Fleet	491	564	451	472	467	479	556	554	570	582	586
Percent Overage	30%	23%	19%	20%	17%	17%	17%	28%	21%	22%	22%
Average Age	16.9	14.9	14.6	15.7	15.3	15.8	15.6	17.3	15.6	15.7	16.5
Average Condition	4.5	4.7	4.7	4.6	4.7	4.6	4.6	4.5	4.5	4.6	4.5
Unpowered Commuter Rail Cars											
Total Fleet	2,137	2,266	2,138	2,154	2,226	2,240	2,402	2,401	2,402	2,487	2,470
Percent Overage	41%	32%	32%	29%	29%	35%	29%	35%	36%	35%	33%
Average Age	19.6	17.3	18.0	17.6	17.3	19.3	18.6	19.5	20.1	19.9	19.8
Average Condition	4.2	4.5	4.4	4.4	4.5	4.2	4.3	4.2	4.1	4.1	4.2
Powered Commuter Rail Cars											
Total Fleet	2,563	2,552	2,421	2,492	2,529	2,541	2,526	2,570	2,645	2,529	2,681
Percent Overage	2%	4%	5%	5%	5%	5%	6%	7%	24%	25%	25%
Average Age	13.3	14.3	15.0	15.9	16.5	17.6	18.2	19.0	19.7	21.0	22.0
Average Condition	4.8	4.7	4.7	4.6	4.6	4.4	4.4	4.3	4.2	3.9	3.7
Heavy Rail Cars											
Total Fleet	10,344	10,419	10,246	10,325	10,170	10,161	10,074	10,153	10,157	10,154	10,173
Percent Overage	15%	19%	17%	28%	29%	30%	27%	32%	37%	36%	36%
Average Age	15.2	15.2	15.4	16.2	16.9	17.7	17.8	18.7	19.3	19.9	21.0
Average Condition	4.7	4.7	4.6	4.6	4.5	4.4	4.4	4.3	4.2	4.1	3.9
Light Rail Vehicles											
Total Fleet	879	890	917	903	954	977	943	969	955	1,099	1,132
Percent Overage	27%	30%	20%	18%	19%	19%	10%	10%	12%	10%	10%
Average Age	17.2	18.9	15.6	15.2	16.6	17.0	14.9	14.8	14.8	14.2	14.6
Average Condition	4.5	4.3	4.6	4.7	4.5	4.5	4.7	4.7	4.5	4.7	4.6
Weighted Average Condition	4.6	4.7	4.6	4.6	4.5	4.4	4.4	4.3	4.2	4.1	4.0
Weighted Average Age	15.6	15.5	15.7	16.3	16.8	17.8	17.7	18.6	19.1	19.5	20.4

Source: Transit Economic Requirements Model, National Transit Database.

The average condition of the rail vehicle fleet in 1997 was 4.0. While this corresponds to a condition rating of "good," it is significantly lower than the average condition of 4.6 for the fleet in 1987. This corresponds to an increase in the average age of the rail fleet from 15.6 to 20.4 years.

The decrease in condition is due primarily to the aging and declining condition of the heavy rail fleet, the most numerous rail vehicle type, which fell from 4.7 to 3.9, as the average age increased from

15.2 years to 21.0. Powered commuter rail cars also posted significant deterioration in average condition over the period, while other commuter rail vehicles were unchanged. Light rail vehicles improved slightly in condition, and their average age decreased from 17.2 to 14.6. This improvement resulted from the many new light rail systems that have come on line during the past decade. Definitions of rail vehicle condition ratings are found in Exhibit 3-38.

Exhibit 3-38

Definitions of Rail Vehicle Condition

Condition	Description
Excellent	Brand new, no major problems exist, only routine preventive maintenance.
Good	Elements are in good working order, requiring only nominal or infrequent minor repairs (greater than six months between minor repairs).
Adequate	Requires frequent minor repairs (less than six months between repairs) or infrequent major repairs (more than six months between repairs).
Substandard	Requires frequent major repairs (less than six months between major repairs).
Poor	In sufficiently poor condition that continued use presents potential problems.

Source: Transit Economic Requirements Model (TERM).

Rail Infrastructure and Maintenance Facilities

Data on the conditions of rail infrastructure and facilities are presented in Exhibit 3-39. Data from 1984 and 1992 are derived from the Rail Modernization Study, while 1997 conditions data are calculated by TERM using unique decay curves for each asset type. It should be noted that the two approaches, while similar, are not perfectly comparable to one another.

Exhibit 3-39

Physical Condition of U.S. Transit Rail Infrastructure, Selected Years, 1984-1997

	Condition														
	Poor			Substandard			Adequate			Good			Excellent		
	1984	1992	1997	1984	1992	1997	1984	1992	1997	1984	1992	1997	1984	1992	1997
Track	0%	0%	7%	7%	5%	10%	49%	32%	10%	31%	49%	49%	12%	14%	24%
Power Systems															
Substations	6%	2%	12%	23%	19%	6%	5%	17%	10%	43%	56%	57%	23%	6%	15%
Overhead	20%	0%	5%	12%	33%	11%	27%	10%	18%	36%	52%	34%	5%	5%	32%
Third Rail	13%	0%	14%	26%	21%	11%	19%	20%	15%	36%	53%	43%	6%	6%	17%
Stations	0%	0%	15%	15%	5%	13%	56%	29%	15%	23%	63%	46%	6%	3%	11%
Structures															
Elevated Structure	na	na	1%	na	na	29%	na	na	12%	na	na	59%	na	na	0%
Bridges	1%	0%	na	16%	11%	na	51%	28%	na	28%	54%	na	4%	7%	na
Elevated Sections	0%	0%	na	1%	1%	na	80%	72%	na	3%	15%	na	16%	12%	na
Underground	0%	0%	9%	5%	5%	19%	49%	34%	18%	35%	51%	47%	11%	10%	7%
Maintenance															
Facilities	4%	2%	6%	54%	34%	17%	14%	12%	17%	24%	35%	53%	4%	17%	7%
Yards	4%	2%	2%	53%	7%	12%	26%	26%	7%	16%	55%	30%	1%	9%	49%

The data show that most rail asset types have significantly improved in condition over the past 13 years, as much of the aging infrastructure has been rehabilitated and replaced. As a result, over half of the rail infrastructure is now in good or excellent condition for every asset type, whereas the same was true for only one asset type (power substations) in 1984. Among the asset types, track has shown the most significant improvement in condition. In 1984, just 43 percent of track mileage was in good or excellent condition; in 1997, the comparable figure was 73 percent.

Rural and Specialized Transit Vehicles and Facilities

The available data on the condition of transit vehicles and facilities in non-urbanized areas has not been updated since the last report, though an effort to do so is currently under way. This older data is presented in Exhibits 3-40 (vehicles) and 3-41 (maintenance facilities).

Exhibit 3-40

Number of Overage Vehicles and Average Vehicle Age in Rural and Special Service Transit, 1994

	Rural Operators			Special Service Operators		
	Total Fleet	Average Age	Percent Overage	Total Fleet	Average Age	Percent Overage
Medium-Size Buses	740	10.4	51%	310	8.4	19%
Small Buses	3,660	4.9	24%	5,250	4.5	18%
Vans and Other	8,050	4.5	44%	23,770	4.4	43%

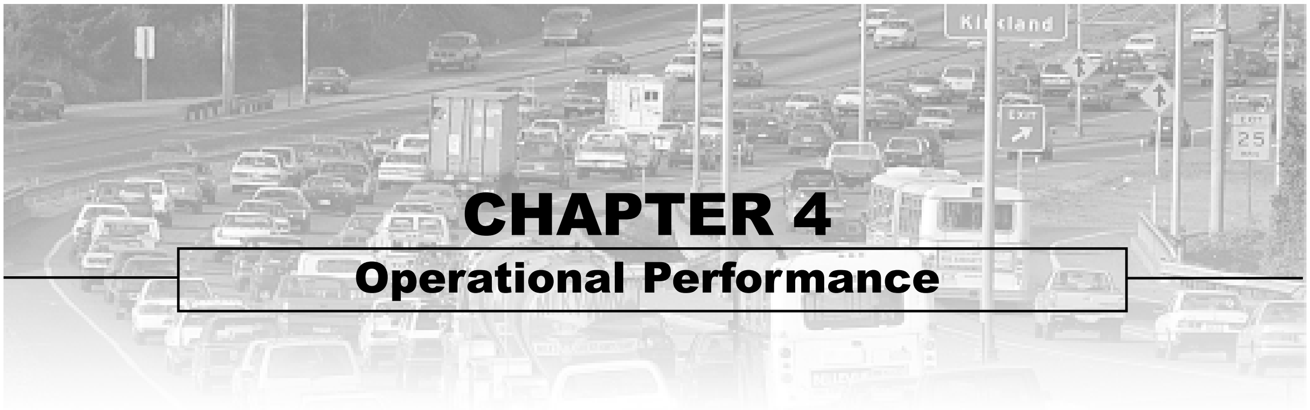
Source: Community Transportation Association of America.

Exhibit 3-41

Condition of Rural Bus Maintenance Facilities, 1992

Condition	Percent
Excellent	30%
Good	52%
Poor	14%
Very Poor	4%
Total	100%

Source: Community Transportation Association of America.



CHAPTER 4

Operational Performance

Introduction

This chapter describes operational performance of the highway and transit infrastructure. Operational performance reflects the quality of service provided by transportation systems. It shows how well each system accommodates travel demand.

The chapter begins with a Summary section highlighting the key highway and transit statistics discussed later in this chapter, and comparing them with the values from the last report. Where the 1995 data have been revised, this is reflected in the summary table.

The highway section of this chapter begins by briefly discussing the costs of congestion. It examines the impact of congestion on highway users and on the entire American economy. The section then describes how congestion, an easy concept to understand, is actually problematic to measure. Because there is no single indicator for congestion, Chapter 4 looks at three measures: daily delay; and Daily Vehicle-Miles Traveled per lane; and Volume Service Flow (V/SF).

The highway section concludes by examining statistics from the Texas Transportation Institute's annual report on urban roadway congestion. These provide a good snapshot of congestion problems in 70 metropolitan areas throughout the United States.

The transit section of this chapter describes how to measure transit operational performance. It describes characteristics from the National Transit Database and passenger survey information.

Summary

Exhibit 4-1 highlights the key highway and transit statistics discussed in this chapter, and compares them with the values from the last report. The first data column contains the values reported in the 1997 C&P report, which were based on 1995 data. Where the 1995 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 1997 data.

Exhibit 4-1

Comparison of Operational Performance Statistics with those in the 1997 C&P Report

Statistic	1995 Data: 1997 Report	1995 Data: Revised	1997 Data
Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile on Rural Interstates	4,640	---	4,952
Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile on Rural Other Principal Arterials	2,410	---	2,522
Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile on Urban Interstates	13,110	---	13,696
Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile on Urban Other Freeways and Expressways	10,300	---	10,620
Daily Vehicle-Miles Traveled (DVMT) per Lane-Mile on Urban Other Principal Arterials	5,650	---	5,768
Percent of Congested Travel on Urban Principal Arterial Highways (V/SF>=.8)	41.1%	40.9%	40.2%
Daily Delay (Hours per Thousand Vehicle Miles Traveled) on all Highways	not reported	9.348	8.973
Passenger-Mile Weighted Average Speed by Rail (miles per hour)	26.6	---	26.1
Passenger-Mile Weighted Average Speed by Non-Rail (miles per hour)	13.7	---	13.8

To examine highway operational performance, this chapter looks at daily travel per lane-mile, peak-hour volume/service flow ratio, and daily delay.

DVMT per lane-mile is the most basic measure, since it is a count-based metric. This measure increased at a faster annual rate on the Interstates than any other segments of the highway system between 1987 and 1997. DVMT per lane-mile increased at an annual rate of 3.40 percent on rural Interstates and by 2.00 percent on urban Interstates. Increased travel has not yet saturated rural highways to the degree it has impacted urban highways, so it has not resulted in similar congestion patterns.

Another way to examine highway congestion is to determine the percentage of peak-hour urban traffic that operates at a volume service flow (V/SF) threshold of 0.80 or higher. Between 1993 and 1997, congestion increased somewhat on urban Interstates while decreasing on other freeways and expressways and other principal arterials. The proportion of peak-hour travel exceeding the 0.80 threshold on urban Interstates increased slightly from 52.6 to 53.3 percent. On all urban principal arterials, it was 40.2 percent in 1997, down from 40.9 percent in 1995. Overall the congestion trends seem to have flattened over the past several years.

Daily delay is a more recently adopted measure of congestion, and is an attempt to use a measure that is readily observed by the traveling public. However, the delay values used in this report are modeled values, not directly observed values. Delay is expressed in terms of hours per thousand vehicle-miles traveled. Between 1993 and 1997, the greatest delay has been on “other principal arterial” highways in urbanized areas with more than 200,000 residents. These are higher-level roads that are accommodating significant metropolitan growth; the delay on these roads includes that caused by stop signs and traffic signals.

There are essentially two ways to examine transit performance. One approach is to use operating data from the National Transit Database to derive average operating speeds and vehicle utilization. For example, passenger-mile weighted average speed decreased slightly between 1995 and 1997, from 20.4 to 20.3 miles per hour. Another approach is to use passenger survey data that identifies travel times, waiting times, and seating conditions upon boarding. For example, the basic mobility group is more dependent on transit and has a higher tolerance for delay (12.1 minutes) and unreliability (13.6 minutes) than the other two groups. People with an automobile alternative, using transit to avoid traffic congestion, have average wait times of 7.3 minutes, with 9.3 minutes in variation. Similarly, *above poverty* households without cars experience wait times that are a little longer than those experienced by households with cars. They also experience a similar reliability factor.

Highway Operational Performance

Operational performance is defined by how well highways accommodate travel demand. Congestion, therefore, is an indicator of poor operational performance. Recent newspaper stories about "road rage" highlight the escalating problem of congestion in the United States. Congestion may contribute to a sense of frustration and hostility on highways, but it also has more specific measurable costs for American drivers. The Texas Transportation Institute's (TTI) *1999 Urban Roadway Congestion Annual Report* estimates that in the 68 urban areas studied in 1997, drivers experienced 4.3 billion hours of delay and wasted 6.7 billion gallons of fuel. Total congestion cost for these areas, including wasted fuel and time, was estimated to be about $72 billion in 1997. Almost 60 percent of that cost was experienced in the 10 metropolitan areas with the most congestion. Exhibit 4-2 shows the 20 urban areas with the highest congestion costs, according to TTI.

Exhibit 4-2

Total Congestion Costs by Urban Area, 1997

	Annual Cost Due to Congestion ($ Millions)			
Urban Area	Delay	Fuel	Total	Rank
Los Angeles, CA	10,855	1,550	12,405	1
New York, NY-Northeastern NJ	7,835	1,050	8,885	2
Chicago, IL-Northwestern IN	3,915	485	4,400	3
Washington, DC-MD-VA	3,190	370	3,560	4
Detroit, MI	2,820	325	3,145	5
San Francisco-Oakland, CA	2,670	395	3,065	6
Boston, MA	2,330	305	2,635	7
Atlanta, GA	2,050	220	2,270	8
Houston, TX	1,980	230	2,210	9
Philadelphia, PA-NJ	1,630	195	1,825	10
Seattle-Everett, WA	1,585	220	1,805	11
Dallas, TX	1,535	180	1,715	12
Miami-Hialeah, FL	1,355	160	1,515	13
Baltimore, MD	1,185	145	1,330	14
St. Louis, MO-IL	1,180	130	1,310	15
San Diego, CA	1,100	165	1,265	16
Denver, CO	930	120	1,050	17
Phoenix, AZ	925	125	1,050	18
Minneapolis-St. Paul, MN	915	115	1,030	19
San Jose, CA	835	120	955	20

Source: Texas Transportation Institute, 1999 Annual Mobility Report.

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, and firms 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.

> ***Q.*** **What is the Federal Highway Administration view of the reports produced by the Texas Transportation Institute on Urban Roadway Congestion?**
>
> ***A.*** The Texas Transportation Institute has studied congestion in a number of cities in the Nation annually since 1982. This is the most significant continuing study being done on congestion in the United States. In order to attain the substantial achievements of this study, TTI has used a straight-forward, simple procedure to define congestion and to estimate the costs of congestion to the public. The TTI studies have provided usable measures of congestion in a large number of metropolitan areas in the Nation, combining measures of congestion delay, incident delay, and fuel consumption. FHWA commends TTI for its contribution to the knowledge base of congestion and believes that the results are useful as measures of the trends of congestion and its costs in the metropolitan areas. Future research may provide the means to further refine this type of study.

Measuring Traffic Congestion

While congestion is conceptually easy to understand, it has no widely accepted definition. This is because 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 with 3 million people, based on varying history and expectations. Because of this, transportation professionals examine congestion from several perspectives.

Three key aspects of congestion are its severity, extent, and duration. The **severity** of congestion refers to the magnitude of the problem, as measured by the average overall travel speed, travel time delay, or the length of queues behind bottlenecks. The **extent** of congestion is defined by the geographic area (the portion of the population or portion of total travel affected). The **duration** of congestion is the lenth of time that the traffic flow is congested, often referred to as the "peak period" of traffic flow.

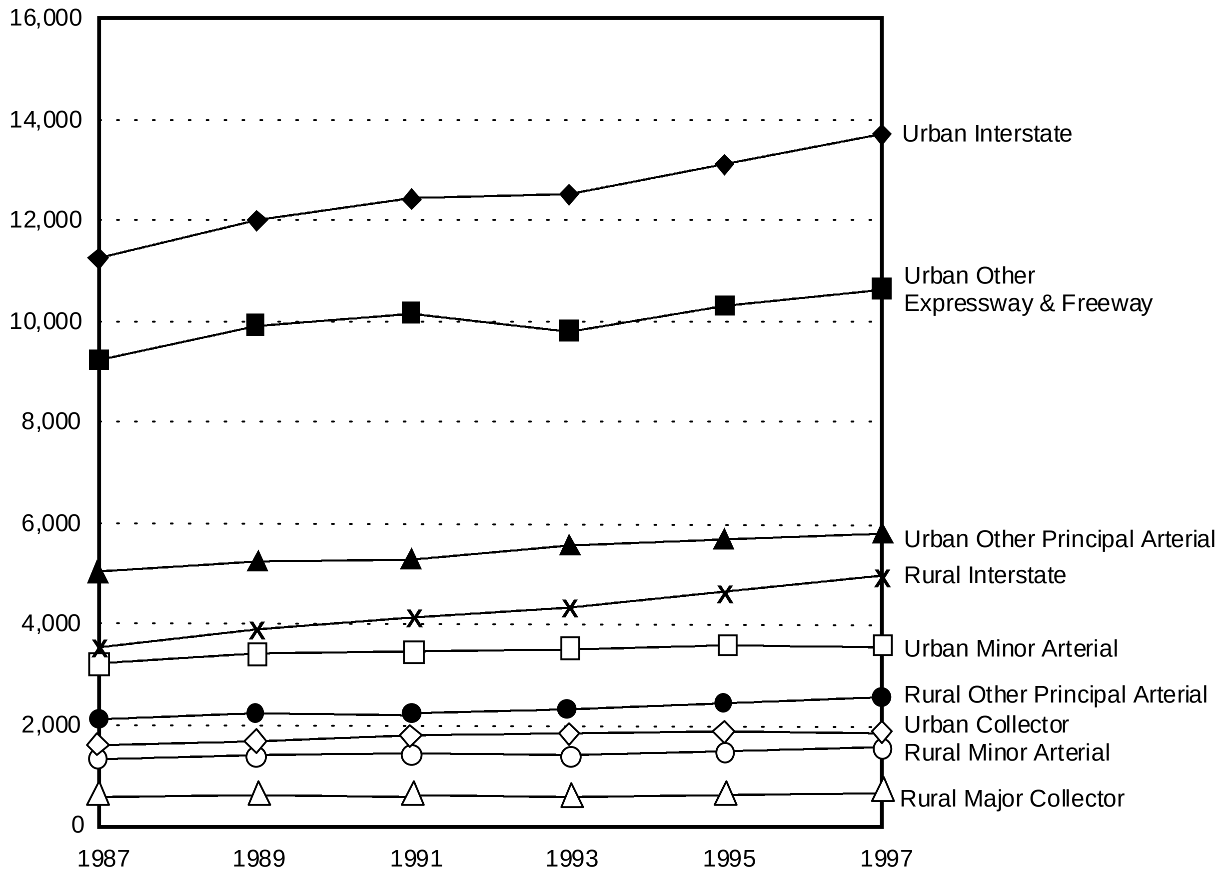
Daily vehicle-miles of travel (DVMT) per lane-mile is the most basic measure of how much travel is being accommodated on our highway systems since it is a count-based metric. It is based on actual counts of traffic, not on calculations which are in turn based on actual data. The traditional congestion measure in this report has been volume service flow (V/SF), the ratio of the volume of traffic using a road in the peak travel hour to the capacity or service flow of that road. V/SF is limited because it only addresses peak-hour and disregards the duration of congestion. As travel volume grows on a given highway section, after a certain point peak-hour congestion tends to stabilize even as total hours of congestion continue to increase. Focusing only on the V/SF measure alone can lead to erroneous conclusions about highway operating performance. This report adds a new indicator of congestion, delay. Delay incorporates the effects of congestion throughout the day, not only during the peak hour of travel.

DVMT per Lane-Mile

The volume of travel per lane-mile has increased over the past 10 years on every functional highway system for which data are collected . For urban Interstate the rate of increase from 1987 to 1997 is 2.0 percent, and for rural Interstate the rate of increase is 3.4 percent. DVMT per Lane-Mile for each system is shown in Exhibit 4-3. Whatever other measure is used to estimate congestion or its effects, there is no doubt that the density of traffic is increasing, especially on the higher functional systems.

Exhibit 4-3

DVMT per Lane-Mile, 1987-1997



Jurisdiction	1987	1989	1991	1993	1995	1997	Annual Rate of Change 1987-1997
Rural							
Interstate	3,530	3,880	4,120	4,310	4,640	4,952	3.40%
Other Principal Arterial	2,090	2,210	2,220	2,310	2,410	2,522	1.90%
Minor Arterial	1,300	1,390	1,440	1,390	1,470	1,556	1.80%
Major Collector	540	580	600	560	590	632	1.60%
Urban							
Interstate	11,230	11,990	12,420	12,520	13,110	13,696	2.00%
Other Expressway & Freeway	9,240	9,910	10,140	9,770	10,300	10,620	1.40%
Other Principal Arterial	5,010	5,240	5,280	5,540	5,650	5,768	1.40%
Minor Arterial	3,220	3,420	3,460	3,490	3,560	3,567	1.00%
Collector	1,600	1,650	1,780	1,830	1,880	1,832	1.40%

Source: June 1999 HPMS.

V/SF Ratio

Volume/service flow (also known as the volume/capacity ratio) is a measure of the severity of congestion. The V/SF is the ratio between the volume of traffic actually using a highway during the peak hour and the theoretical capacity of the highway to accommodate traffic. The higher the ratio, the more congested the facility.

Congestion reported in this chapter is based on a threshold value of 0.80. This typically represents Level of Service (LOS) D, as described in Exhibit 4-4. This volume of traffic is 80 percent of the maximum that can be accommodated on a highway, but freedom to maneuver is noticeably limited and incidents result in substantial delays. Higher V/SF ratios represent more severe congestion, escalating into a breakdown in traffic flow at LOS F. Procedures for calculating the V/SF ratio are described in the Transportation Research Board's *Highway Capacity Manual* (HCM). It should be noted that this measure of congestion is still a subjective issue, even with engineering standards.

Exhibit 4-4

Description of Levels of Service

Level of Service	Description
A	LOS A generally describes free-flow operations. Average operating speeds at the free-flow level generally prevail. Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream. The effects of incidents are easily absorbed.
B	LOS B also represents reasonably free flow, and speeds at the free-flow level are generally maintained. The ability to maneuver within the traffic stream is only slightly restricted, and the general level of physical and psychological comfort provided to drivers is still high. The effects of minor incidents are still easily absorbed, although local deterioration in service may be more severe than for LOS A.
C	LOS C provides for flow with speeds still at or near the free-flow speed of the freeway. Freedom to maneuver within the traffic stream is noticeably restricted at LOS C. Minor incidents may still be absorbed, but the local deterioration in service will be substantial. The driver experiences a noticeable increase in tension.
D	LOS D is the level at which speeds begin to decline slightly with increasing flows. Freedom to maneuver within the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort levels. Even minor incidents can be expected to create queuing.
E	LOS E describes operation at or near capacity. Operations are volatile, because there are virtually no usable gaps in the traffic stream. Any disruption can cause the following vehicles to give way, which can establish a disruption wave that propogates throughout the upstream traffic flow. The traffic stream has no ability to dissipate even the most minor disruptions, and any incident can be expected to produce a serious breakdown with extensive queuing. The level of physical and psychological comfort afforded the driver is extremely poor.
F	LOS F describes breakdowns in vehicular flow. Such conditions generally exist with queues forming breakdown points. Such breakdowns occur because of traffic incidents, recurring points of congestion, or peak-hour flow demand exceeding the capacity of the location.

Source: Highway Capacity Manual, 1994.

Exhibit 4-5 describes the percentage of peak-hour urban traffic that operates at a V/SF threshold of 0.80 or higher. The severity of congestion was somewhat greater on urban Interstates in 1997 than in 1993, increasing from 52.6 to 53.3 percent of all peak-hour traffic operating under congested conditions. For the same period peak-hour congestion was declining on other freeways and expressways until 1997, when it increased to 45.7 percent. Meanwhile, congestion severity decreased on other urban principal arterials between 1993 and 1997. Further years of estimating congestion may provide a clearer picture of the long-term trends in congestion.

Exhibit 4-5

Percent of Congested Travel on Urban Principal Arterial Highways, 1993-1997
Peak-hour travel with V/SF >= 0.80 based on 1994 Highway Capacity Manual

Year	All Urban Principal Arterial Highways	Urban Interstate Highways	Urban Other Freeways and Expressways	Urban Other Principal Arterials
1993	42.4%	52.6%	48.3%	31.4%
1994	41.0%	51.5%	46.3%	29.9%
1995	40.9%	51.6%	44.7%	30.1%
1996	40.3%	54.0%	44.8%	26.6%
1997	40.2%	53.3%	45.7%	26.5%

Source: June 1999 HPMS.

Delay

The *Federal Highway Administration 1998 National Strategic Plan* established a target of reducing delays on Federal-aid highways by 20 percent in 10 years, in terms of hours of delay per 1000 VMT. The delay values used in this report are modeled rather than measured. Currently we have no efficient way to measure delay directly. (See "Future Research," on page 4-12.) Delay is calculated as the difference between estimated actual travel speed and free-flow travel speed. Note that the delay calculations are in terms of vehicle-hours of delay, so that one hour of delay affects the same number of vehicles in one location as another. To the extent that vehicle occupancy differs from place to place, the number of people affected by one vehicle hour of delay may differ.

Delay is a new measure relative to the other two measures used in this report. How well it tracks perceived congestion remains to be seen. Several more years of use will be needed to determine the validity of the procedures used to calculate the value and the credibility of the results.

Exhibit 4-6 shows trends in delay since 1993. **For each of the four types of areas shown, delay in 1997 was greater than in 1993**. Delay increased from 8.27 to 9.35 hours between 1993 and 1995, but declined to 8.97 hours in 1997. Most urban highways have experienced less delay since 1995. Delay on Urban Interstates has fallen below 1993 levels. As shown in Exhibit 4-7, there is far more delay on Urban Interstates in the areas with more than 200,000 population than in the smaller urban areas or in rural areas.

The greatest delay occurs on urban other principal arterials, in urbanized areas with more than 200,000 residents. These are higher-level roads that are accommodating metropolitan growth. As shown in Exhibit 4-8, delay on these routes was 50 percent greater than delay on the same functional system in small urban areas under 50,000 population.

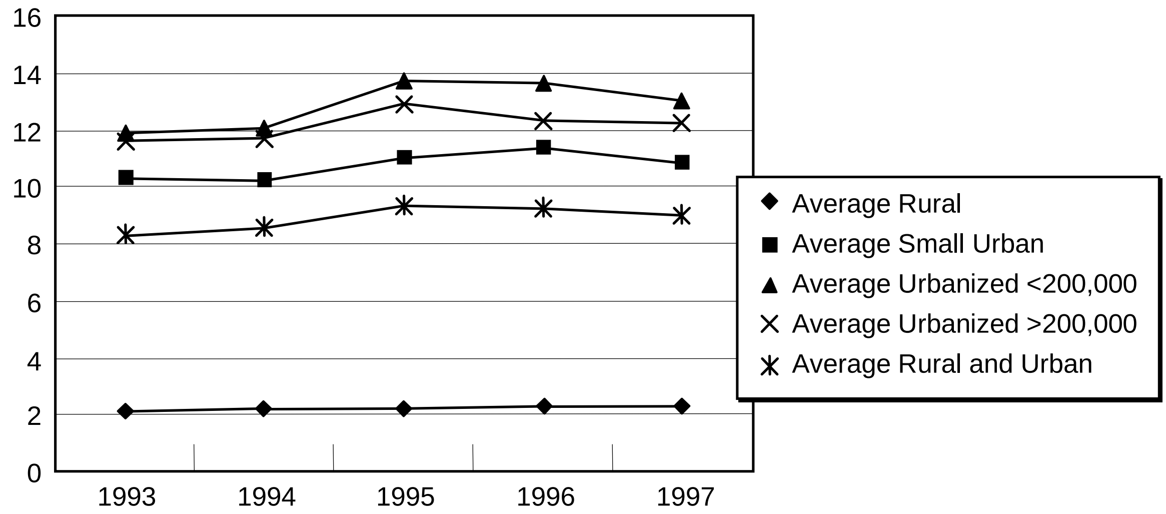
Despite the overall decline in delay observed since 1995, rural delay continues to increase. Every rural functional system had higher average delay in 1997 than in 1995.

Congestion in Metropolitan Areas

The Texas Transportation Institute (TTI) annually estimates congestion costs for travelers in many urbanized areas. The latest TTI study evaluates travel conditions and operations of arterial networks in 68 urbanized areas from 1982 to 1997. The TTI estimates are not directly based on HCM

Exhibit 4-6

Daily Delay, 1993-1997 (Hours per Thousand Vehicle Miles Traveled)



	1993	1994	1995	1996	1997
Rural					
Interstate	0.537	0.591	0.412	0.418	0.463
Other Principal Arterial	1.921	2.094	2.235	2.228	2.259
Minor Arterial	2.548	2.553	2.681	2.926	3.004
Major Collector	3.389	3.694	3.491	3.581	3.666
Average Rural	**2.074**	**2.186**	**2.204**	**2.249**	**2.313**
Small Urban					
Interstate	0.613	0.588	0.473	0.471	0.496
Other Freeways & Expressways	2.579	2.585	2.705	3.129	2.751
Other Principal Arterial	9.548	9.891	11.023	11.025	10.717
Minor Arterial	11.708	11.733	12.654	13.517	12.827
Collector	13.159	12.404	13.419	13.319	12.721
Average Small Urban	**10.268**	**10.160**	**11.020**	**11.316**	**10.772**
Urbanized <200,000					
Interstate	1.394	1.534	0.962	0.913	0.909
Other Freeways & Expressways	3.481	3.341	2.790	3.062	2.949
Other Principal Arterial	14.630	14.756	16.914	16.588	15.987
Minor Arterial	13.423	13.283	15.304	15.909	14.555
Collector	12.484	12.776	14.075	13.419	13.355
Average Urbanized <200,000	**11.891**	**12.062**	**13.720**	**13.614**	**13.027**
Urbanized >200,000					
Interstate	3.175	3.051	2.213	2.413	2.533
Other Freeways & Expressways	4.277	4.408	3.929	3.963	3.833
Other Principal Arterial	15.963	16.047	17.648	16.387	16.091
Minor Arterial	14.449	14.338	16.734	15.755	15.576
Collector	12.702	12.621	14.628	14.657	14.210
Average Urbanized >200,000	**11.593**	**11.694**	**12.938**	**12.329**	**12.176**
Average Rural and Urban	**8.268**	**8.517**	**9.348**	**9.223**	**8.973**

procedures, but assume that a given traffic volume per lane everyday (depending on the facility type) defines the threshold of congestion. TTI then incorporates an estimate of the cost of delay caused by incidents and an allowance for increased fuel consumption. Unlike methodology in the HCM, TTI reports do not account for changes in driver behavior over time. Continuing research supports changes in the HCM procedures which recognizes that drivers today are willing to drive closer together with less space between vehicles and at higher speeds than was the case 15 years ago. Thus, a highway facility with the same traffic volume that it accommodated 15 years ago will be reported as having less congestion today than formerly, using the latest HCM procedures. HCM procedures, however, do not account for delay caused by incidents, which in many cities may be a large portion of the total delay to traffic.

Exhibit 4-7

Daily Delay on Interstate Highways in 1997 (Hours per Thousand Vehicle Miles Traveled)

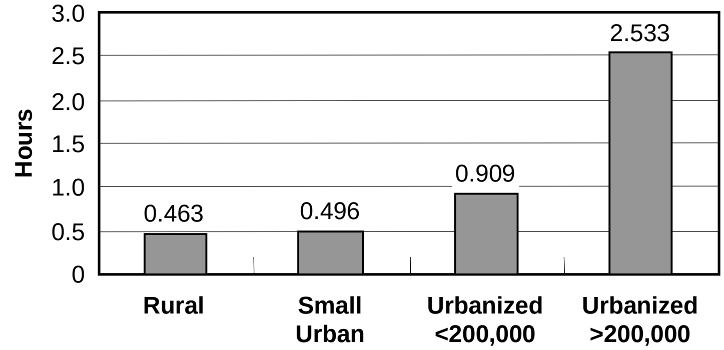
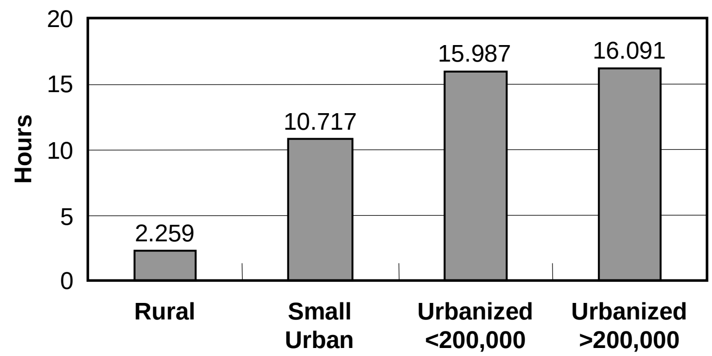


Exhibit 4-8

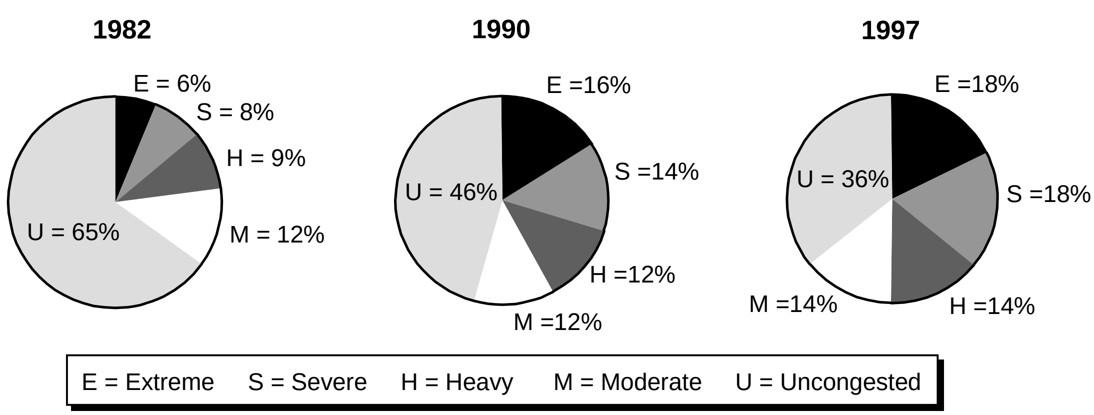
Daily Delay on Other Principal Arterials in 1997 (Hours per Thousand Vehicle Miles Traveled)



According to TTI, the percentage of travel in congested conditions (moderate to extreme) almost doubled, rising from 35 percent in 1982 to 64 percent in 1997. Looking at this from another perspective, about two-thirds of urban travel in 1982 was in uncongested conditions. This has dropped to about one-third of travel by 1997. These statistics are described in Exhibit 4-9.

Exhibit 4-9

Growth of Congested Travel, 1982-1997



The heart of the TTI mobility report is a travel rate index (TRI). Urban mobility levels are estimated using a ratio of travel time during the peak period to that experienced during free-flow travel. The estimates are developed from travel information on freeways and arterial highways. The travel time ratios on each system are combined into a single value using the amount of travel on each portion of the system. This variable weighting factor allows comparisons between cities like Phoenix, AZ, where principal arterials carry about 50 percent more traffic than freeways, and Portland, OR, where the ratio is reversed.

The estimated peak-period travel rate—in minutes per mile—is divided by the travel rate at the speed limit to identify the time penalty due to congestion. A travel rate index of 1.3 indicates a 30 percent time penalty during the peak—a 20-minute trip becomes a 26-minute trip. The average travel rate index for the 69 urban areas studied by TTI is 1.29. Of the 68 areas, 34 have TRI values in excess of 1.2 and 8 more are within 0.03 of exceeding this level.

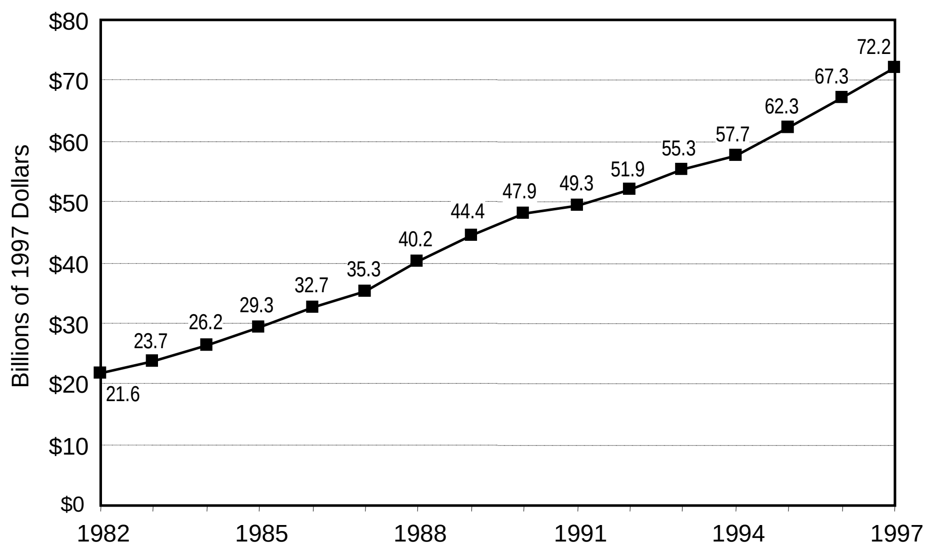
Q. **How many metropolitan areas have experienced increased congestion since 1996?**

A. According to the Texas Transportation Institute, 46 of 68 urban areas studied showed decreased mobility between 1996 and 1997. Eight areas showed improved mobility.

TTI has estimated the cost of congestion from 1982 to 1997, normalizing the values to the same number of metropolitan areas and to 1997 dollars. This cost, by their estimation, has risen from $21 billion to $72 billion for this 16-year period. This trend is shown is Exhibit 4-10.

Exhibit 4-10

Cost of Congestion 1982-1997 in Constant 1997 Dollars



Source: Texas Transportation Institute, 1999 Annual Mobility Report.

Reducing Congestion

The U.S. Department of Transportation is committed to improving the highway system's operational performance. However, solving the congestion problem requires more than adding capacity. The U.S. Department of Transportation is involved with its State and local partners on a variety of techniques to reduce congestion. These include:

- Adding capacity through new and expanded highways;
- Reducing the number of vehicles by promoting transit;
- Increasing the number of passengers in each vehicle through incentive programs;
- Changing when vehicles use the highway, which reduces the load on the highway system at peak-travel time;
- Using the Intelligent Transportation System (ITS) to more efficiently direct traffic; and
- Providing better land use patterns by more efficiently locating employment centers, shopping, and residential neighborhoods.

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.

Transit Operational Performance

Transit system performance can be measured in a variety of ways. One approach is to use operating data from the National Transit Database (NTD). Two nationwide performance measures that can be calculated from the NTD are average operating speeds and vehicle utilization rates, which are used as inputs to the Performance Enhancement Module of the Transit Economic Requirements Model (TERM). Where operating speeds are especially low or vehicle utilization rates are especially high, TERM calls for new investment in those areas to improve nationwide performance. The TERM is discussed in greater detail in Appendix I.

Another approach is to use passenger survey data describing the characteristics of a particular trip. The data source for this approach is the 1995 Nationwide Passenger Transportation Survey (NPTS). Survey observations are for individual transit trips, and include data on travel times, waiting times, and seating conditions upon boarding. These performance measures can be calculated for transit trips by public policy function (See Chapter 2).

Operating Speeds

Average speeds for transit systems are presented for both rail and non-rail modes in Exhibit 4-11. Vehicle speeds are calculated by dividing vehicle revenue miles by vehicle revenue hours, yielding a measure of miles per hour. These are calculated for each operator and mode. The average speeds are then obtained by weighting operator-mode speeds by passenger miles. This weighting allows for a better measure of the speed at which the average transit passenger in the U.S. travels.

The average speed for transit passengers was 20.3 miles per hour (mph) in 1997. This represents an increase of 1.0 mph since 1987, but it is down slightly since 1995. Rail speeds, which are substantially higher than non-rail speeds, were also higher in 1997 (at 26.1 mph) than they were a decade prior, but have decreased slightly since 1995. Non-rail speeds showed a slight increase to 13.8 mph since 1987, but have remained virtually unchanged for the last nine years.

Q. **Why did average rail speeds fall between 1995 and 1997?**

A. Much of the decrease in weighted-average speeds during that period can be attributed to the substantial rise in passenger miles in the New York City subway system, which has a lower operating speed (18.3 mph) than the average for all rail systems (which include commuter rail).

Exhibit 4-11

Passenger-Mile Weighted Average Speed by Transit Mode, 1987-1997

	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

Source: National Transit Database.

Vehicle Utilization

Vehicle utilization is measured as annual passenger miles of travel per capacity-equivalent vehicle operated in maximum service. It incorporates both vehicle operating intensity (the number of miles a vehicle is driven per year) and passenger usage intensity (the number of passengers per vehicle). Exhibit 4-12 shows vehicle utilization for the five highest-PMT modes for 1987 through 1997. Rail modes (heavy rail, light rail, and commuter rail) show much higher utilization rates than do the non-rail modes (bus and demand response), with annual utilization rates over 600,000 passenger miles per vehicle for each of the rail modes.

The trend shows that bus utilization was lower in 1997 than in the late 1980s, but rose slightly in the last two years. Heavy rail utilization fell in the early 1990s, but has now recovered and surpassed the level of 1987. Commuter rail and demand response modes have seen their utilization rates increase over the last decade. Light rail has shown by far the largest increase in vehicle utilization, up 6.8 percent annually since 1987.

Exhibit 4-12

Vehicle Utilization
Annual Percentage Miles Per Capacity-Equivalent Vehicle by Mode (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
Annual Rate of Change 1987-97	-0.4%	0.1%	0.9%	6.8%	0.8%

Source: National Transit Database.

Waiting Times and Reliability

Two important measures of transit performance to the user are the length of time that the user must wait at a transit stop for a transit vehicle to arrive, and the reliability of those waiting times. Studies of travel behavior have found that transit passengers find waiting time to be even more onerous than in-vehicle travel time. Thus, an important measure of transit service is the amount of time that passengers must spend waiting to continue on their journey. Reliability, as measured by the variation in waiting times, is also an important measure of performance. As expected waiting times become more uncertain, transit passengers are less able to rely on transit to deliver them to their destinations at their desired arrival time.

Exhibit 4-13 shows the difference in wait times and reliability across the three niches. The basic mobility group is more “dependent” on transit and has a higher tolerance for delay (12.1 minutes) and

Exhibit 4-13

Waiting Times and Reliability

	Average Waiting Time (minutes)	Variation in Waiting Time*
Basic Mobility	12.1	13.6
Location Efficiency	8.9	8.8
Congestion Relief	7.3	9.3

*standard deviation in waiting time.

Source: FTA analysis of 1995 NPTS Database.

unreliability (13.6 minutes) than the other two groups. People with an automobile alternative, using transit to avoid traffic congestion, have average wait times of 7.3 minutes, with 9.3 minutes in variation. Similarly, *above-poverty* households without cars experience wait times that are slightly longer than those experienced by households with cars. They also experience a similar degree of reliability. These observations are consistent with the professional literature, which indicates that higher-income individuals generally place a greater value on their time, as their opportunity cost of not being at work is higher. Thus, passengers who use transit for its location benefits or to avoid traffic congestion are more likely than others to use it only if the system is reliable and minimizes schedule delay.

Seating Conditions

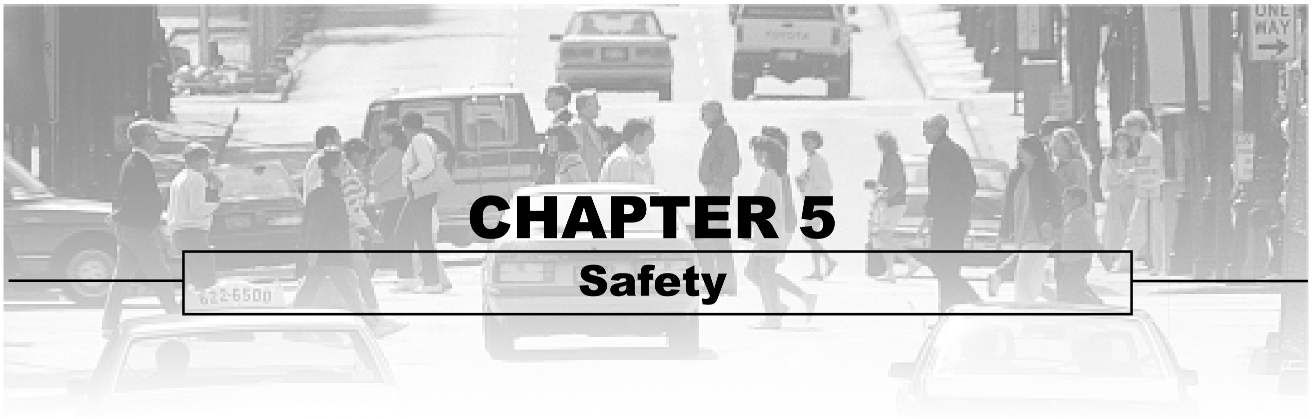
Exhibit 4-14 shows the degree of crowding in transit vehicles, according to the function transit is performing, as measured by the proportion of passengers who are unable to find a seat upon boarding. Transit vehicles are crowded (i.e., transit seating capacity is periodically insufficient) in all three market niches for more than ¼ of riders. Basic mobility passengers experience slightly more crowding than others, while passengers who look to transit as an alternative to their cars experience the least. This relative "equality" of crowding reflects transit's perennial need to serve each of its three constituencies in a balanced way with the limited resources it has available, in this case by allocating capacity such that similar proportions of passengers in each niche are forced to stand at the beginning of their trip.

Exhibit 4-14

Seating Conditions

	Seat Unavailable Upon Boarding
Basic Mobility	29.7%
Location Efficiency	26.3%
Congestion Relief	25.0%

Source: 1995 NPTS Database.



CHAPTER 5

Safety

Introduction

This chapter describes safety statistics for the Nation's highway and transit systems. It begins by summarizing safety characteristics, including the national fatality and injury rates; fatalities by functional class; and fatalities from single vehicle run-off-the-road crashes, pedestrian crashes, speed-related crashes, and large truck crashes. The high incidence of fatal crashes among young and older Americans is noted. The highway portion of this chapter concludes with a discussion of some of the contributing factors that have made the Nation's highways safer. The transit portion discusses the general safety trends by transit mode: Bus, Heavy Rail, Commuter Rail, Light Rail, and Demand Response.

Summary

This section summarizes the trends in both highway and transit related fatality and injury information. In Exhibit 5-1 highway data are represented in “vehicle-miles-traveled” (VMT) and transit data are represented in “passenger-miles-traveled” (PMT).

Highway fatalities rose slightly from 1995 to 1997, from 41,817 to 42,013. Despite this increase, both the number of fatalities and the fatality rate have sharply declined since 1966. In 1966 the fatality rate was 25.9 per 100,000 people. By 1997, that rate had declined to 15.7 per 100,000 people. This plummeting fatality rate occurred even as the number of licensed drivers grew by nearly 80 percent. Similarly, the number of injuries and injury rate have diminished, although not as dramatically as fatalities.

A number of factors have contributed to these improvements in highway safety, including increased safety belt use, reduced alcohol-impaired driving, and infrastructure-related safety improvements (e.g. roadway and roadside improvements and improvements at highway-rail grade crossings) at locations with known or potential crash problems. Surveys showed that 69 percent of vehicle occupants used seat belts by 1997. An aggressive education and law enforcement campaign had reduced the percentage of fatalities attributable to alcohol to 39 percent by 1997. Among the infrastructure-related improvements which have helped contribute to improved highway safety include the installation and upgrading of traffic signs and pavement markings, traffic signals, guardrails, median barriers, impact attenuators, and roadway lighting; improvements to pavement skid resistance; and the installation of lights, gates and other warning devices at highway-rail grade crossings. While safety advocates can take comfort in an improved driving environment, there are several disturbing trends on the Nation’s highways, including the increasing numbers of young and older Americans involved in fatalities.

Transit related fatalities remained nearly the same with 274 in 1995 and 275 in 1997. Among the transit modes, Commuter Rail Service has one of the highest fatality rates, reflecting the higher speeds at which these vehicles operate. Discussion on the general transit-related safety trends are addressed in the Transit Safety section.

Exhibit 5-1

Comparison of Safety Statistics with Those in the 1997 C&P Report

	1995 Data		
Highway Safety	1997 Report	Revised	1997 Data
Fatalities	N/A	41,817	42,013
Fatality Rate per 100,000 People	N/A	15.91	15.69
Fatality Rate per 100 million VMT	N/A	1.7	1.6
Injuries	N/A	3,465,000	3,348,000
Injury Rate per 100,000 People	N/A	1,319	1,250
Injury Rate per 100 million VMT	N/A	143	131
Percent of Fatalities on Rural Highways	58%	N/A	57%
Percent of Fatalities on Urban Highways	41%	N/A	43%
Percent of Fatalities Attributed to Alcohol	N/A	41.2	38.6
Transit Safety			
Transit-Related Fatalities	N/A	274	275
Fatality rate per 100 million PMT (by mode)			
Bus	N/A	0.50	0.65
Heavy Rail	N/A	0.75	0.64
Commuter Rail	N/A	1.21	1.13
Light Rail	N/A	1.75	0.29

Highway Safety

The U.S. Department of Transportation has long made safety one of its highest priorities. Over 90 percent of all transportation-related deaths and injuries are highway-related, and the economic cost of highway-related crashes exceeds $150 billion annually. The Department has aggressively worked with other Federal agencies, business leaders, and its state and local partners to reduce highway fatalities and injuries. Through such measures as education programs, aggressive law enforcement, and the implementation of infrastructure-related safety improvements, fatalities on the Nation's highway system have been sharply reduced. This is one of the most important transportation "success stories" of the 1990s.

Exhibit 5-2 describes the considerable improvement in highway safety since Federal legislation first addressed this issue in 1966. That year, the fatality rate was 25.9 per 100,000 people. By 1997, the fatality rate was 15.7 per 100,000 people. **This plummeting fatality rate occurred even as the number of licensed drivers grew by nearly 80 percent**. Some of the contributing factors for this reduced rate will be discussed later in this chapter.

While the fatality rate has sharply dropped, the number of traffic deaths also decreased between 1966 and 1997—despite the increase in motor vehicle traffic on the nation's highways. As Exhibits 5-3 and 5-4 describe, the reduction in the number of fatalities has not been as consistent as the fatality rate. In 1972 and 1973, the number exceeded 54,000. In 1974, following the implementation of a national maximum speed limit, the number of fatalities declined by 16 percent to 45,196. Fatalities began to increase in 1976 and exceeded 51,000 in both 1979 and 1980 before declining significantly in the early 1980s. The number of fatalities generally increased from 1984–1988. Between 1989 and 1992, the number of fatalities declined each year, achieving a 30-year low of 39,250 in 1992. However, the number of fatalities increased steadily from 1993 through 1996 before declining slightly in 1997. The Federal Highway Administration's Strategic Plan targets a 20 percent reduction in highway-related fatalities and injuries by 2008. Appendix F describes the motor carrier safety plan in greater detail. In addition to the agency's safety goal, the Department of Transportation has specifically identified a 50 percent reduction in the number of truck fatalities over the next ten years. FHWA has identified four focus areas: single vehicle run-off-the-road crashes; pedestrian crashes; speed-related crashes; and large truck crashes. Many States have identified similar priorities.

Single vehicle run-off-the-road crashes account for 36 percent of all highway-related fatalities. This represents about 15,000 fatalities each year. To reduce these crashes, FHWA is promoting devices to keep vehicles on the road (rumble strips to alert fatigued and distracted drivers, pavement markings, signs and delineation) and devices to reduce crash severity if the vehicle does leave the roadway (guardrails, breakaway devices, and crash cushions). These crashes occur on all types of roadways. *[See Exhibit 5-5]*.

Pedestrian crashes represent 13 percent of all highway-related fatalities. About 5,300 pedestrians are killed and approximately 77,000 pedestrians are injured each year. The number of pedestrian fatalities exceeds the combined total of fatalities related to air, sea, and train crashes each year. Crashes can be reduced by implementing available countermeasures, such as far side bus stops and pedestrian barriers. These accidents can also be reduced by better accommodating pedestrians through sidewalks, clearly-marked crosswalks, and grade separations. *[See Exhibit 5-6]*.

Exhibit 5-2

Summary of Fatality and Injury Rates, 1966-1997

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 per100 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	260,289	15.64	175,403	1.7	3,266,000	1,255	139
1995	41,817	262,765	15.91	176,628	1.7	3,465,000	1,319	143
1996	42,065	265,190	15.86	179,539	1.7	3,483,000	1,314	140
1997	42,013	267,744	15.69	182,709	1.6	3,348,000	1,250	131

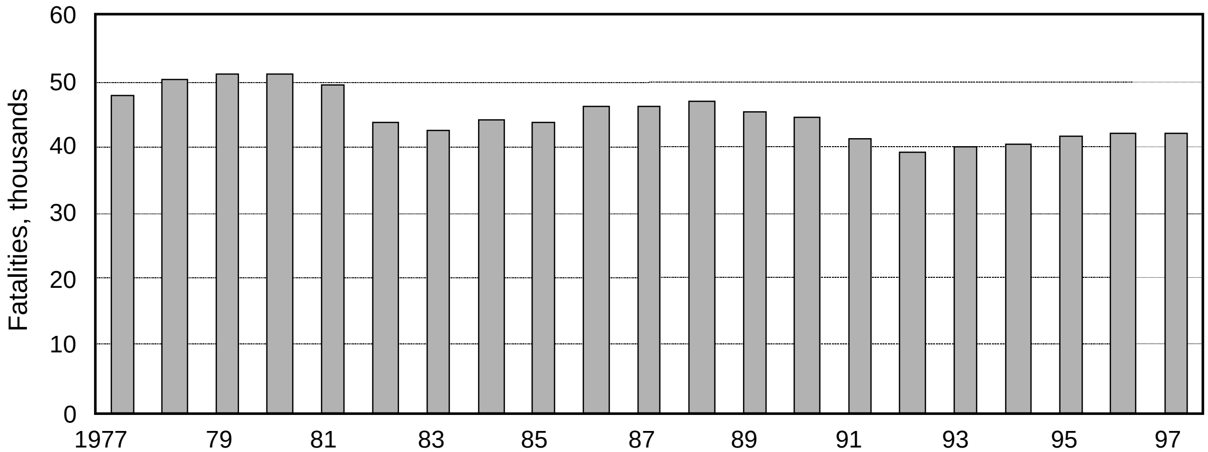
Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

Pedestrian fatalities have been decreasing since 1984; however, this may just mean that more people are driving because they consider walking inconvenient or dangerous. TEA-21 has increased funding for pedestrian and bicycle safety, and it requires that bicyclists and pedestrians be given due consideration in the long-range transportation plans for states and metropolitan planning organizations.

Speeding is a contributing factor in a third of all fatal crashes. This represents about 13,000 fatalities and 742,000 injuries annually. The 1995 National Highway System Designation Act ended Federal involvement in setting maximum speed limits for States; however, FHWA provides research and guidance to its State and local partners. For example, FHWA has supported the development of new

Exhibit 5-3

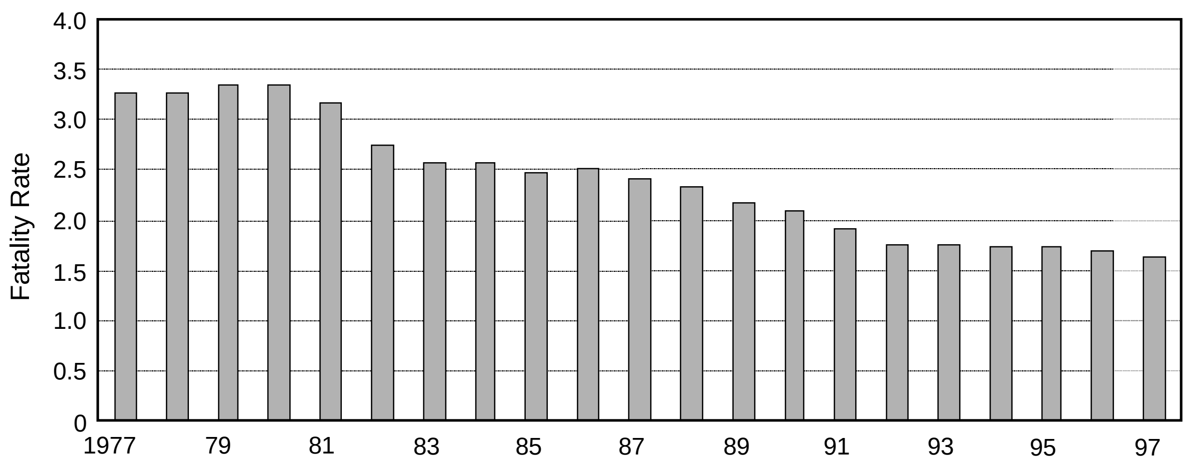
Fatalities, 1977-1997



Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

Exhibit 5-4

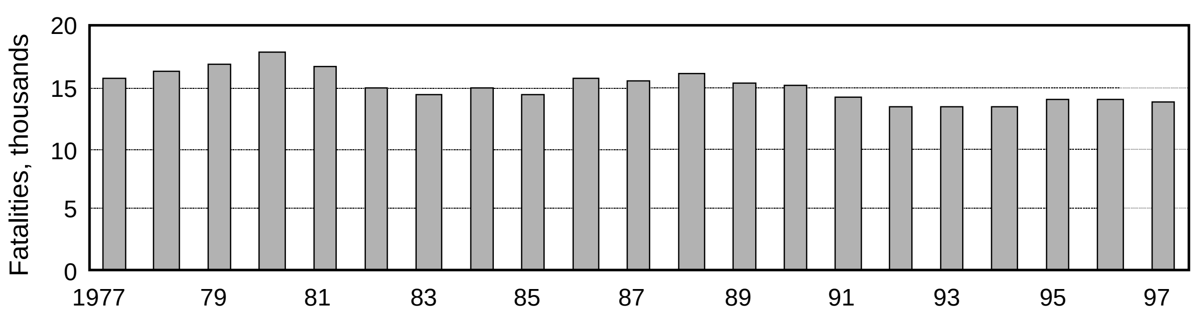
Fatality Rate, 1977-1997



Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

Exhibit 5-5

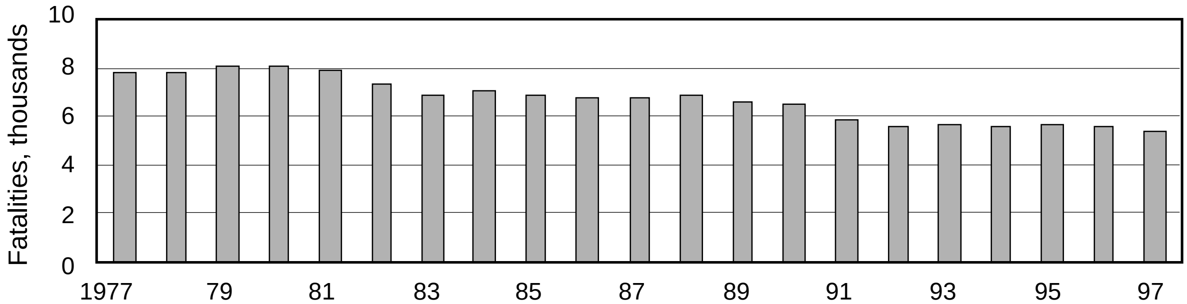
Single Vehicle Run-Off-The-Road Fatalities, 1977-1997



Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

Exhibit 5-6

Pedestrian Fatalities, 1977-1997



Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

speed management techniques. The concept of variable speed limits—moving away from a posted speed limit with its "one size fits all" approach—is a promising concept for the future. Iowa, Colorado, and Washington all have VSL tests that adjust speed to weather conditions. Additionally, FHWA is also examining the use of advanced technologies to combat speeders, red light runners, and other aggressive drivers.

Large truck crashes resulted in about 5,350 fatalities and 133,000 injuries in 1997. This represents a 20 percent increase since 1992, which might be explained by a growth in motor carrier traffic. The deployment of Intelligent Transportation System (ITS) technologies represents one possible solution to this problem. ITS will also probably first be tested on trucks before being made available for use on passenger cars. There are two reasons for this. First, many trucking fleets are committed to safety and believe that safety is good business. Second, the cost of installing ITS technology on trucks is proportionally much smaller than it would be for cars. Though the number of crashes has risen, the fatality rate per drivers and occupants of large trucks has dropped significantly, from 3.7 fatalities per 100 million VMT in 1988 to 2.6 fatalities per 100 million VMT in 1997.

Q. **What has contributed to the decline in the fatality rate for truck drivers?**

A. This decline is not a result of any single factor, but may be a result of a combination of factors including an increase in seat belt usage, a shifting of truck travel from other arterials to the Interstate, a decrease in alcohol-related truck crashes, and an increase in an overall truck safety awareness.

When driver fatality rates are calculated on the basis of estimated annual travel, the highest rates are found among the youngest and oldest driving drivers. Compared with the fatality rate for drivers aged 25 through 69 years old, the rate for teenagers is about 4 times as high and the rate for the oldest group (70 years and older) is almost 9 times as high. State officials are trying to reduce the teenage crash rates through changes in driver licensing. Currently, 20 States have enacted legislation in this area and another 9 have partial graduated licensing systems. Additionally, States are trying to combat drunken driving, a major cause of teenage death on the highways.

On the other side of the age spectrum, the solutions for older driver safety are not as obvious. Americans older than 85 years have the highest fatality rate—approximately 7.9 persons killed per 100 million vehicle miles traveled. Men aged 85 and older have a rate of 9.9, while the rate for women in this demographic group is 5.5. Older drivers have a relatively low crash rate, but their fatality rate is twice that of teenagers. As the "baby boom" generation ages, older driver safety will become an even greater concern.

Safety Belt Use

> **Q. Have air bags been a factor in reducing fatalities and saving lives?**
>
> **A.** Yes. Seat belt usage in conjunction with vehicular air bag systems provide additional protection in potentially fatal crashes. In general, air bags can reduce the risk of driver fatality by 31 percent for direct frontal crashes and 11 percent for all types of crashes. According to the National Highway Traffic Safety Administration, it is estimated that air bags have saved 2,263 lives from 1987 through 1997, including 842 lives in 1997 alone.

The public's acceptance of safety belts and child safety seats represents one of the great success stories of government policy in past two decades. This resulted from a two-pronged effort of education and enforcement. Prompted by an intense public service campaign, surveys showed that 69 percent of vehicle occupants used seat belts by 1997. Additionally, 49 States had mandatory safety belt laws by 1997, and 13 States and the District of Columbia had primary enforcement laws that allow police to stop a car when they observe a safety belt violation. Safety belt use is 79 percent in those jurisdictions with primary enforcement, compared to 62 percent in the 36 States that only allow police to issue citations if a vehicle is stopped for another offense.

The 1995 National Personal Transportation Survey provides information about the frequency of safety belt use. Exhibit 5-7 shows that overall 73 percent of respondents said that they "always" wear a seat belt, but that those less likely to wear one are men, teenagers, and respondents with a high school education or lower.

Exhibit 5-7

Frequency of Safety Belt Use by Selected Variables, 1995

	How Often Do You Wear a Seat Belt? (%)			
	Always	Most of the Time	Sometimes	Never
Overall	**73.3**	**14.8**	**7.9**	**3.9**
By Gender				
Men	68.1	16.8	9.9	5.1
Women	78.1	12.9	6.1	2.9
By Age Group				
5-15	75.8	15.8	6.7	1.7
16-19	68.2	17.1	10.0	4.8
20-29	70.1	15.7	9.5	4.7
30-49	73.2	14.2	8.4	4.2
50-64	73.4	14.5	7.4	4.7
65-74	74.9	14.0	6.9	4.2
75+	77.0	12.1	5.4	5.3
Education Level of Respondent				
Some high school or high school grad	68.0	16.2	10.0	5.7
Some college or college grad	76.1	13.5	7.0	3.3
Graduate school	82.4	14.8	7.9	3.9

Source: National Personal Transportation Survey, 1995.

Alcohol Involvement in Crashes

Alcohol-impaired driving is a serious public safety problem in the United States. The National Highway Traffic Safety Administration estimates that alcohol was involved in 39 percent of fatal crashes and in 7 percent of all crashes in 1997. There are three main groups involved in alcohol-impaired driving:

- The largest group, **21 to 34-year-old young adults**, is responsible for approximately 50 percent of all crashes. Recent studies also indicate these drivers tend to have much higher levels of intoxication than other age groups.
- While **chronic drunk drivers** represent only 1 percent of all drivers on weekend nights, they represent nearly 50 percent of fatal crashes at that time.
- **Underage drinkers** are disproportionately overrepresented in impaired driving statistics. Not only are they inexperienced new drivers, but they are inexperienced drinkers.

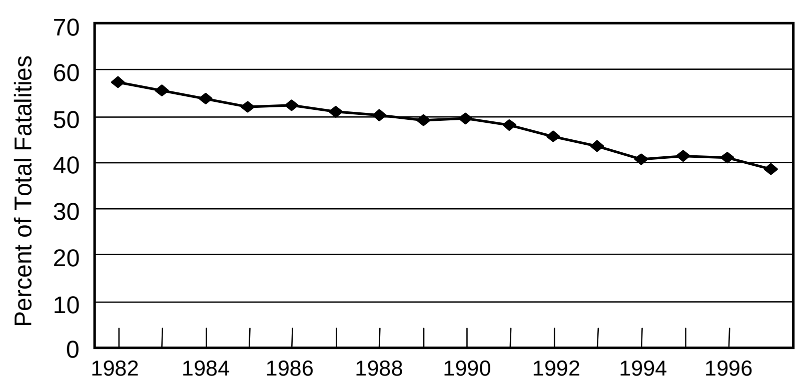
In addition to the problems caused by alcohol-impaired drivers, alcohol is also a significant factor in pedestrian-related fatalities. In nearly 30 percent of pedestrian fatalities, the victims were alcohol-impaired.

Since the 1980s, officials at every level of government have worked with the private sector to aggressively reduce alcohol-impaired driving. Like the safety belt campaign, this effort has used a combination of education and law enforcement to curtail the problem. Additionally, all States and the District of Columbia now have 21-year-old minimum drinking age laws. NHTSA estimates that these laws have reduced traffic fatalities involving drivers 18 to 20 years old by 13 percent, and that these statutes have saved over 17,000 lives since 1975.

While the campaign against impaired driving continues, evidence suggests that this has profoundly reduced fatalities in the United States. The number of alcohol-impaired fatalities has plummeted in the United States, from 25,165 in 1982 to 16,189 in 1997. The proportion of fatalities attributable to alcohol dropped from about 57 percent in 1982 to 39 percent in 1997. Exhibit 5-8 describes this trend.

Exhibit 5-8

Fatalities Attributed to Alcohol, 1982-1997



Source: National Highway Traffic Safety Administration, Fatality Analysis Report System, 1997.

Conclusion

Safety has long been a high priority for the Department of Transportation. The fatality rate has declined over the past 30 years even though the number of drivers and the miles driven has increased substantially over the same period. The FHWA Strategic Plan targets a 20 percent further reduction in highway-related fatalities and injuries by the year 2008. Many factors contribute to highway crashes and injuries, such as driver behavior, driving while intoxicated, vehicle condition, roadway geometrics and clearances, and weather conditions. Vehicle safety features such as seat belts and air bags and the proper use of child safety seats help to reduce the severity of injuries. With emphasis on all of these factors, serious injuries and fatalities can be further reduced.

Transit Safety

National data on public transit safety are reported in the National Transit Database. This data includes the total number of incidents, fatalities, and injuries reported by transit operators. The figures here are for directly operated service only; reporting of safety data for purchased transportation services has only recently begun. Comparable data on transit safety are available since the 1990 reporting year.

Reportable transit safety incidents include all incidents involving injuries, deaths, fire, or property damage over $1,000. Property damage includes both damage to transit vehicles and facilities and other vehicles that may be involved. Injuries and fatalities include those suffered by *both riders and non-riders*. Injuries and fatalities to riders may be sustained while boarding, alighting, or waiting for transit vehicles, as well as traveling inside transit vehicles. Non-rider injuries and fatalities include those sustained by pedestrians, trespassers, bicyclists, and the occupants of other motorized vehicles involved in a collision with a transit vehicle.

Exhibit 5-9 shows annual transit incidents, injuries, and fatalities for the period 1990 to 1997, expressed both as annual totals and as rates per 100 million passenger miles. The data show that safety incidents involving transit have declined considerably since 1990, falling from 251 per 100 million PMT to 165. Injuries sustained in transit incidents, however, have remained relatively stable over the same time period, at roughly 150 per 100 million PMT. Fatality rates have also declined considerably over the 7-year period, from .89 per 100 million PMT to .73.

Exhibit 5-9

Annual Transit-Related Incidents, Injuries, and Fatalities, 1990-1997
Directly Operated Service

	Incidents		Injuries		Fatalities	
Year	Total	Per 100 million PMT	Total	Per 100 million PMT	Total	Per 100 million PMT
1990	91773	251	53844	148	325	0.89
1991	87346	245	51625	145	296	0.83
1992	73795	210	54518	155	277	0.79
1993	66233	192	53057	154	270	0.78
1994	71429	200	58794	164	318	0.89
1995	62938	176	57589	161	274	0.77
1996	59709	165	55643	154	265	0.73
1997	62009	165	56535	151	275	0.73

Source: National Transit Database.

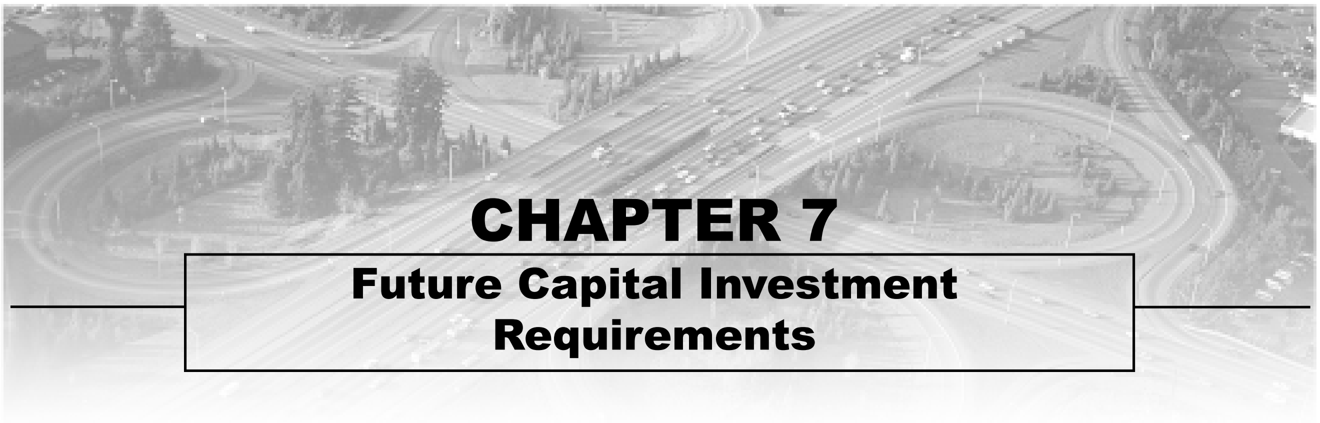
Exhibit 5-10 shows incident, injury, and fatality rates for the five largest transit modes. Incident and injury rates have consistently been highest for demand response services. Commuter rail service has the lowest injury and incident rates, but has one of the highest fatality rates, reflecting the higher speeds at which these vehicles operate. Buses, on the other hand, have consistently had above-average injury and incident rates coupled with below-average fatality rates. Fatality rates for light rail have shown considerable year-to-year variation over the period, while heavy rail fatality rates have been consistently decreasing.

Exhibit 5-10

Transit Incidents, Injuries, and Fatalities
Annual Rates Per 100 Million Passenger Miles by Mode, 1990-1997
Directly Operated Service

Incidents	1990	1991	1992	1993	1994	1995	1996	1997
Bus	409	378	314	277	296	264	252	242
Heavy Rail	114	142	144	147	150	136	119	126
Commuter Rail	51	47	47	33	42	38	34	44
Light Rail	282	257	217	168	170	148	141	115
Demand Response	1790	1435	946	766	801	785	964	627
Injuries	1990	1991	1992	1993	1994	1995	1996	1997
Bus	224	218	237	233	257	254	248	234
Heavy Rail	89	89	97	103	109	106	96	102
Commuter Rail	34	33	37	24	32	31	27	34
Light Rail	221	189	181	139	142	152	168	106
Demand Response	709	611	581	511	549	627	662	482
Fatalities	1990	1991	1992	1993	1994	1995	1996	1997
Bus	0.63	0.50	0.59	0.51	0.65	0.50	0.63	0.65
Heavy Rail	0.98	0.95	0.85	0.81	0.80	0.75	0.64	0.64
Commuter Rail	1.44	1.34	1.17	1.35	1.52	1.21	1.01	1.13
Light Rail	0.88	1.97	1.00	2.13	1.56	1.75	0.63	0.29
Demand Response	0.00	2.95	0.00	1.57	1.52	4.04	8.26	3.00

Source: National Transit Database.



CHAPTER 7

Future Capital Investment Requirements

Introduction

This chapter provides general investment benchmarks as a basis for the development and evaluation of transportation policy and program options. The 20-year investment requirement estimates reflect the total capital investment required from **all sources** to achieve certain levels of performance. This chapter does not directly address which revenue sources might be used to finance the investment required by each scenario. It also does not identify how much might be contributed by each level of government.

The **Maximum Economic Investment** scenario for highways, the **Eliminate Deficiencies** scenario for bridges, and the **Cost to Improve** scenario for transit are intended to define the upper limit of appropriate national investment based on engineering and economic criteria. The lower highway, bridge, and transit scenarios are designed to show the level of performance that might be attained at different funding levels. The benchmarks included in this chapter are intended to be illustrative, and do not represent comprehensive alternative transportation policies.

The investment requirement projections in this report are developed using models which evaluate current system condition and operational performance, and make 20-year projections based on certain assumptions about the life spans of system elements, and future travel growth. **The accuracy of these projections depends in large part on the underlying assumptions used in the analysis.** For example, the highway travel growth forecasts included in previous versions of this report have traditionally been understated. If the highway VMT projections included in this chapter turn out to be too low, then the investment requirements may be understated. Chapter 10 explores the impacts that varying travel growth and some other key assumptions would have on the investment requirements.

The chapter begins with a summary comparing key highway, bridge and transit statistics with the values shown in the last report. The investment requirements for 1996-2015 for bridges and transit used in the last C&P report were based on 1995 data (and stated in constant 1995 dollars). In the second column of this table, these values have been indexed up to constant 1997 dollars, to make them more directly comparable to the new investment requirement projections for 1998-2017, which are based on 1997 data and shown in the third column. The highway investment requirements for 1996-2015 have been revised much more significantly, to incorporate new analytical procedures introduced in this report, and to correct some errors that were inadvertently introduced into the highway database during the preparation of the last report.

The next section contains a general discussion of the economics-based approach to analyzing transportation investments. The procedures for developing the investment requirements have evolved over time, to incorporate new research, new data sources, and improved estimation techniques. This transition to economic analysis is consistent with continued emphasis within transportation agencies toward asset management, value engineering, and greater cost-effectiveness in decision making.

Highway Investment Requirements

The highway section of this chapter begins with a discussion of the Highway Economic Requirements System (HERS), and describes how the model is used to develop future highway investment scenarios. 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 separate bridge models consider only investment requirements related to bridge preservation and bridge replacement.

The highway investment requirements section of the report has changed significantly from prior years. Since the release of the "1997 Status of the Nation's Surface Transportation System—Condition and Performance" report to Congress (C&P report), the FHWA has conducted a series of outreach meetings with members of the academic community and other transportation professionals on the report and the HERS model. As a result of this process, the FHWA has reevaluated several of the procedures used in the development of previous reports. For example, in earlier reports the analytical model outputs were adjusted using external procedures in an attempt to estimate investment requirements for some types of capital improvements that were not modeled. Some other types of capital improvements, such as system enhancements, were not included in the investment requirements at all. In this version of the report, the external adjustment process has been simplified, and expanded to include all types of highway capital outlay. Therefore, the investment requirements shown 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. The scenarios now attempt to include all elements of system preservation, system expansion, and system enhancement.

The 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. To meet these requirements, HERS has been modified to calculate backlog figures, a new scenario has been added to roughly correspond to the old **Cost to Maintain** scenario in the 1995 C&P report, and the Highway Performance Monitoring System (HPMS) data used to develop the 1995 and 1997 C&P reports have been rerun through the current version of HERS.

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.

Two main highway investment requirement scenarios are developed fully in this report, the **Maximum Economic Investment** scenario and the **Maintain Conditions** scenario. To facilitate comparisons between reports, the **Maintain User Costs** scenario introduced in the 1997 C&P report has been retained, but it is described as a “benchmark” in this report, and is not developed in as much detail as the two major scenarios. The investment required to **Maintain Travel Time Costs** is also identified as a separate benchmark, in response to suggestions received during the outreach meetings on the C&P report and HERS.

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 Conditions** scenario, the **Maintain User Cost** benchmark, and the **Maintain Travel Time** benchmark 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 Conditions** scenario, the minimum BCR cutoff point was raised until the point where the projected average pavement condition at the end of the 20-year analysis period matched the current 1997 values. Under this investment strategy, existing and accruing system deficiencies would be selectively corrected. Some highway sections would improve, some would deteriorate; overall, average pavement condition in 2017 would match that observed in 1997. The **Maintain User Costs** benchmark shows the level of investment required so that highway user costs (travel time costs, vehicle operating costs, and crash costs) in 2017 would match the baseline highway user costs calculated from the 1997 data. The **Maintain Travel Time** benchmark shows the level of investment to maintain only the travel time costs component of the **Maintain User Costs** benchmark.

Bridge Investment Requirements

The bridge section of this chapter 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, and are shown as highway investment requirements.

The investment backlog for bridges is calculated as the total investment required to correct all bridges currently determined to be structurally deficient or functionally obsolete. Under the **Eliminate Deficiencies** scenario, all existing bridge deficiencies and all new deficiencies expected to develop by 2017 would be eliminated through bridge replacement, rehabilitation or widening. 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 investment required to correct all structurally deficient and functionally obsolete bridges would remain the same as the current amount.

This section also contains a brief discussion of the Bridge Needs and Investment Process (BNIP) used to develop the investment requirements for this report, as well as the National Bridge Investment Analysis System (BIAS) which is currently under development. BIAS will incorporate benefit cost analysis into the bridge investment requirement evaluation in future C&P reports.

Combined Highway and Bridge Investment Requirements

The separate highway and bridge sections of this chapter are followed by a combined highway and bridge section. This portion of the chapter breaks down investment requirements by functional class. It contains an analysis of investment requirements for system preservation, system expansion, and system enhancements.

The **Cost to Maintain** Highways and Bridges combines the **Maintain Conditions** scenario for highways, and the **Maintain Backlog** scenario for bridges. The **Cost to Improve** Highways and Bridges combines the **Maximum Economic Investment** scenario for highways, and the **Eliminate Deficiencies** scenario for bridges.

The **Maintain User Costs** benchmark for Highways was not combined with a bridge scenario, because BNIP is not capable of developing a comparable user-oriented investment requirement projection.

Transit Investment Requirements

The transit section begins with a discussion of the Transit Economic Requirements Model (TERM), which was used to develop two 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. All investments identified by TERM are subject to a benefit-cost test, and only those with a BCR greater than 1.0 are implemented. Greater detail on the TERM methodology is presented in Appendix I.

The **Cost to Maintain** scenario maintains equipment and facilities in the 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 makes additional improvements to improve the condition of transit assets to a “good” rating, and improve the performance of transit operations. Investments in performance enhancements are evaluated on an urbanized area basis for TERM forecast investments. The intermediate scenarios of Maintain Conditions/Improve Performance and Improve Conditions/Maintain Performance are also presented.

Breakdowns of transit investment requirements by type of improvement and type of asset are also presented for both the **Cost to Maintain** and the **Cost to Improve** scenarios.

Summary

Exhibit 7-1 compares the 20-year investment requirements in this report with those in the 1997 C&P report. The first column shows the projection for 1996-2015, as shown in the 1997 C&P report, stated in constant dollars. (Note the 1997 C&P report did not contain a comparable scenario to the Highway Maintain Conditions scenario in this report.) The second column restates the bridge and transit values in 1997 dollars, to offset the effect of inflation. The highway values shown in this column have been recalculated using the current analytical procedures. The third column shows new average annual investment requirement projections for 1998-2017.

Exhibit 7-1

Comparison of Highway, Bridge and Transit Investment Requirement Projections with those in the 1997 C&P Report

Statistic	1996-2015 Projection Based on 1995 Data		1998-2017 Projection Based on 1997 Data
	1997 Report	Revised and/or Adjusted for Inflation	
Average Annual Investment Requirements	1995 Dollars	1997 Dollars	1997 Dollars
Cost to Improve Highways, Bridges and Transit			
Highway Maximum Economic Investment scenario	$70.2 bil	$82.6 bil	$83.4 bil
Bridge Eliminate Deficiencies scenario	$ 9.3 bil	$10.0 bil	$10.6 bil
Highway plus Bridge	$79.6 bil	$92.6 bil	**$94.0 bil**
Transit Cost to Improve scenario	$14.2 bil	$14.8 bil	**$16.0 bil**
Cost to Maintain Highways, Bridges and Transit			
Highway Maintain Conditions scenario	N/A	N/A	$50.8 bil
Bridge Maintain Backlog scenario	$5.6 bil	$6.0 bil	$5.8 bil
Highway plus Bridge	N/A	N/A	**$56.6 bil**
Transit Cost to Maintain scenario	$9.7 bil	$10.1 bil	**$10.8 bil**

Transit

The projected average annual transit investment requirements for 1998-2017 are higher than those estimated for 1996–2015 in the 1997 report. While some of this increase is due to inflation, most of the difference is accounted for by the increasing backlog of existing deficiencies, and to certain improvements made to the methodology employed by TERM. Adjusting for inflation, the **Cost to Maintain** increased by 6.9 percent to $10.8 billion, and the **Cost to Improve** scenario increased by 8.1 percent to $16.0 billion.

Bridges

The projected average annual bridge investment requirements for 1998–2017 are higher than those estimated for 1996–2015 from the 1997 C&P report. However, much of this increase is the result of inflation. Converting the values from the last C&P report from 1995 dollars to 1997 dollars reveals that in constant dollar terms, the Bridge **Eliminate Deficiencies** scenario increased by 6.6 percent to $10.6 billion. The Bridge **Maintain Backlog** scenario declined by 3.3 percent in constant dollar terms to $5.8 billion.

Highways

The projected average annual highway investment requirements shown for 1998–2017 are not directly comparable to those shown for 1996–2015 in the 1997 C&P report. The scope of the reported investment requirements has also been expanded to include all types of capital improvements, making it easier to relate them to actual highway capital program levels. Also, during the preparation of the last report, some errors were inadvertently introduced into the highway database that had an impact on the results for the **Maximum Economic Investment** scenario. When these data issues were resolved, it became apparent that they had been masking some undesirable interactions between the new travel demand elasticity features in HERS, and some HERS settings and external adjustment procedures that had previously been in place. To address these problems, a number of changes have been made to the analytical procedures used to develop the investment requirements in this report. These changes are explained in more detail in Appendix G of this report. To facilitate direct comparisons, the 1995 data used to develop the last report have been corrected and reprocessed through the current version of HERS, with the results restated in 1997 dollars.

Under the highway **Maximum Economic Investment** scenario, the projected average annual investment requirements based on 1997 data of $83.4 billion are 1.0 percent higher in constant dollar terms than the restated average investment requirements based on 1995 data. This increase is largely attributable to the growth in highway travel between 1995 and 1997.

The 1997 C&P report did not contain a scenario directly comparable to the highway **Maintain Conditions** scenario in this report. The 1995 C&P report based on 1993 data projected average annual investment requirements of $49.7 billion in 1993 dollars as the Cost to Maintain highways. Reprocessing this 1993 information through the latest analytical procedures results in an estimate of $47.6 billion in 1997 dollars for the highway **Maintain Conditions** scenario. This decline is mainly the result of incorporating the procedures contained in the most recent Highway Capacity Manual (Special Report 209 of the Transportation Research Board) as discussed on page 61 of the 1997 C&P report. The projected average annual investment requirements for the **Maintain Conditions** scenario based on 1997 data are $50.8 billion, 6.7 percent higher than the restated projections based on the 1993 HPMS data, keeping all other factors constant. This is partially the result of the improvement in pavement conditions since 1993, which makes “Maintaining Conditions” at 1997 levels a more stringent standard than maintaining them at 1993 levels was.

Highways and Bridges

The **Cost to Improve** highways and bridges was $94.0 billion in 1997, combining the highway **Maximum Economic Investment** scenario with the bridge **Eliminate Deficiencies** scenario. The **Cost to Maintain** highways and bridges was $56.6 billion in 1997, combining the highway **Maintain Conditions** scenario and the bridge **Maintain Backlog** scenario.

Based on the conditions and performance of the highway system as of 1997, the backlog of cost-beneficial highway investments is estimated to be $166.7 billion. The backlog of bridge investments is estimated to be $87.3 billion in 1997.

Economics-Based 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 is founded on engineering principles: engineering standards define which system attributes are considered deficient and the improvement option "packages" assigned to potentially correct given deficiencies are based on standard engineering practice.

In 1988, the FHWA embarked on a long-term research, development, testing and critical review effort to produce an alternative, economic-based simulation procedure. 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, "Principles 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 incorporates benefit cost analysis into its improvement selection procedures.

The FHWA is currently developing the National Bridge Investment Analysis System (BIAS), which will incorporate economic analysis into the bridge investment requirements in future C&P reports.

Economic Focus Versus Engineering Focus

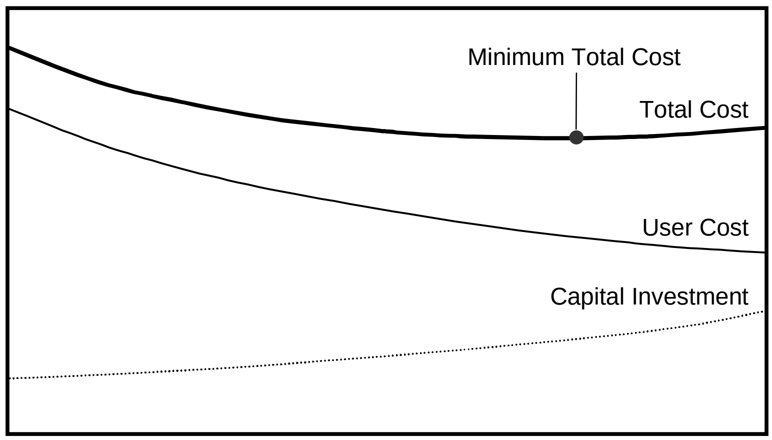
Traditional engineering-based analytical tools focus mainly on transportation agency costs and the resources required to maintain or improve the condition and performance of infrastructure. This type of analytical approach can provide valuable information about the cost effectiveness of transportation 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 BIAS models have a broader focus than traditional engineering-based models, looking at the service that the transportation system provides to its users. The goal of this economic analysis is generally to maximize benefits, and to minimize the combined costs incurred by transportation agencies, transportation system users, and third parties that are affected by the operation of the transportation system.

One way to conceptualize the goal of the HERS, TERM, and BIAS models is presented in Exhibit 7-2. The lines marked “user cost” and “capital investment” indicate that as transportation investment increases, user costs decline. However, at some point the additional increment of investment will fail to result in user cost reductions sufficient to warrant the additional investment. This point is indicated on the “total cost” line as the Minimum Total Cost.

Exhibit 7-2

Economic-Based Approach to Transportation Investments Schematic



Note: This diagram is a general representation that does not fully reflect specific cost and benefits considered by each of the individual models. The lines are not drawn to scale.

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 economic-based approach also provides a more sophisticated method for prioritizing potential improvement options when funding is constrained. This helps ensure that limited transportation capital investment resources are directed to the areas that will provide the most benefits to transportation system users.

Multimodal Analysis

HERS, TERM, and BIAS 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 BIAS 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. As HERS, TERM, and BIAS continue to evolve, it should become easier to integrate their separate approaches.

Highway Investment Requirements

The highway investment requirements shown in this report are developed primarily from the Highway Economic Requirements System (HERS), a simulation model that employs incremental benefit/cost analysis to evaluate highway improvements. The HERS analysis relies on the Highway Performance Monitoring System (HPMS) to provide information on the current conditions and performance and anticipated future travel growth for a nation-wide sample of more than 120,000 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.

The HERS results are supplemented by external adjustments to account for functional classes not included in the HPMS database, and for types of capital investment that are not currently modeled. This procedure has been streamlined for this report, replacing some old procedures originally developed to supplement the HPMS Analytical Process, that are not fully compatible with the new HERS approach. The external adjustment process has also been expanded to account for all types of highway capital investment. In previous reports, some types of improvements were not included in the reported investment requirements. These 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.

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 separate bridge models consider only investment requirements related to bridge preservation.

Q. **What is the reliability of the highway investment requirement projections made in this report?**

A. The HERS model is deterministic, rather than probabilistic, meaning that it provides a single predicted value rather than a range of likely values. Therefore, we can not make specific statements about confidence intervals. However, we can make some general statements about the limitations of the projections, based on the characteristics of the process used to develop them.

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 system reliability, and on the economy. To some extent, such external effects cancel each other out, but to the extent that they don’t the “true” investment requirements may be either higher or lower than those predicted by the model. Some projects that HERS views as economically justifiable may not be in reality. Other projects that HERS would reject might actually be justifiable, if all factors were considered.

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 HPMS sample dataset. Using section-specific traffic growth projections, HERS forecasts future conditions and performance for four 5-year periods. At the end of each period, the model checks for deficiencies in eight highway section characteristics: pavement condition, surface type, volume/capacity (V/C) ratio, lane width, right shoulder width, shoulder type, horizontal alignment (curves), and vertical alignment (grades).

When 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: improve curves and grades, improve curves only, improve 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, crashes, 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 declines. However, up until the point where the marginal BCR falls below 1.0 (i.e., costs exceed benefits), total 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 benefits.

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 models may recommend making 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 required to achieve the outcome desired under the scenarios could be higher than that shown in this report.

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 condition 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".

Travel Demand Elasticity

The States furnish projected travel for each sample highway section in the HPMS dataset. 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. Travel demand elasticity procedures have been added to HERS to recognize that as a highway becomes more congested, travel volume on the facility is constrained, 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, consumers will be inclined to consume less of it, and either consume more of a substitute product or simply do without. Conversely, if the price of a product decreases, consumers will be inclined to consume more of it, either in place of some other product or in addition to their current overall consumption.

The travel demand elasticity procedures in HERS treat the cost of traveling a facility as its price. As a highway becomes more congested, the cost of traveling the facility (i.e., travel time costs) increases, which tends to constrain the volume of traffic growth. Conversely, when lanes are added and the highway user costs decreases, the volume of travel will tend to increase.

The travel demand elasticity values used in this report are higher than the values used in the 1997 C&P report. This increase further constrains travel growth in congested urbanized areas. This change was made partly to capture some of the effects of Travel Demand Management (TDM) programs that were previously simulated by reducing the HPMS baseline forecasts. The rationale for this change is explained in Appendix G.

Q. **What assumptions does the HERS model make about the travel forecasts in the HPMS dataset?**

A. HERS assumes that the forecasts for each sample highway segment represent the travel that will occur if the level of service remains constant on that section. This implies that travel will only occur at this level if pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway-user costs at current levels. Note that at current funding levels, HERS assumes that VMT will grow more slowly than the HPMS baseline forecasts, particularly in large urbanized areas.

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. This might cause highway users to shift to mass transit, or it might 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 life-styles 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 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 the majority of the impact on travel demand will occur in the short term, within 5 years.

For short term elasticity, HERS now uses a value of -1.0. An additional -0.6 (total, -1.6) is used for long-term elasticity. The short-term elasticity is used within the 5-year period being analyzed and long-term elasticity is used in the remainder of the overall analysis period.

For example, if highway-user costs on a given highway facility increased by 10 percent, the model predicts that travel on the facility would decline by 10 percent below the baseline forecast within 5 years, and by an additional 6 percent within 20 years. Conversely, a reduction of user costs would cause a corresponding increase in highway travel on the facility.

As a result of travel demand elasticity, the overall level of highway investment has an impact on the projected travel growth. For any highway investment requirement scenario that results in a decline in average highway user costs,

Q. **How do the travel demand elasticity features in HERS reflect the effects of Transportation Demand Management (TDM) programs?**

A. To some extent, the HERS elasticity features mimic the effect that transportation demand management programs would be expected to have on the level and location of future travel growth. The elasticity features suppress highway travel growth in areas where widening is not feasible, or congestion is increasing. The model assumes that individual highway users will change their driving patterns and lifestyle choices in response to these factors, which will slow the rate of highway travel growth in large urbanized areas. However, these shifts will not occur at the assumed rate unless these drivers have viable alternatives.

Federal, State and local TDM programs serve to provide these alternatives. The 1990 Clean Air Act Amendments require States and localities to reduce vehicular emissions by implementing transportation control measures to manage travel demand and improve traffic flow. These measures include TDM programs that provide alternatives to single-occupant-vehicle travel such as options for carpooling, transit, and bicycling. These include:

- Bicycle/pedestrian facilities - provision of paths, special lanes, lockers, showers, or other facilities.
- Area-wide ridesharing - a program that provides carpool matching and information services.
- HOV lanes - highway lanes reserved for high-occupancy vehicles, i.e., buses, vanpools, and carpools.
- Park & ride facilities - parking lots or facilities located to provide access to a transit station, HOV lane, bus service, or to encourage carpooling.
- Transit improvements - transit service expansion or improvements.

In addition, the following TDM measures are available for implementation by employers:

- Compressed workweeks - extension of the typical workday in order to reduce the number of days worked, thereby reducing the number of work trips.
- Telecommuting - arrangements allowing employees to work at home or at satellite offices close to home.
- Employer trip reduction - a State or local government regulated program requiring employers, usually above a certain size, to implement plans that encourage employees to reduce vehicle travel to work.

The HERS elasticity values are set at a relatively high level. If the TDM programs listed above are less than fully successful in providing viable transportation alternatives, VMT growth will probably exceed the levels predicted by HERS. If TDM programs are more successful than the elasticity values in HERS imply, then VMT growth could be lower than the level projected by HERS. Chapter 10 explores the effects that different travel growth assumptions would have on the investment requirement projections.

the effective VMT growth rate will tend to be higher than the baseline rate. For scenarios in which high-way user costs increase, the effective VMT growth rate will tend to be lower than the baseline rate. This effect is discussed in more detail in Chapter 9.

Q. **Are the travel demand elasticity values used in HERS appropriate for use in other types of applications?**

A. Since HERS analyzes individual highway segments in isolation, rather than corridors, or the highway network as a whole, the elasticity values need to account for trips that might shift to or from a parallel highway route, as well as trips that might shift to or from other modes of transportation, or that might be induced or suppressed entirely. For network analysis, it would be more appropriate to use lower elasticity values.

Highway Investment Backlog

As defined in this report, the highway investment backlog represents all highway improvements that could be economically justified to be implemented now, based on the current conditions and operational performance of the highway system. To calculate the backlog, 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. Based on this "Year 0" analysis, HERS estimates that a total of $166.7 billion of investment could be justified based solely on the current conditions and operational performance of the highway system. Note that the backlog represents a one-time cost, rather than an annual value. Note also that this figure does not include rural minor collectors, or rural and urban local roads and streets, since HPMS does not contain sample section data for these functional systems.

Q. **How does the highway backlog cited in this report compare with the value included in the 1993 C&P report?**

A. The backlog cited in this report is lower, primarily due to a change in assumptions about widening. In earlier versions of the C&P report, it was assumed that if a State coded that widening was "infeasible" for a certain HPMS sample section, that any new lanes added to that section would be very expensive. For this report, if a State has indicated that widening is "infeasible" for a section, HERS will not add lanes to the section under any circumstances. [See the discussion of "High-Cost Lanes" in Appendix G.] The implication of this change in assumptions is that some projects involving high-cost lane additions that were included in the backlog in the 1993 C&P report are not included in this report.

The values included in the 1993 C&P report were derived from the HPMS Analytical Process (AP) model. Using the same assumptions about widening feasibility, the AP produces estimates of highway backlog that are similar to the HERS-derived values shown in this report.

Approximately 72 percent of the backlog is in urban areas, with the remainder in rural areas. About 42 percent of the backlog relates to capacity deficiencies on existing highways; the remainder are pavement deficiencies. The backlog figure does not contain any estimate for system enhancements or for the construction of new roads and bridges.

Highway Investment Requirement Scenarios and Benchmarks

The investment requirement scenarios and benchmarks in this report project total investment requirements for period 1998–2017. The **Maximum Economic Investment** scenario would implement all improvements with a BCR greater than or equal to 1.0. This scenario 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.

The **Maximum Economic Investment** scenario is of interest mainly because it defines the upper limit of highway investment that could be economically justified. This scenario does not target any particular level of desired system performance. However, by varying the minimum BCR cutoff, HERS can identify the impact that different levels of investment have on certain key indicators. Exhibit 7-3 demonstrates how this approach was used.

The graph shows the impact that varying the minimum BCR cutoff has on the level of investment recommended by HERS. The table shows the impact that the various levels of investment have on average IRI, average total user costs, and average travel time costs. (See Chapter 9 for other impacts of different levels of investment.) Each row in the table represents a different minimum BCR cutoff point, shown in the first column.

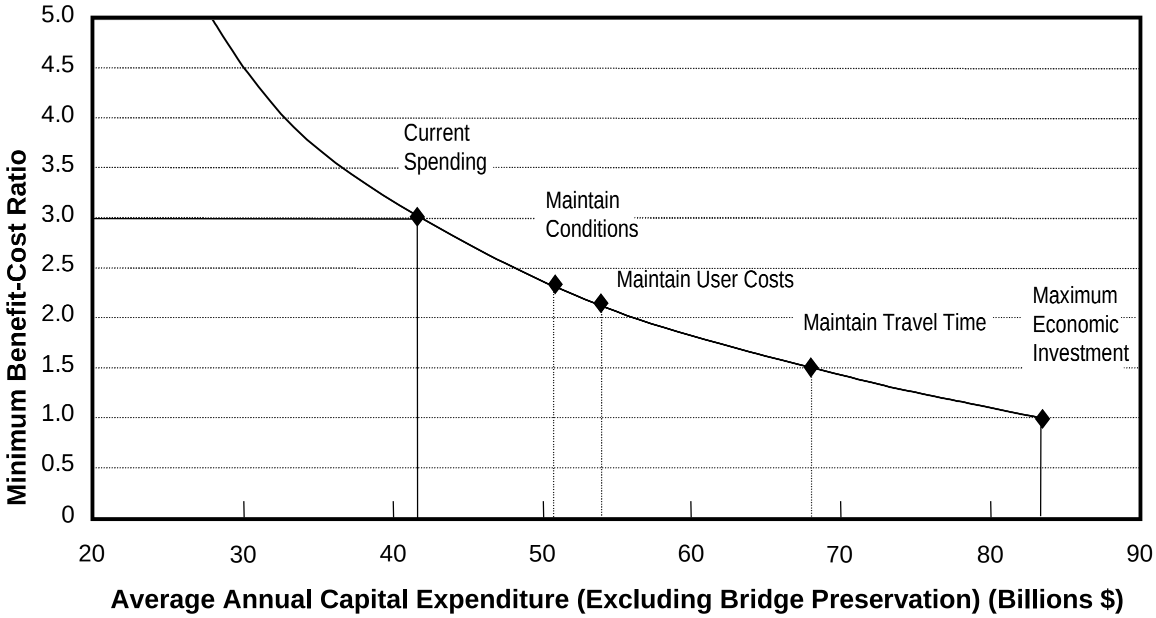
The top row in the table in Exhibit 7-3 represents a minimum BCR of 1.00, and is defined as the **Maximum Economic Investment** scenario, as indicated in the far-right hand column of the table. As shown in the third column, the average annual investment required under this scenario is $83.4 billion. The fifth, sixth, and seventh columns of the table reflect that at this level of investment, average pavement roughness, highway user costs and travel time costs would all improve. Average IRI would decline (improve) 18.3 percent compared to the baseline 1997 level. Average total highway user costs (including travel time costs, vehicle operating costs, and crash costs) would decline by 1.8 percent below the baseline 1997 level in constant dollar terms. The travel time costs component of highway user costs would decline by 0.9 percent below the 1997 baseline. As shown in the second column, at the average investment level required under the Maximum Economic Investment scenario, the average BCR would be 3.67, since many of the projects implemented would have a BCR that is much higher than the minimum BCR cutoff of 1.0. This indicates that an average of $3.67 dollars of benefits would be obtained from every dollar of expenditure.

Although the graph in Exhibit 7-3 has been drawn to include the total highway investment requirements shown in the third column of the table, the minimum and average BCRs reported in Exhibit 7-3 are actually based only on the “Directly Modeled” amounts shown in the fourth column of the table. The total investment requirements shown in the third column include both amounts derived from HERS, and additional amounts added to account for functional classes not included in the HPMS database, and for types of capital investment that are not currently modeled. These additional investment requirements have not been subjected to the same sort of benefit cost analysis as those developed in the HERS model. The external adjustments are discussed in more detail in Appendix G.

The remaining rows in Exhibit 7-3 show the effect of varying the minimum BCR cutoff point. As shown in the fourth row of the table, raising the minimum BCR cutoff to 1.50 would reduce the level of recommended investment to the level required to keep travel time costs constant at 1997 levels. Setting the minimum BCR cutoff to 2.15 (eighth row) would reduce the level of recommended investment to the level required to maintain user costs at 1997 levels. Raising the minimum BCR cutoff point to 2.33 (tenth row) would reduce the level of recommended investment to the level required to maintain average pavement roughness at 1997 levels. The level of total investment shown for the bottom row of the table (minimum BCR = 3.00) approximates actual spending in 1997 for types of improvements that are modeled in HERS.

Exhibit 7-3

Investment Requirements at Different Minimum BCRs



Benefit Cost Ratios		Average Annual Investment Required ($ billions)		Percent Change In			
Minimum	Average	Total	Directly Modeled	Average IRI	Average Total User Costs	Average Travel Time Costs	Funding Level Description
1.00	3.67	83.4	47.9	-18.3%	-1.8%	-0.9%	**Maximum Economic Investment**
1.20	3.98	76.5	44.0	-15.7%	-1.6%	-0.7%	
1.40	4.31	70.7	40.6	-13.0%	-1.3%	-0.2%	
1.50	4.49	67.9	39.1	-12.2%	-1.1%	**0.0%**	Maintain Travel Time
1.60	4.66	65.4	37.6	-10.4%	-1.0%	0.2%	
1.80	5.02	60.8	35.0	-7.8%	-0.6%	0.7%	
2.00	5.40	56.6	32.7	-5.2%	-0.3%	1.1%	
2.15	5.70	53.9	31.1	-2.6%	**0.0%**	1.5%	Maintain User Costs
2.20	5.80	52.9	30.6	-1.7%	0.1%	1.8%	
2.33	6.08	50.8	29.4	**0.0%**	0.4%	2.0%	**Maintain Conditions**
2.40	6.21	49.8	28.8	1.7%	0.5%	2.2%	
2.60	6.62	46.9	27.2	4.3%	0.9%	2.6%	
2.80	7.07	44.2	25.6	7.0%	1.3%	3.1%	
3.00	7.48	41.8	24.3	9.6%	1.6%	3.5%	

Maximum Economic Investment Scenario

As indicated above, based on HERS results and the external adjustment procedures for types of capital improvements not modeled in HERS, the maximum level of highway investment that could be economically justified is $83.4 billion. At this level of investment, average pavement roughness, total highway user costs, and travel time costs would all improve. Additional impacts of investing at the Maximum Economic Investment scenario are discussed in Chapter 9.

Exhibit 7-4 shows the 20-year total and average annual investment requirements under this scenario, broken down by functional class. These totals are further broken down into their system preservation, system expansion, and system enhancement components later in this chapter in the Combined Highway and Bridge Investment Requirements section.

Exhibit 7-4

Highway Investment Requirements 1998-2017
Maximum Economic Investment Scenario
Billions of Dollars (1997 Dollars)

Functional Class	20-Year Total	Average Annual
Rural Arterials & Collectors		
Interstate	$103.1	$5.2
Other Principal Arterial	$167.0	$8.4
Minor Arterial	$95.3	$4.8
Major Collector	$142.6	$7.1
Minor Collector	$29.6	$1.5
Subtotal	**$537.6**	**$26.9**
Urban Arterials & Collectors		
Interstate	$254.3	$12.7
Other Freeway & Expwy	$102.3	$5.1
Other Principal Arterial	$222.5	$11.1
Minor Arterial	$141.2	$7.1
Collector	$77.4	$3.9
Subtotal	**$797.7**	**$39.9**
Subtotal, Rural and Urban	**$1,335.3**	**$66.8**
Rural and Urban Local	$332.5	$16.6
Total	**$1,667.8**	**$83.4**

Source: Highway Economic Requirements System.

Maintain Conditions Scenario

The second major highway investment requirement scenario in this report is the **Maintain Conditions** scenario. As shown in Exhibit 7-3, raising the minimum BCR cutoff point to 2.33 results in fewer improvements being implemented, so that the average pavement condition at the end of the 20-year analysis period is the same as in 1997. The average annual investment required under this scenario is $50.8 billion.

Under this investment strategy, existing and accruing system deficiencies would be selectively corrected; some highway sections would improve, some would deteriorate, but overall, average pavement condition in 2017 would match that observed in 1997. This scenario is roughly equivalent to the Cost-to-Maintain scenario in the 1995 C&P report. The major differences are that the Cost-to-Maintain scenario was not based on economic criteria, and attempted to maintain an index of pavement condition and operational performance for four 5-year intervals. This Maintain Conditions scenario attempts to maintain pavement condition on a 20-year interval; operational performance may improve or decline depending on the mix of improvements implemented at this particular minimum BCR level.

The average BCR under this scenario is 6.08, indicating that an average of $6.08 of benefits would be obtained from every dollar of expenditure. This average is higher than the average under the Maximum Economic Investment scenario, since the Maintain Conditions scenario omits all projects with a minimum BCR between 1.00 and 2.33.

Average highway user costs would rise by 0.4 percent above baseline levels in constant dollar terms under this scenario. The travel time cost component of user costs would grow by 2.0 percent in constant dollar terms. Additional impacts of investing at the Maintain Conditions scenario level are identified in Chapter 9.

Exhibit 7-5 shows the 20-year total and average annual investment requirements under this scenario, broken down by functional class. These totals are further broken down into their system preservation, system expansion, and system enhancement components later in this chapter in the Combined Highway and Bridge Investments Requirements section.

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.

Exhibit 7-5

Highway Investment Requirements 1998-2017
Maintain Current Conditions Scenario
Billions of Dollars (1997 Dollars)

Functional Class	20-Year Total	Average Annual
Rural Arterials & Collectors		
Interstate	$73.7	$3.7
Other Principal Arterial	$115.8	$5.8
Minor Arterial	$61.5	$3.1
Major Collector	$81.8	$4.1
Minor Collector	$17.9	$0.9
Subtotal	**$350.6**	**$17.5**
Urban Arterials & Collectors		
Interstate	$161.5	$8.1
Other Freeway & Expwy	$59.4	$3.0
Other Principal Arterial	$133.0	$6.7
Minor Arterial	$76.1	$3.8
Collector	$35.2	$1.8
Subtotal	**$465.2**	**$23.3**
Subtotal, Rural and Urban	**$815.8**	**$40.8**
Rural and Urban Local	$200.4	$10.0
Total	**$1,016.2**	**$50.8**

Source: Highway Economic Requirements System.

Maintain User Costs Benchmark

As shown in Exhibit 7-3, setting the minimum BCR cutoff point to 2.15 results in a level of investment sufficient to allow total highway user costs per VMT at the end of the 20-year analysis period match the baseline levels. Highway user costs include travel time costs, vehicle operating costs, and crash costs. The average annual investment required to attain this benchmark is estimated to be $53.9 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 and focusing on highway users, rather than the traditional engineering-based criteria, which are oriented more toward highway agencies. The **Maintain User Costs** benchmark is an important technical point that provides insight into 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 investment required to maintain user costs is identified as a "benchmark" rather than a

Q. **Why is the investment required to Maintain User Costs treated as a "bench-mark" rather than a full-fledged "scenario"?**

A. Recent C&P reports have emphasized two scenarios to illustrate future investment requirements. During outreach meetings following the release of the 1997 C&P report, readers indicated that it would be more useful to have a scenario oriented around maintaining physical conditions rather than maintaining user costs. Also, the current bridge model does not evaluate user costs, so the highway Maintain Conditions scenario is more appropriate for the joint highway/bridge analysis that appears later in this chapter, and in subsequent parts of the report.

Limited information on the investment required to maintain user costs was retained in the report to preserve continuity with the 1997 C&P report.

"scenario" in this report, and is not discussed in as much detail as the two main highway scenarios.

The average BCR for this benchmark is 5.70 indicating that an average of $5.70 of benefits would be obtained from every dollar of expenditure. Pavement condition would improve at this level of investment, as average IRI would decrease by 2.6 percent.

While average highway user costs in 2017 would match baseline levels in constant dollar terms, individual highway user cost components would vary. Travel time costs would increase 1.5 percent, vehicle operating costs would decrease 1.2 percent while crash costs would decline 1.6 percent. This indicates that at this investment level, HERS predicts there would be a relatively greater rate of return on improvements aimed at reducing crashes, rather than those aimed at reducing congestion or improving pavement condition.

Q. What are the strengths and weaknesses of the Maintain User Costs Benchmark?

A. The strength of this benchmark is that it provides a broad way to measure changes that will impact highway users, the consumers of the highway system. This benchmark is more encompassing than a simple measure of pavement conditions, and less arbitrary than a pre-determined index of the value of capacity, pavement, and safety improvements that has been used in some previous reports.

The main drawback with this benchmark is that it is somewhat abstract and hard to visualize. Pavement condition, congestion, and the number of crashes can all be directly observed. User costs, on the other hand, are calculated values. This benchmark may also be more sensitive than others to changes in some of the underlying assumptions of the analysis. For example, while changing the assumed value of time or value of life would have an effect on the benefit/cost analysis for any of the scenarios, it would also change the performance target under this scenario, since these values are used to calculate the baseline highway user costs that the scenario attempts to maintain.

The Maintain User Costs benchmark in this report is calculated slightly differently than its equivalent in the 1997 report, maintaining user costs over a 20-year interval rather than four 5-year intervals.

Maintain Travel Time Benchmark

Another point of interest on the curve shown in Exhibit 7-3 is the investment required to maintain travel time. Changes in average travel time per VMT are an indicator of the operational performance of the highway system. This benchmark focuses on one aspect of the Maintain User Costs benchmark, travel time costs. Since travel time costs happen to rise at the investment requirement level for the Maintain User Costs benchmark based on the 1997 data, the average annual investment requirements for the Maintain Travel Time benchmark are higher at $67.9 billion. This would not necessarily always be the case; this benchmark could theoretically be lower in certain circumstances. Maintaining travel time costs requires the minimum BCR cutoff point be set at 1.50, below the level used for the Maintain User Costs benchmark.

Comparison with Previous Reports

The projected average annual investment requirements shown for 1998-2017 in this report are not directly comparable to those shown for 1996–2015 in the 1997 C&P report, due to inflation, data corrections, model enhancements, and changes in the methodology used to develop the estimates. To facilitate direct comparisons between the two reports, the 1995 data used to develop the last report have been corrected and reprocessed through the current version of HERS, with the results restated in 1997 dollars. The adjustments to the 1995 data are discussed in Appendix G.

Exhibit 7-6 compares the investment requirement projection in this report with the original projections reported in the 1995 and 1997 C&P reports, as well as with the values obtained by re-analyzing the older data using the latest analytical procedures.

Exhibit 7-6

Comparison of Highway Investment Requirements 1995, 1997 and 1999 C&P Reports (Billions of Dollars)

	As Reported				Re-analyzed and Converted to 1997 Dollars		
Report Year	Maximum Economic Investment Scenario (1)	Maintain Conditions Scenario (2)	Maintain User Costs Benchmark (3)	Dollar Year	Maximum Economic Investment Scenario	Maintain Conditions Scenario	Maintain User Costs Benchmark
1995 (Avg. Annual 1994-2013)	$65.1	$49.7	N/A	1993	$83.1	$47.6	N/A
1997 (Avg. Annual 1996-2015)	$70.0	N/A	$40.5	1995	$82.6	N/A	$48.2
1999 (Avg. Annual 1998-2017)	$83.4	$50.8	$53.9	1997	$83.4	$50.8	$53.9

(1) Identified as the Economic Efficiency Scenario in the 1995 C&P Report.
(2) Roughly corresponds to the Cost-to-Maintain Highways Scenario in the 1995 C&P Report.
(3) Corresponds to the Maintain User Cost Scenario in the 1997 C&P Report.

Source: Highway Economic Requirements System.

Comparison with 1995 Data Used in the 1997 C&P Report

Keeping all other factors constant, highway investment requirements for the Maximum Economic Investment Scenario based on the 1997 HPMS data are 0.9 percent higher than the restated highway investment requirements based on the 1995 HPMS data. The small increase is largely the result of changes in the composition of highway spending between 1995 and 1997, which affects the external adjustment procedures for non-modeled expenditures as described earlier.

Highway investment requirements for the Maintain User Costs scenario based on the 1997 HPMS data are 11.8 percent higher than those based on the 1995 HPMS data, keeping all other factors constant. Part of this is attributable to the decline in delay discussed in Chapter 4. Travel time costs and total highway user costs are lower in 1997 than in 1995. Therefore "Maintaining User Costs" at their 1997 levels for 20 years is actually a more stringent standard that maintaining them at their 1995 levels for 20 years, and is therefore more expensive to achieve. This is an inherent shortcoming in any of the scenarios that "Maintain" a conditions or performance characteristic, that makes comparisons between reports difficult. As pavement conditions, highway-user costs, and travel time costs change over time, the targets for the Maintain Conditions scenario, the Maintain User Costs benchmark, and the Maintain Travel Time benchmark also change.

Appendix G includes a discussion of the source of the differences between the original investment requirement projections reported in the 1997 C&P report using 1995 HPMS data, and the updated values using the latest analytical approach.

Comparison with 1993 Data Used in the 1995 C&P Report

Keeping all other factors constant, highway investment requirements for the Maximum Economic Investment Scenario based on the 1997 HPMS data are only 0.4 percent higher than the restated highway investment requirements based on the 1993 HPMS data. Highway investment requirements for the Maintain Conditions scenario based on the 1997 HPMS data are 6.7 percent higher than those based on the 1993 HPMS data, keeping all other factors constant. This is partially the result in the improvement in pavement condition since 1993, which makes "Maintaining Conditions" at their 1997 level a more stringent standard. The increase is also influenced by changes in the composition of highway spending between 1995 and 1997, which affects the external adjustment procedures for non-modeled expenditures as described earlier.

The Maintain Conditions projection using the re-analyzed 1993 HPMS data, $47.6 billion in 1997 dollars, is lower than the original projection of $49.7 billion in 1993 dollars for the Cost-to-Maintain scenario in the 1993 C&P Report. This is partially the result of changes in the scenario definition, but mainly the differences are the result of incorporating the procedures contained in the most recent *Highway Capacity Manual* 1994 (Special Report 209 of the Transportation Research Board), as discussed on page 61 of the 1997 C&P report. These reductions more than offset the effects of inflation on the projections.

Bridge Investment Requirements

The bridge investment requirements shown in this report are developed primarily from the Bridge Needs and Investment Process (BNIP). Using the National Bridge Inventory, the process identifies bridge deficiencies, selects improvements, and simulates the costs of these improvements. An engineering ranking scheme is used to prioritize potential actions.

Bridge Investment Backlog

As defined in this report, the bridge investment backlog represents the cost of improving all bridges that are currently deficient. BNIP estimates that $87.3 billion of investment would be required to repair or replace all functionally obsolete or structurally deficient bridges.

More than half of all existing bridge deficiencies are structural deficiencies. If these types of deficiencies are not corrected in a timely manner, further deterioration could require major rehabilitation or bridge replacement. These actions cost significantly more than highway pavement repair on a unit cost basis. In addition, deferred investments on deficient bridges may impose public safety hazards more dangerous than the risks of deferred pavement improvements.

Bridge Investment Requirement Scenarios

The investment requirements scenarios in this report project total investment requirements for the period 1998-2017. The **Eliminate Deficiencies** scenario is the equivalent of the **Cost to Improve Bridge Conditions** shown in previous reports. The **Maintain Backlog** scenario is the equivalent of the **Cost to Maintain Bridge Conditions** shown in previous reports. The scenarios were renamed to clarify their intent, and to emphasize that the bridge investment requirements analyses focus on bridge deficiencies, rather than average bridge conditions.

Eliminate Deficiencies Scenario

This scenario would eliminate the existing bridge investment backlog, and correct other deficiencies that are expected to develop over the next 20 years. The average annual investment required under this scenario is $10.6 billion. Exhibit 7-7 shows the 20-year total and average investment requirements for each functional class under this scenario. This table also contains the number of bridges that would be rehabilitated or replaced during the analysis period.

Q. **HERS is used as an economic tool for roadway investment analysis. Is there a similar tool for bridge analysis?**

A. The national Bridge Investment Analysis System (BIAS) is currently being developed to add an economic component to the bridge analysis. BIAS is based on the optimization procedures of Pontis, a bridge management system developed initially with input from FHWA, several States, the Transportation Research Board, and other interests. Pontis is now supported by the American Association of State Highway and Transportation Officials and is being further enhanced at the suggestion of the States for use as their bridge management system.

Pontis was developed to analyze individual bridges, using data on the condition of a variety of bridge elements. BIAS takes a similar approach to bridge analysis, but relies on the National Bridge Inventory which is less detailed. BIAS can not analyze individual bridges, but can provide information on a more aggregate, national level basis, without requiring all the detailed information that Pontis needs.

Exhibit 7-7

Bridge Investment Requirements 1998-2017 Eliminate Deficiencies Scenario

Functional System	Number of Repaired or Replaced Bridges	20-Year Requirements (Billions of 1997 Dollars)	Average Annual Requirements (Billions of 1997 Dollars)
Rural Arterials and Collectors			
Interstate	30,301	$16.8	$0.8
Other Principal Arterial	25,101	$14.5	$0.7
Minor Arterial	24,476	$9.6	$0.5
Major Collector	59,488	$11.5	$0.6
Minor Collector	31,914	$3.7	$0.2
Subtotal	**171,281**	**$56.0**	**$2.8**
Urban Arterials and Collectors			
Interstate	53,832	$71.6	$3.6
Other Freeway & Expressway	24,020	$22.7	$1.1
Other Principal Arterial	25,554	$25.9	$1.3
Minor Arterial	19,612	$12.5	$0.6
Collector	12,436	$4.9	$0.2
Subtotal	**135,454**	**$137.7**	**$6.9**
Total Non-Local	**306,735**	**$193.7**	**$9.7**
Rural Local	140,906	$12.2	$0.6
Urban Local	16,868	$5.6	$0.3
Total Local	**157,774**	**$17.8**	**$0.9**
Total	**464,508**	**$211.5**	**$10.6**

Source: Bridge Needs and Investment Process.

Maintain Backlog Scenario

Under the **Maintain Backlog** scenario, the bridge investment backlog would be maintained at its current level. Under this scenario, existing deficiencies and newly accruing deficiencies would be selectively corrected, to minimize the investment required to maintain the same backlog of deficient bridges in 2018 that exists in 1998. The average annual investment required under this scenario is estimated at $5.8 billion. Exhibit 7-8 shows the 20-year total and average investment requirements under this scenario, by functional class, as well as the number of bridges that would be rehabilitated or replaced during the analysis period.

It should be noted that the **Maintain Backlog** scenario focuses on deficient bridges, rather than on average bridge conditions. Average bridge conditions would not necessarily be maintained under this scenario.

Comparison with Previous Reports

Exhibit 7-9 contains a comparison of the bridge investment requirements for this report and the previous three reports. The values reported have grown over time for both scenarios, but this is largely due to inflation. In constant dollar terms, the investment required for Maintain Backlog scenario (Cost to Maintain in the 1993, 1995, and 1997 reports) has declined over this time. This is because the number of deficient bridges has declined. The investment required for the Eliminate Deficiencies scenario (Cost to Improve in the 1993, 1995, and 1997 reports) has fluctuated, but remained between $10 and $11 billion annually in constant dollars.

Exhibit 7-8

Bridge Investment Requirements 1998-2017 Maintain Backlog Scenario

Functional System	Number of Repaired or Replaced Bridges	20-Year Requirements (Billions of 1997 Dollars)	Average Annual Requirements (Billions of 1997 Dollars)
Rural Arterials and Collectors			
Interstate	10,330	$8.1	$0.4
Other Principal Arterial	7,130	$6.1	$0.3
Minor Arterial	1,991	$1.6	$0.1
Major Collector	1,314	$0.6	$0.0
Minor Collector	22,459	$2.9	$0.1
Subtotal	**43,224**	**$19.3**	**$1.0**
Urban Arterials and Collectors			
Interstate	30,853	$50.9	$2.5
Other Freeway & Expressway	8,173	$11.8	$0.6
Other Principal Arterial	9,646	$15.0	$0.7
Minor Arterial	3,560	$3.8	$0.2
Collector	737	$0.6	$0.0
Subtotal	**52,969**	**$82.1**	**$4.1**
Total Non-Local	**96,193**	**$101.4**	**$5.1**
Rural Local	105,948	$9.9	$0.5
Urban Local	15,024	$5.3	$0.3
Total Local	**120,972**	**$15.2**	**$0.8**
Total	**217,165**	**$116.6**	**$5.8**

Source: Bridge Needs and Investment Process.

Exhibit 7-9

Comparison of Bridge Investment Requirements 1993, 1995, 1997 and 1999 C&P Reports (Billions of Dollars)

	As Reported			Converted to 1997 Dollars	
Report Year	Maximum Backlog Scenario	Eliminate Deficiencies Scenario	Dollar Year	Maintain Backlog Scenario	Eliminate Deficiencies Scenario
1993 (Average Annual 1992-2011)	$5.2	$8.2	1991	$6.3	10.0
1995 (Average Annual 1994-2013)	$5.1	$8.9	1993	$6.2	10.7
1997 (Average Annual 1996-2015)	$5.6	$9.3	1995	$6.0	10.0
1999 (Average Annual 1998-2017)	$5.8	$10.6	1997	$5.8	10.6

Q. **Are any preliminary results available from the BIAS model?**

A. The National Bridge Investment Analysis System (BIAS) is an analytical system being developed as a bridge investment/performance tool to supplement the Bridge Needs and Investment Process (BNIP) that has been used for a decade to estimate bridge capital investment requirements. BIAS adds economic analysis to this estimation process. This box contains provisional results of BIAS so the reader may become aware of the model and its possible future use to project bridge investment requirements. Please note that future results may differ from the interim results presented here.

BIAS estimates that an annual bridge investment from all levels of government of $6.4 billion for the 20-year period 1999 to 2018 would maintain the same overall backlog amount in 2018 as in 1999. However, this figure cannot be directly compared to BNIP results because the BIAS figure includes some amount of maintenance or minor rehabilitation not included in BNIP. It is estimated that the average benefit cost ratio for the predicted improvements over the 20-year period would be about 4.0, meaning that an average of $4 dollars of benefits would be obtained from every dollar invested. Much of these benefits would derive from trucks not having to detour over a longer route because of deficient bridge load carrying capacity.

An annual investment of $10.7 billion for the same 20-year period is projected to eliminate the backlog for major improvements such as replacement and functional improvements. It would not eliminate the requirement for continued rehabilitation and maintenance. The average benefit cost ratio for this scenario is estimated to be about 2.7. Again, this should be taken as a provisional result.

These BIAS results are tentative and should not be taken as directly comparable to the BNIP results contained elsewhere in this report. Future enhancements to BIAS may incorporate further refinements to relationships contained in the model and information not currently included, such as the benefits to the user of various types of bridge improvements. Such further enhancements may modify the results.

Combined Highway and Bridge Investment Requirements

The highway investment requirement scenarios and the bridge investment requirement scenarios are defined differently, due to the different natures of the models used to develop them. However, it is frequently useful to combine these separate scenarios, to show combined investment requirements for highways and bridges. 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 and the investment requirements outlined in this section.

Of the four highway investment requirements and scenarios laid out earlier in this chapter, the Highway Maintain Conditions scenario corresponds most closely to the Bridge Maintain Backlog scenario. The Highway Maximum Economic Investment scenario corresponds most closely to the Bridge Eliminate Deficiencies scenario.

Backlog

Combining the $188.7 billion highway investment backlog estimated by HERS with the $87.3 billion bridge investment backlog estimated by BNIP results in a combined backlog of $266.0 billion. However, as indicated earlier in the chapter, the two components of backlog are defined differently, and are not fully comparable.

Cost to Maintain Highways and Bridges

Combining the Highway Maintain Conditions scenario with the Bridge Maintain Backlog scenario results in a combined average annual Cost to Maintain Highways and Bridges of $56.6 billion. This total is broken down by functional class in Exhibit 7-10. The investment requirements are classified into three categories, system preservation, system expansion, and system enhancement. System Preservation consists of the investment required to preserve and maintain the pavement and bridge infrastructure. This includes the costs of resurfacing, rehabilitation, and reconstruction. System Expansion includes the costs related to adding lanes to existing facilities, or adding new roads and bridges. System Enhancements include safety enhancements, traffic operations improvements, and environmental improvements.

The investment requirements for urban arterials and collectors total $27.4 billion or 48.3 percent

***Q.* How were the investment requirements identified by HERS split between system preservation and system expansion?**

A. 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 these two categories, since widening projects typically improve the existing lanes of a facility to some degree when adding new ones. 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.

To classify these improvements, the HERS analysis for this scenario was rerun with a constraint added to prevent the model from adding any lanes. The difference between these two runs was taken to be the amount attributable solely to system expansion.

HERS does not currently identify investment requirements for system enhancements.

Exhibit 7-10

Average Annual Investment Required to Maintain Highways and Bridges (Billions of 1997 Dollars)

Functional Class	System Preservation: Highway	System Preservation: Bridge	System Preservation: Total	System Expansion	System Enhancements	Total
Rural Arterials & Collectors						
Interstate	$2.1	$0.4	$2.5	$1.3	$0.3	$4.1
Other Principal Arterial	$2.7	$0.3	$3.0	$2.8	$0.3	$6.1
Minor Arterial	$2.2	$0.1	$2.3	$0.6	$0.3	$3.2
Major Collector	$3.5	$0.0	$3.5	$0.4	$0.2	$4.1
Minor Collector	$0.4	$0.1	$0.6	$0.4	$0.1	$1.0
Subtotal	**$10.9**	**$1.0**	**$11.9**	**$5.5**	**$1.1**	**$18.5**
Urban Arterials & Collectors						
Interstate	$2.9	$2.5	$5.4	$4.3	$0.8	$10.6
Other Freeway & Expressway	$1.2	$0.6	$1.8	$1.4	$0.4	$3.6
Other Principal Arterial	$3.4	$0.8	$4.1	$2.7	$0.6	$7.4
Minor Arterial	$2.3	$0.2	$2.5	$1.0	$0.5	$4.0
Collector	$1.2	$0.0	$1.2	$0.3	$0.2	$1.8
Subtotal	**$11.0**	**$4.1**	**$15.1**	**$9.8**	**$2.5**	**$27.4**
Subtotal Rural and Urban	**$21.9**	**$5.1**	**$27.0**	**$15.2**	**$3.6**	**$45.9**
Rural and Urban Local	$4.0	$0.8	$4.8	$5.1	$0.9	$10.8
Total	**$26.0**	**$5.8**	**$31.8**	**$20.3**	**$4.5**	**$56.6**

of the average annual Cost to Maintain Highways and Bridges. Investment requirements for rural arterials and collectors total $18.5 billion (32.7 percent), while the investment requirements for rural and urban local roads and streets total $10.8 billion (19.0 percent).

System Preservation

Average annual system preservation investment requirements total $31.8 billion, comprising 56.1 percent of the total Cost to Maintain Highways and Bridges. As shown in Exhibit 7-11, system preservation makes up a much larger share of total investment requirements in rural areas than in urban areas.

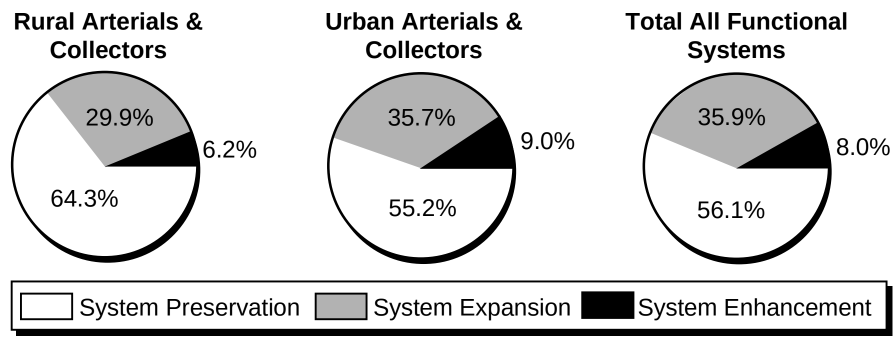
The system preservation investment requirements are derived primarily from the HERS and BNIP models. An adjustment was made to the highway figures, to account for rural minor collectors and local functional class roads which are not included in the HPMS sample section database on which HERS relies.

Q. **Would it be necessary to invest the full amount identified as the Cost to Maintain Highways and Bridges, in order to maintain average pavement condition and the backlog of bridge deficiencies?**

A. No. The $56.6 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 $31.8 billion of system preservation investment would be sufficient to maintain physical conditions. However, if total highway and bridge capital investment were limited to $31.8 billion annually, the analytical procedures used in this report would 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.

Exhibit 7-11

1998-2017 Cost to Maintain Highways and Bridges, Distribution By Improvement Type



System Expansion

The $20.3 billion in average annual investment requirements for system expansion represents 35.9 percent of the total Cost to Maintain Highways and Bridges. This includes investment requirements derived from HERS for widening existing highways and bridges. External adjustments were applied to cover types of investment that HERS does not consider, the widening of rural minor collectors and local functional class roads, and the construction of new roads and bridges.

> ***Q.* Can highway capacity be expanded without adding new lanes or new roads and bridges?**
>
> ***A.* Yes.** Highway capacity can be increased by improving the utilization of the existing infrastructure. In many cases, increased investment in intelligent transportation systems may be more cost beneficial than building new roads, double decking roads, or adding new lanes in high cost urban areas. *(See the discussion of High-cost lanes in Appendix G).* Some of the investment requirements identified as for "System Expansion" could also be met through increased investment in types of "System Enhancements" that also increase capacity.

System Enhancements

The $4.5 billion in average annual investment requirements for system enhancements represents 8.0 percent of the total Cost to Maintain Highways and Bridges. 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 earlier. Long range plans for the HERS model include expanding its scope to consider some of the ITS and safety improvements included under system enhancements.

Cost to Improve Highways and Bridges

Combining the Highway Maximum Economic Investment scenario with the Bridge Eliminate Deficiency Backlog scenario results in a combined average annual Cost to Improve Highways and Bridges of $94.0 billion. This total is broken down by type of improvement and functional class in Exhibit 7-12.

The investment requirements for urban arterials and collectors total $46.8 billion, or 49.8 percent of the total average annual Cost to Improve Highways and Bridges. Investment requirements on rural arterials and collectors are $29.7 billion or 31.6 percent of the total.

System Preservation, System Expansion, and System Enhancement make up 51.2 percent, 40.8 percent, and 8.0 percent respectively of the Cost to Improve Highways and Bridges. As shown in Exhibit 7-13, system preservation makes up a much larger share of total investment requirements in rural areas than in urban areas.

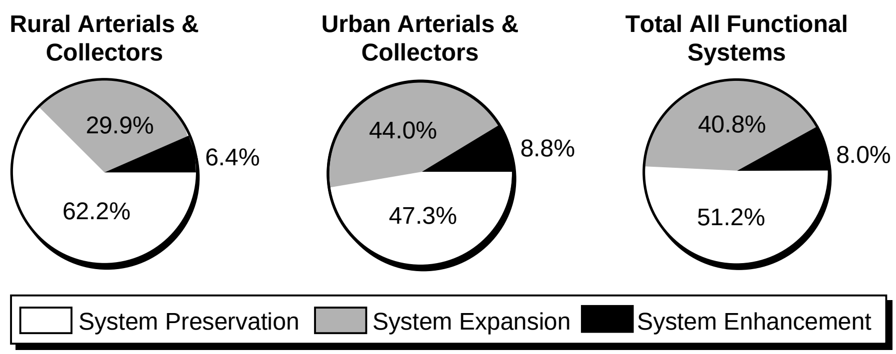
Exhibit 7-12

Average Annual Investment Required to Improve Highways and Bridges (Billions of 1997 Dollars)

Functional Class	System Preservation: Highway	System Preservation: Bridge	System Preservation: Total	System Expansion	System Enhancements	Total
Rural Arterials & Collectors						
Interstate	$2.5	$0.8	$3.3	$2.1	$0.6	$6.0
Other Principal Arterial	$3.3	$0.7	$4.0	$4.6	$0.4	$9.1
Minor Arterial	$3.1	$0.5	$3.6	$1.2	$0.5	$5.2
Major Collector	$6.1	$0.6	$6.7	$0.7	$0.3	$7.7
Minor Collector	$0.7	$0.2	$0.9	$0.6	$0.1	$1.7
Subtotal	**$15.7**	**$2.8**	**$18.5**	**$9.3**	**$1.9**	**$29.7**
Urban Arterials & Collectors						
Interstate	$3.4	$3.6	$7.0	$7.9	$1.4	$16.3
Other Freeway & Expressway	$1.4	$1.1	$2.6	$3.1	$0.6	$6.2
Other Principal Arterial	$4.3	$1.3	$5.6	$5.9	$0.9	$12.4
Minor Arterial	$3.7	$0.6	$4.3	$2.6	$0.7	$7.7
Collector	$2.4	$0.2	$2.7	$1.1	$0.4	$4.1
Subtotal	**$15.2**	**$6.9**	**$22.1**	**$20.6**	**$4.1**	**$46.8**
Subtotal Rural and Urban	**$30.9**	**$9.7**	**$40.6**	**$29.9**	**$6.0**	**$76.5**
Rural and Urban Local	$6.7	$0.9	$7.6	$8.4	$1.5	$17.5
Total	**$37.6**	**$10.6**	**$48.1**	**$38.3**	**$7.5**	**$94.0**

Exhibit 7-13

1998-2017 Cost to Improve Highways and Bridges, Distribution By Improvement Type



Transit Investment Requirements

The Transit Economic Requirements Model (TERM) (see Appendix I for a technical description) generates estimates of future transit investment requirements. TERM uses inputs on the existing transit asset base, transit system operating statistics, and projections of future transit ridership growth to forecast the amount of capital investment which would be required from 1998-2017 in order to meet various asset condition and operational performance goals. These goals are:

- **Maintain Conditions**
  Transit assets are replaced and rehabilitated over the 20-year period such that the average condition of assets present at the beginning of the period remains the same at the end of the period.
- **Maintain Performance**
  New transit vehicles and infrastructure are deployed in order to maintain vehicle utilization rates (one of the system performance measures discussed in Chapter 4) at a constant rate even as transit passenger miles increase over time. Estimates of future growth in transit passenger miles are obtained from forecasts made by Metropolitan Planning Organizations (MPOs).
- **Improve Conditions**
  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 "good" level (see Chapter 3) by 2017.
- **Improve Performance**
  The performance of the Nation's transit system are improved as additional investments are made in the urbanized areas with the most crowded vehicles and the slowest systems, reducing average vehicle utilization rates and increasing average transit operating speeds. Service would be improved by reducing headways and/or increasing coverage. Vehicle crowding would also be reduced.

Investment Requirements

Exhibit 7-14 shows the necessary levels of annual capital investment that would be necessary to meet the goals described above. The annual cost to **Maintain Conditions and Performance** is $10.8 billion. Improving performance while maintaining current conditions would require an investment of $14.4 billion, while improving conditions at the current level of performance would cost $11.1 billion annually. The cost to **Improve Conditions and Performance** is $16.0 billion each year.

Exhibit 7-14

Summary of Transit Average Annual Investment Requirements 1998-2017 (Billions of Dollars)

Conditions	Performance	Average Annual Cost
Maintain	Maintain	10.8
Maintain	Improve	14.4
Improve	Maintain	11.1
Improve	Improve	16.0

Source: Transit Economic Requirements Model.

Transit investment requirements by type of improvement are displayed in Exhibit 7-15. The replacement and rehabilitation of the existing transit capital stock would cost $7.0 billion annually if conditions are to be maintained, and $8.6 billion if conditions are to be improved. Asset expansion to accommodate transit PMT growth requires $3.7 billion under maintained conditions ($3.8 billion if conditions are also improved). Enhancements to raise the overall performance of the Nation's transit system carries an annual price tag of $3.6 billion when conditions are maintained ($3.7 billion when conditions are improved). The totals in each column in Exhibit 7-15 reflect the total amounts for the Maintain Conditions/Improve Performance and the Improve Conditions/Improve Performance scenarios, respectively.

Exhibit 7-15

Annual Transit Investment Requirements by Type of Improvement (Billions of 1997 Dollars)

Type of Improvement	Maintain Conditions	Improve Conditions
Replacement and Rehabilitation	$7.0	$8.6
Asset Expansion	$3.7	$3.8
Performance Improvements	$3.6	$3.7
Total	**$14.4**	**$16.0**

Source: Transit Economic Requirements Model.

Exhibits 7-16 and 7-17 show the costs to maintain conditions and to make incremental improvements in performance and conditions. The exhibits disaggregate the forecast investments in transit capital by

Exhibit 7-16

Annual Average Cost to Maintain and Improve Transit Conditions and Performance 1998-2017 (Millions of 1997 Dollars)

Mode, Purpose, & Asset Type	Cost to Maintain Conditions	Incremental Cost to Maintain Performance	Incremental Cost to Improve Performance	Total
Areas Over 1 Million in Population				
Bus				
Replacement & Rehabilitation (Vehicles)	966			966
Replacement & Rehabilitation (Non-Vehicles)	350			350
Fleet Expansion (Vehicles)		311		311
Fleet Expansion (Non-Vehicles)		466		466
New Bus (Vehicles & Non-Vehicles)			375	375
Elderly and Disabled (Vehicles & Non-Vehicles)	24			24
Subtotal Bus	**1,339**	**777**	**375**	**2,492**
Rail				
Replacement & Rehabilitation (Vehicles)	1,360			1,360
Replacement & Rehabilitation (Non-Vehicles)	3,549			3,549
Fleet Expansion (Vehicles)		273		273
Fleet Expansion (Non-Vehicles)		2,501		2,501
New Rail (Vehicles & Non-Vehicles)			3,151	3,151
Subtotal Rail	**4,909**	**2,774**	**3,151**	**10,835**
Total Areas Over 1 Million	**6,248**	**3,551**	**3,527**	**13,327**
Areas Under 1 Million in Population				
Bus				
Replacement & Rehabilitation (Vehicles)	352			352
Replacement & Rehabilitation (Non-Vehicles)	164			164
Fleet Expansion (Vehicles)		94		94
Fleet Expansion (Non-Vehicles)		102		102
New Bus (Vehicles & Non-Vehicles)			121	121
Elderly and Disabled (Vehicles & Non-Vehicles)	135			135
Nonurbanized Area (Vehicles & Non-Vehicles)	110			110
Subtotal Bus	**761**	**196**	**121**	**1,078**
Rail				
Replacement & Rehabilitation (Vehicles)	2			2
Replacement & Rehabilitation (Non-Vehicles)	5			5
Fleet Expansion (Vehicles)		0		0
Fleet Expansion (Non-Vehicles)		0		0
Subtotal Rail	**7**	**0**		8
Total Areas Under 1 Million	**769**	**196**	**121**	**1,086**
Total	**7,017**	**3,748**	**3,648**	**14,413**

Source: Transit Economic Requirements Model (TERM).

urbanized area population (over and under 1 million), mode (bus and rail), improvement purpose, and asset type (vehicles and non-vehicles). Investment requirements are greatest in major urbanized areas, reflecting the fact that 90 percent of the Nation's transit passenger miles are on transit systems in these 33 areas. The most expensive investments for replacement, expansion, and performance improvements are in non-vehicle rail infrastructure. Replacement of the bus fleet, with its relatively short useful life (approximately 12 years), is also a major expense.

Exhibit 7-17

Annual Average Cost to Maintain and Improve Transit Conditions and Performance 1998-2017 (Millions of 1997 Dollars)

Mode, Purpose, & Asset Type	Cost to Maintain Conditions	Incremental Cost to Improve Conditions	Incremental Cost to Maintain Performance	Incremental Cost to Improve Performance	Total
Areas Over 1 Million in Population					
Bus					
Replacement & Rehabilitation (Vehicles)	966	1			966
Replacement & Rehabilitation (Non-Vehicles)	350	344			693
Fleet Expansion (Vehicles)			333		333
Fleet Expansion (Non-Vehicles)			466		466
New Bus (Vehicles & Non-Vehicles)				405	405
Elderly and Disabled (Vehicles & Non-	24	21			45
Subtotal Bus	**1,339**	**365**	**799**	**405**	**2,909**
Rail					
Replacement & Rehabilitation (Vehicles)	1,360	301			1,661
Replacement & Rehabilitation (Non-Vehicles)	3,549	419			3,968
Fleet Expansion (Vehicles)			272		272
Fleet Expansion (Non-Vehicles)			2,493		2,493
New Rail (Vehicles & Non-Vehicles)				3,151	3,151
Subtotal Rail	**4,909**	**720**	**2,765**	**3,151**	**11,546**
Total Areas Over 1 Million	**6,248**	**1,085**	**3,564**	**3,556**	**14,454**
Areas Under 1 Million in Population					
Bus					
Replacement & Rehabilitation (Vehicles)	352	0			352
Replacement & Rehabilitation (Non-Vehicles)	164	268			432
Fleet Expansion (Vehicles)			101		101
Fleet Expansion (Non-Vehicles)			102		102
New Bus (Vehicles & Non-Vehicles)				141	141
Elderly and Disabled (Vehicles & Non-	135	118			253
Nonurbanized Area (Vehicles & Non-Vehicles)	110	93			203
Subtotal Bus			**203**	**141**	**1,584**
Rail					
Replacement & Rehabilitation (Vehicles)	2	2			4
Replacement & Rehabilitation (Non-Vehicles)	5	1			7
Fleet Expansion (Vehicles)			0		0
Fleet Expansion (Non-Vehicles)			0		0
Subtotal Rail	**7**	**3**	**0**		10
Total Areas Under 1 Million	**7**	**3**	**203**	**141**	**1,595**
Total	**6,256**	**1,088**	**3,767**	**3,698**	**16,049**

Source: Transit Economic Requirements Model (TERM).

Exhibit 7-18 provides a more detailed description of investment requirements by asset type. Annual costs are shown for each of the five major transit asset categories used in TERM (guideways, facilities, systems, stations, and vehicles), as well as other project costs. The largest expenditures on rehab and replacement are for vehicles, followed by guideway elements (new busways, track, roadbeds, bridges, and tunnels). Guideway elements are the largest expense for system expansion and performance improvements, as fixed-guideway systems (both new and expansions of existing systems) are constructed to accommodate increased passenger growth and to increase operating speeds.

Exhibit 7-18

Average Annual Investment Requirements by Asset Type and Type of Improvement (Billions of 1997 Dollars)

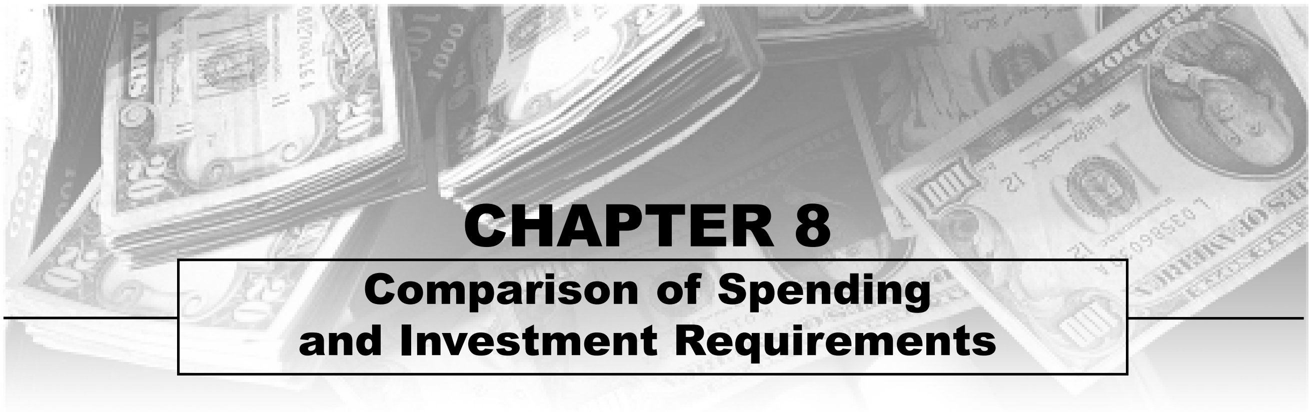
	Maintain Conditions			
Asset Type	Replacement/ Rehabilitation	Asset Expansion	Performance Improvements	Total
Guideway Elements	2,268	1,113	941	**4,323**
Facilities	654	594	259	**1,507**
Systems	958	191	154	**1,304**
Stations	277	393	325	**995**
Vehicles	2,860	678	298	**3,836**
Other Costs	0	777	1,672	**2,448**
Total	**7,017**	**3,748**	**3,648**	**14,413**

	Improve Conditions			
Asset Type	Replacement/ Rehabilitation	Asset Expansion	Performance Improvements	Total
Guideway Elements	2,480	1,109	941	**4,531**
Facilities	1,492	594	259	**2,344**
Systems	1,039	190	154	**1,383**
Stations	257	393	325	**975**
Vehicles	3,317	706	347	**4,370**
Other Costs	0	775	1,672	**2,447**
Total	**8,584**	**3,767**	**3,698**	**16,049**

Source: Transit Economic Requirements Model.

Existing Deficiencies

In addition to projecting annual investment requirements for future years, TERM also calculates the amount of investment that would be required to correct existing deficiencies in the nation's transit system. This is similar to the highway needs backlog calculated by HERS. TERM does this by immediately replacing assets whose condition is below the specified replacement level (see Appendix I). These corrective expenditures in the first year then become part of the 20-year investment totals. Eliminating the 1997 deficiencies under the Maintain Conditions scenario would cost $15.1 billion, while eliminating deficiencies under the Improve Conditions scenario totals $25.1 billion.



CHAPTER 8

Comparison of Spending and Investment Requirements

Introduction

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 gaps between the investment requirement scenarios 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.

The chapter begins with a brief summary, contrasting the investment requirements versus spending comparisons in this report with those included in the 1997 C&P report.

The highway and bridge portion of this chapter starts by comparing average annual investment requirements for the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges with 1997 capital expenditure data. This includes an analysis of the current and recommended mix of improvement types. The section continues by making a projection of capital spending for 1998-2003, and comparing these with the investment requirement scenarios. This is followed by a year-by-year analysis of investment requirements. The section concludes with a comparison of the results with those shown in previous C&P reports.

The transit portion of this chapter follows the approach used in the highway and bridge section. Average annual investment requirements are first compared to 1997 transit capital expenditures, both in total and by spending on vehicles versus non-vehicles. Investment requirements are then contrasted with the projected capital spending for 1998-2003 given the funding levels authorized by TEA-21. Forecast capital expenditures by 5-year segments are noted, and the funding gap between actual expenditures and estimated investment requirements in previous reports is compared to the current estimates of the gap.

Summary

Exhibit 8-1 compares the difference between investment requirements and spending in this report, with the corresponding difference based on the data reported in the 1997 C&P report. The first column contains values shown in the 1997 C&P report, which compared 1995 spending with estimated investment requirements for 1996. The second column restates these values, comparing 1995 spending with the average annual investment requirements reported in the 1997 C&P report. These restated values are comparable to the latest values based on 1997 data, shown in the third column.

Exhibit 8-1

Highway, Bridge and Transit Spending Versus Investment Requirements, Compared with Data from the 1997 C&P Report

Statistic	Based on 1995 Data		Based on 1997 Data
	1997 Report	Restated	
Percent by Which Investment Requirements Exceed Current Spending:			
Cost to Improve Highways, Bridges and Transit			
Highway Maximum Economic Investment scenario	N/A	---	95.6%
Bridge Eliminate Deficiencies scenario	N/A	---	73.8%
Highway plus Bridge	93%	108.9%	**92.9%**
Transit Cost to Improve scenario	103%	---	**110.2%**
Cost to Maintain Highway, Bridges and Transit			
Highway Maintain Conditions scenario	N/A	---	19.2%
Bridge Maintain Backlog scenario	N/A	---	-4.2%
Highway plus Bridge	13%	21.0%	**16.3%**
Transit Cost to Maintain scenario	38%		**41.0%**
Percent by Which Investment Requirements Exceed Projected 1998-2003 Spending:			
Cost to Improve Highways and Bridges	N/A	---	**75.3%**
Transit Cost to Improve Scenario	N/A	---	**68.3%**
Cost to Maintain Highways and Bridges	N/A	---	**5.7%**
Transit Cost to Maintain Scenario	N/A	---	**12.9%**

This chapter compares current highway and bridge spending with average annual investment requirements, while the 1997 C&P report cited figures based on a comparison of current spending with estimated "Year 1" (1996) investment requirements. The procedure for estimating the distribution of the investment requirements within the 20-year period was changed in this report. The 1997 C&P report used a process called "ramping," in which it was assumed that investment requirements for capacity expansion would grow in proportion to average annual VMT growth. In this report, the distribution of highway, bridge, and transit investment requirements is based more directly on the outputs of the Highway Economic Requirements System (HERS), the Bridge Needs and Investment Process (BNIP), and the Transit Economic Requirements Model (TERM).

When measured using the comparable procedures, the gaps between highway and bridge spending and the investment requirement scenarios have declined since the last report, and are expected to decline further in the future, as a result of increased funding for highways, bridges, and transit under TEA-21. While this comparison was not shown in the 1997 C&P report, the average investment requirements for the Maintain User Costs scenario developed using 1995 data were 21.0 percent higher than 1995 report-related capital expenditures. The comparable difference using 1997 data for the Cost to Maintain Highways and Bridges and 1997 spending is 16.3 percent ($7.9 billion), and is expected to decline to an average of 5.7 percent ($3.0 billion) annually over the six-year period 1998 through 2003.

Average annual transit investment requirements for the Cost to Maintain Transit in the 1997 C&P report were 38.6 percent higher than actual 1995 capital expenditures. The comparable difference using the most recent data increased to 41.0 percent ($3.2 billion), but is expected to decline to an average of 12.9 percent ($1.2 billion) annually from 1998 through 2003.

The average investment requirements for the Maximum Economic Investment scenario in the 1997 C&P report were 108.9 percent higher than the 1995 report-related capital expenditures. This difference declined to 92.9 percent ($45.3 billion) based on the most recent data, and is projected to decline to an average of 75.3 percent ($40.4 billion) annually from 1998 through 2003. For the Transit Cost to Improve scenario, the difference has increased from 102.9 percent to 110.2 percent ($8.4 billion) since the 1997 C&P report, but is expected to decline to an average of 68.3 percent ($6.5 billion) annually from 1998 through 2003.

Highway and Bridge Spending Versus Investment Requirements

> **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.

This section starts by comparing the average annual investment requirements identified in Chapter 7 with the 1997 highway and bridge capital spending outlined in Chapter 6. A second analysis compares average annual investment requirements with projected spending for 1998–2003, since highway capital investment is expected to rise sharply during this period, as a result of the higher funding levels under TEA-21.

Previous C&P reports utilized a technique called "ramping" to turn the average annual investment requirement projections into estimates for individual years. The investment requirements required for system preservation were assumed to be approximately the same for each year, while the amount for capacity improvement was assumed to grow at the same rate as average annual growth in highway travel. This technique has been criticized, because the values for individual years that it produces are not consistent with the results of the HERS and BNIP analyses. Investments at the annual levels developed using the ramping technique might not have the effect on conditions and performance that would be expected, since the timing of the investments would be different than those specified by the models. In this report, the "ramping" technique has not been utilized.

One significant change in this report is that the concept of "Reported-Related Capital Outlay" has been eliminated. As discussed in Chapter 7, the investment requirements have been expanded in this report to include all types of highway capital improvements. Therefore, there is no need to make adjustments to the 1997 capital expenditure data when making comparisons, as was done in previous C&P reports.

Average Annual Investment Requirements Versus 1997 Spending

Exhibit 8-2 compares the average annual investment requirements to maintain highways and bridges with 1997 capital expenditures. Chapter 7 identifies the Cost to Maintain Highways and Bridges as the combination of the Highway Maintain Conditions scenario and the Bridge Maintain Backlog scenario. As indicated in Chapter 7, investment requirements for bridge expansion are included in the highway investment requirement scenarios. Therefore, the $1.0 billion expended for new bridges in 1997 is included as part of the $42.6 billion of "highway" expenditures, rather than as part of the $6.1 billion of "bridge" expenditures.

The average annual Cost to Maintain Highways and Bridges for the 1998–2017 period is $7.9 billion (16.3 percent) higher than 1997 capital expenditures. The gap is larger for highways ($8.2 billion), because 1997 bridge preservation expenditures were $0.3 billion higher than the average annual investment required under the Bridge Maintain Backlog scenario.

Exhibit 8-2

Average Annual Investment Required to Maintain Highways and Bridges Versus 1997 Capital Outlay

	Investment Requirements (Billions of 1997 Dollars)				1997 Capital Outlay ($Billions)	Percent Difference
	System Preser-vation	System Expansion	System Enhance-ments	Total		
Highway Maintain Conditions Scenario	26.0	20.3	4.5	50.8	42.6	19.2%
Bridge Maintain Backlog Scenario	5.8	^^^	^^^	5.8	6.1	-4.2%
Cost to Maintain Highways and Bridges	31.8	20.3	4.5	56.6	48.7	**16.3%**

Exhibit 8-3 compares the average annual investment requirements to improve highways and bridges with 1997 capital expenditures. Chapter 7 identifies the Cost to Improve Highways and Bridges as the combination of the Highway Maximum Economic Investment scenario and the Bridge Eliminate Deficiencies scenario.

The average annual Cost to Improve Highways and Bridges for the 1998–2017 period is $45.3 billion (92.9 percent) higher than 1997 capital expenditures. The relative difference is larger for highways (95.6 percent), and smaller for bridges (73.8 percent).

Exhibit 8-3

Average Annual Investment Required to Improve Highways and Bridges Versus 1997 Capital Outlay

	Investment Requirements (Billions of 1997 Dollars)				1997 Capital Outlay ($Billions)	Percent Difference
	System Preser-vation	System Expansion	System Enhance-ments	Total		
Highway Maximum Economic Investment Scenario	37.6	38.3	7.5	83.4	42.6	95.6%
Bridge Eliminate Deficiencies Scenario	10.6	^^^	^^^	10.6	6.1	74.2%
Cost to Improve Highways and Bridges	48.1	38.3	7.5	94.0	48.7	**92.9%**

Q. **To what extent is the “gap” between current funding levels and the investment requirement scenarios the result of assumptions made about future VMT growth?**

A. The specific impacts that changing the VMT growth projections would have on the investment requirement projections is discussed in Chapter 10. In general terms, the projections in the HPMS database assume that VMT will grow more slowly in the future than in the past. The travel demand elasticity features in HERS serve to channel growth away from urbanized areas with rising highway user costs, diverting traffic to other areas or to other modes of transportation. (To some extent, the HERS elasticity features mimic the effect that transportation demand management programs would be expected to have on the level and location of future travel growth. Elasticity is discussed in more detail in Appendix G.) If VMT growth is higher than predicted in HPMS **as modified by the HERS elasticity features**, then the investment requirements would be higher, and the gap between current funding and the investment requirement scenarios would be larger.

Conversely, the rate of VMT growth has declined in recent years. If VMT increases more slowly than expected due to demographic changes, or if TDM programs are more successful in affecting future travel growth than the travel demand elasticity values in HERS assume, then future highway investment requirements would be lower. In this case, the gap between current funding and the investment requirements would be smaller (and could close entirely).

Note that HERS assumes the future VMT projections for individual highway segments in HPMS are accurate only at the level of investment required to maintain a constant level of service. At lower levels of investment, HERS assumes future VMT will be lower than the projections in the HPMS database.

Types of Improvements

Exhibit 8-4 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 1997. In 1997, 47.6 percent of highway capital outlays went for highway and bridge preservation. The investment requirement scenarios developed using the Highway Economic Requirements System (HERS), and the Bridge Needs and Investment Process (BNIP) suggest that a greater percentage of capital investment should be devoted to system preservation in the future. For the Cost to Maintain Highways and Bridges, 56.1 percent of the projected 20-year investment requirements are for system preservation. If funding increases above this level, the models recommend increasing system expansion expenditures more quickly, so that for the Cost to Improve Highways and Bridges, 51.2 percent of the total investment requirements are for system preservation.

Exhibit 8-4

Highway and Bridge Investment Requirements and 1997 Capital Outlay, Percentage by Improvement Type

	System Preservation					
	Highway	Bridge	Total	System Expansion	System Enhance-ments	Total
Cost to Improve Highways and Bridges	40.0%	11.3%	51.2%	40.8%	8.0%	100.0%
Cost to Maintain Highways and Bridges	45.8%	10.3%	56.1%	35.9%	8.0%	100.0%
1997 Capital Outlay	35.1%	12.5%	47.6%	44.4%	8.0%	100.0%

As discussed in Chapter 7, investment requirements for non-modeled items were determined by assuming that future increasing 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 was set at 8.0 percent, to match the percentage of expenditures in 1997.

Investment Requirements Versus Projected 1998-2003 Spending

The passage of the TEA-21 will result in significant increases in Federal highway funding. This will help to close the gap between the investment requirement scenarios and current spending levels identified earlier in this chapter. As 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. The largest percentage increases in cash outlays for highways by the Federal Government are expected to occur in 1999, 2000, and 2001. Federal cash outlays are projected to increase in 2002 and 2003 as well, but are expected to grow more slowly than inflation.

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. 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 predicts that annual increases in State highway funding will range from 4.5 percent to 5.1 percent during the period from 1997 to 2003. This report assumes that State and local government funding for highway capital expenditures will increase by approximately the same rates.

Q. What factors do the State Highway Funding Models use in their projections?

A. 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). State Highway Funding Model II makes more detailed forecasts of each major State revenue source. Model II bases its projections for individual revenue components on estimates of future VMT, nominal GDP, licensed drivers, State general fund revenues, State general fund expenditures, commuter railway miles and Treasury Bill Yields. The future funding levels projected by the two models are fairly consistent with each other.

Model I was utilized in this report, since the detailed revenue component projections provided by Model II were not needed.

Projected Federal, State and Local Capital Expenditures

Exhibit 8-5 shows projected expenditures by all levels of government for highway capital projects in current dollars and constant 1997 dollars. As indicated in Chapter 6, historical capital expenditures are converted to constant dollars using the 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.

Stated in constant 1997 dollars, highway capital expenditures are expected to rise from $48.7 billion in 1997 to $56.5 billion in 2003, a 16 percent increase. The growth in capital spending is expected to outpace inflation in each year during this period, with the largest increases occurring between 1999 and 2001.

Exhibit 8-5

Projected Highway Capital Expenditures 1998-2003, All Levels of Government

Year	Projected Capital Expenditures Stated in Billions of Nominal Dollars: Amount	Projected Capital Expenditures Stated in Billions of Nominal Dollars: Increase Over Prior Year	Projected Annual Rate of Inflation*	Projected Capital Expenditures Stated in Billions of Constant 1997 Dollars: Amount	Projected Capital Expenditures Stated in Billions of Constant 1997 Dollars: Increase Over Prior Year
1997	48.7	---	---	48.7	---
1998	49.6	1.9%	1.6%	48.8	0.2%
1999	53.2	7.1%	2.1%	51.2	4.9%
2000	57.3	7.7%	2.4%	53.9	5.2%
2001	60.3	5.2%	2.4%	55.4	2.7%
2002	62.3	3.4%	2.5%	55.9	0.9%
2003	64.6	3.6%	2.5%	56.5	1.1%

* CPI projections are from the Mid-Session Review of the Fiscal Year 2000 Budget.

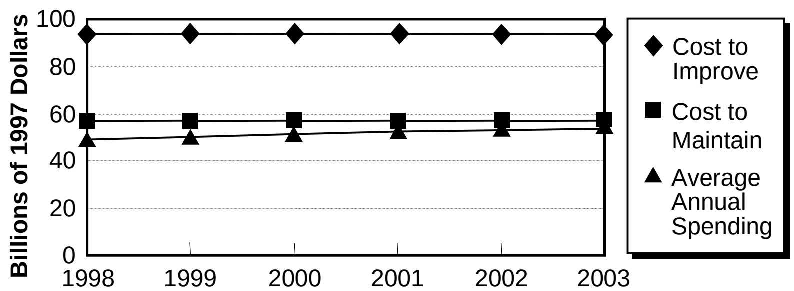
Comparison of Investment Requirements and Projected 1998–2003 Spending

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 end of 20 years, cumulative spending over the 20-year period would need to match the cumulative investment requirements specified for that target. For example, if spending in 2017 matched the average annual investment requirements identified as the Cost to Maintain Highways and Bridges, but spending in 1998 through 2016 fell below this threshold, highway and bridge conditions would be expected to decline. Highway and bridge conditions would only be maintained under this scenario if the cumulative average annual spending for the 1998–2017 period reached $56.6 billion, the average annual Cost to Maintain Highways and Bridges.

Exhibit 8-6 compares the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges with projected spending for the years 1998 through 2003. The row for 1997 is included to relate the table to Exhibits 8-2 and 8-3, but the 1997 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 $51.3 billion average annual expenditures shown for the year 2000 represent the average expenditures for the three-year period 1998 to 2000.

Exhibit 8-6

Average Annual Investment Required to Maintain and Improve Highways and Bridges Versus Projected 1998-2003 Capital Outlay



Year	Projected Capital Expenditures Stated in Billions of Constant 1997 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
1997	48.7	---	---	56.6	16.3%	94.0	92.9%
1998	48.8	48.8	48.8	56.6	16.1%	94.0	92.6%
1999	51.2	100.1	50.0	56.6	13.3%	94.0	87.9%
2000	53.9	153.9	51.3	56.6	10.4%	94.0	83.2%
2001	55.4	209.3	52.3	56.6	8.3%	94.0	79.7%
2002	55.9	265.2	53.0	56.6	6.9%	94.0	77.3%
2003	56.5	321.6	53.6	56.6	5.7%	94.0	75.3%

If State and local government spending increases at the predicted rates, then combined highway capital spending by all levels of government is projected to reach $56.5 billion in 2003. This is virtually identical to the $56.6 billion average annual Cost to Maintain Highways and Bridges. However, the “gap” between cumulative average annual spending and the average annual investment requirement for this scenario would not be eliminated at this point, since spending from 1998 through 2002 is projected to be below the Cost to Maintain threshold. Average annual capital expenditures from 1998 through 2003 are expected to reach $53.6 billion, $3.0 billion below the average annual Cost to Maintain Highways and Bridges. Spending would need to increase an additional 5.7 percent to reach the Cost to Maintain level.

Exhibit 8-6 shows the gap between cumulative average annual spending and the average annual investment requirements closing steadily between 1997 and 2003. If highway capital expenditures by all levels of government continue to grow faster than inflation beyond 2003, capital expenditures might exceed the Cost to Maintain Highways and Bridges within the 20-year period covered by the investment requirement projections.

Timing of the Investment Requirements

While the investment requirement analysis in this report centers around the average annual investment requirements for the 20-year period 1998 through 2017, the HERS and BNIP models do provide information on how investment requirements would vary within this period. Each model reports investment requirements for four 5-year funding periods.

Effect of Backlog on Early Year Investment Requirements

For the Cost to Improve Highways and Bridges, the pattern of investment is heavily influenced by the existence of a backlog of highway and bridge investments. As indicated in Chapter 7, HERS estimates that a total of $166.7 billion of investment could be justified based solely on the current conditions and operational performance of the highway system. The BNIP estimates that $87.3 billion of investment would be required to repair or replace all bridges that are currently functionally obsolete or structurally deficient. For the highway Maximum Economic Investment scenario and the Bridge Eliminate Deficiencies scenario that are included in the Cost to Improve Highways, the models assume that the backlog will be addressed as quickly as possible, within the first 5-year funding period.

The existence of a backlog means that HERS and BNIP have a wide variety of potential improvements to choose from, when selecting investments included as part of the Cost to Maintain Highways and Bridges for the first 5-year funding period. This would tend to reduce investment requirements in this period, as the models would tend to implement the improvements with the greatest returns first. However, for highways this reduction is more than offset by another effect of the backlog, which tends to increase investment requirements in the early years. Some of the highway deficiencies that currently exist could be addressed relatively inexpensively in the short term, but will become much more expensive to correct if they are deferred. HERS recognizes this, and incorporates the potential costs of delaying improvements into its analysis process.

Investment Requirements by Funding Period

Exhibit 8-7 shows the distribution of investment requirements among the four 5-year analysis periods in HERS and BNIP. For the Cost to Improve Highways and Bridges, 36.6 percent of the investment requirements are for the first five years. This investment would eliminate the existing highway and bridge investment backlog, as well as correct new deficiencies that are expected to arise during this period. Investment requirements for the years 6 to 10 are sharply lower than for years 1 to 5. Investment requirements for years 11 to 20 are higher than for the preceding five years, but are still well below those for years 1 to 5.

Exhibit 8-7

Distribution of Investment Requirements by Five-Year Periods

	Cost to Maintain Highways and Bridges (Billions of 1997 Dollars)				Cost to Improve Highways and Bridges (Billions of 1997 Dollars)			
	Highways	Bridges	Total	Percent	Highways	Bridges	Total	Percent
Cumulative								
1998-2002	283.1	22.5	301.6	26.6%	585.7	102.4	688.1	36.6%
2003-2007	228.7	29.0	257.6	22.7%	359.8	25.1	384.8	20.5%
2008-2012	243.2	31.4	275.9	24.4%	363.1	40.0	403.2	21.5%
2013-2017	261.2	33.7	297.8	26.3%	359.1	44.0	403.2	21.5%
Total	1,016.2	116.6	1,132.8	100.0%	1,667.8	211.5	1,879.3	100.0%
Average Annual	50.8	5.8	**56.6**		83.4	10.6	**94.0**	

For the Cost to Maintain Highways and Bridges, the differences in investment requirements between the funding periods is lower. For the Cost to Maintain Highways and Bridges 26.6 percent of investment requirements are for the first five years. Investment requirements for years 6 to 10 are lower. During the final 10 years the investment requirements increase, but not quite to the level for the initial 5-year funding period.

Q. **How would the "gap" between current funding levels and the investment requirement scenarios be affected if spending was compared with investment requirements for the first 5-year funding period rather than the average annual investment requirements over 20 years?**

A. Since the combined highway and bridge investment requirements projected by HERS and BNIP are highest in the early years of the analysis, the "gap" would be larger.

Comparison with Previous Reports

The comparison between spending and investment requirements is presented differently in this report than in previous versions. Exhibits 8-2 and 8-3 emphasize the difference between current spending and average annual investment requirements. Exhibit 8-8 takes the same approach, and applies it to the spending and investment requirement information in the 1995 and 1997 C&P reports.

The difference between current spending and the Cost to Maintain Highways and Bridges has shrunk in recent years. 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. As shown in Exhibit 8-8, a comparable analysis of the data in the 1997 C&P report would have shown a 21.0 percent difference between the average investment requirements to Maintain User Costs, and 1995 spending. As indicated in Exhibit 8-6, the trend is expected to continue, as this difference is projected to close from 16.3 percent in 1997 to an average of 5.7 percent from 1998 through 2003.

Exhibit 8-8

Average Annual Investment Requirements Versus Current Spending: 1995, 1997 and 1999 C&P Reports

		Percent Above Current Spending	
Report Year	Relevant Comparison	Cost to Maintain Highways & Bridges (Low Scenario *)	Cost to Improve Highways & Bridges (High Scenario *)
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%

* The investment requirement scenarios are not fully consistent between reports. See Chapter 7.

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. This difference would have fallen to 108.9 percent based on the 1997 C&P report. As indicated earlier, the difference is projected to close further, from 92.9 percent in 1997 to an average of 75.3 percent from 1998 through 2003.

Transit Capital Spending Versus Investment Requirements

This section compares transit capital spending to the investment requirements estimated by TERM and presented in Chapter 7. The first point of comparison is the actual total transit capital spending in 1997, which was discussed and reported in Chapter 6. A second point of comparison, to estimated capital expenditures for the period 1998-2003, is warranted given the dramatic growth in Federal funding for mass transit that is authorized by TEA-21.

Average Annual Investment Requirements Versus 1997 Capital Spending

Capital expenditures for transit in 1997 totaled $7.636 billion (Exhibit 6-23). This sum is well below the required investment amounts in each of the scenarios estimated by TERM, with the exception of the pure rehabilitation and replacement necessary solely to maintain current conditions. This "gap" between funding and investment requirements is presented in Exhibit 8-9. The estimates from TERM imply that simply maintaining the current physical condition and operating performance of the Nation's transit system over the next 20 years would require expenditures 41 percent above actual transit capital spending in 1997. The difference between actual expenditures and the cost of improvements to conditions and performance is much greater: improving both conditions and performance would cost more than double the amount actually spent in 1997.

Exhibit 8-9

Average Annual Transit Investment Requirements Versus 1997 Capital Expenditures

	Billions of Dollars	Percent Above Actual Spending
1997 Capital Spending	7.6	---
Cost to Maintain Conditions & Performance	10.8	41.0%
Cost to Maintain Conditions & Improve Performance	14.4	88.7%
Cost to Improve Conditions & Maintain Performance	11.1	45.5%
Cost to Improve Conditions & Performance	16.0	110.2%

Exhibit 8-10 disaggregates investment requirements and 1997 capital funding into vehicle and non-vehicle expenditures. For the **Maintain Conditions and Performance** scenario, the percent difference between spending and needs is much greater for vehicles (58 percent) than it is for non-vehicle expenditures (34 percent). For the **Improve Conditions and Performance** scenario, however, the percent difference for non-vehicle spending (116 percent) is somewhat larger than for vehicle spending (95 percent).

Q. **Why does moving from the Maintain Conditions and Performance scenario to the Improve Conditions and Performance scenario have a much greater impact on investment requirements for non-vehicle expenditures than it does on vehicle expenditures?**

A. The larger impact on non-vehicle investment requirements is due primarily to the performance improvements that TERM makes. In order to alleviate crowding and improve operating speeds, TERM will often build new or expand existing rail systems relative to bus system expansion, as rail transit generally has a greater capacity and speed. Since rail investments require relatively more non-vehicle capital (such as guideways) than bus system expansions do, the relative share of estimated non-vehicle capital investment will also increase.

Exhibit 8-10

Average Annual Transit Investment Requirements Versus 1997 Capital Spending by Asset Type

	Vehicles		Non-Vehicles	
	Billions of $	Percent Above Actual Spending	Billions of $	Percent Above Actual Spending
1997 Capital Spending	2.2	---	5.4	---
Cost to Maintain Conditions & Performance	3.5	58%	7.2	34%
Cost to Improve Conditions & Performance	4.4	95%	11.7	116%

Investment Requirements Versus Projected 1998-2003 Spending

As is the case with highway funding, TEA-21 substantially increases the authorized funding levels for Federal Transit Administration programs relative to the past levels of Federal assistance. It is therefore useful to compare the projected transit capital funding levels over the period of the TEA-21 authorization, 1998-2003, to the investment requirements estimated by TERM.

Exhibit 8-11 shows projected transit capital funding levels for 1998-2003 (see sidebar for an explanation of how these levels were computed). Transit capital spending is expected to grow well in excess of the rate of inflation throughout the period, with an especially large increase in the 1999 fiscal year. The expected inflation rates are projections of the Consumer Price Index used in the Federal budgeting process.

Exhibit 8-11

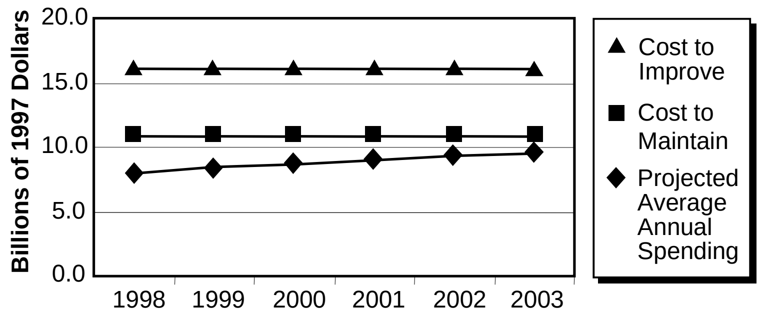
Projected Transit Capital Expenditures 1998-2003, All Levels of Government (Billions of Dollars)

Year	Expenditures in Nominal Dollars	Increase Over Prior Year	Projected Rate of Inflation	Expenditures in Constant 1997 Dollars	Increase Over Prior Year
1997	7.6			7.6	
1998	8.1	5.7%	1.6%	7.9	4.1%
1999	9.2	13.6%	2.1%	8.8	11.3%
2000	10.0	8.6%	2.4%	9.4	6.1%
2001	10.8	7.9%	2.4%	9.9	5.4%
2002	11.5	7.3%	2.5%	10.4	4.7%
2003	12.3	6.9%	2.6%	10.8	4.3%

Exhibit 8-12 compares projected cumulative average annual funding levels for 1998-2003 to the average annual investment requirements for both the **Maintain Conditions and Performance** and **Improve Conditions and Performance** scenarios. The considerable bump in projected capital expenditures has a corresponding effect in lowering the investment gap. By 2003, transit capital spending is projected to reach $10.8 billion in constant 1997 dollars, matching the average annual investment required to maintain conditions and performance. However, over the full six-year period 1998-2003, projected average annual capital expenditures would rise only to $9.5 billion from $7.6 billion in 1997. Average annual spending would need to increase an additional 12.9 percent to reach the level of the average annual investment requirements under the maintain scenario. Six-year spending would need to increase 68.3 percent above projected levels to reach the level of the improve scenario.

Exhibit 8-12

Projected Capital Expenditures Versus Investment Requirements, 1998-2003



	Projected Capital Expenditures (Billions of 1997 Dollars)		Cost to Maintain Conditions and Performance		Cost to Improve Conditions and Performance	
Year	Annual	Average Annual	Average Annual	Percent Above Projected Average Annual Spending	Average Annual	Percent Above Projected Average Annual Spending
1997	**7.6**	**---**	**10.8**	**41.0%**	**16.0**	**110.2%**
1998	7.9	7.9	10.8	35.4%	16.0	101.9%
1999	8.8	8.4	10.8	28.2%	16.0	91.1%
2000	9.4	8.7	10.8	23.4%	16.0	84.0%
2001	9.9	9.0	10.8	19.4%	16.0	78.0%
2002	10.4	9.3	10.8	15.9%	16.0	72.9%
2003	10.8	9.5	10.8	12.9%	16.0	68.3%

Q. **How were the projected transit capital expenditures for the period 1998-2003 calculated?**

A. TEA-21 includes guaranteed funding level caps for all Federal Transit Administration programs. Three of these programs, the Section 5308 Clean Fuels Formula Grant Program, the Section 5309 Capital program and the Section 5310 Formula Program (Elderly and Individuals With Disabilities) are exclusively for capital needs (see 49 U.S.C. 5308, 5309, 5310). Two others, the Section 5307 Urbanized Area and 5311 Nonurbanized Area Formula Programs, are used for both capital and operating expenses (see 49 U.S.C. 5307, 5311). To estimate Federal capital funding for each year, the guaranteed funding levels for Sections 5308, 5309, and 5310 funding were added to the capital share of the guaranteed funding levels for Sections 5307 and 5311. These shares were based on the capital shares of the 1998 obligations made for these two programs. This method provides a reasonable upper bound on what Federal capital expenditures are expected under TEA-21.

Unlike FHWA, FTA has no model for forecasting State and local transit capital expenditures. In 1997, the Federal share of capital spending was 54 percent (Exhibit 6-24), which represented an increase from recent years, when the share was slightly below one-half. While it is possible that State and local governments may decrease their matching of Federal capital funds as those funds increase substantially, there is no way to clearly predict how much “crowding out” of State and local funds there will be. Therefore, it was assumed that State and local governments would match the increased Federal funding levels at a 1:1 ratio, approximating recent experience. These calculations yielded the projected amounts shown in Exhibits 8-11 and 8-12.

The Timing of Investment

Exhibit 8-13 shows how the investment requirements over the entire 20-year horizon are distributed among each 5-year period. Investments under the Maintain scenario are relatively backloaded, with 54 percent of investment in the latter 10 years. This largely reflects the need for greater capital investments in later years to accommodate transit passenger travel growth. Under the improve scenario, investments in the initial period are equal in the first and last periods. This is due primarily to the larger investment under this scenario during the early period that is necessary to eliminate the initial backlog of deficiencies.

Exhibit 8-13

Distribution of Transit Investment Requirements by Five-Year Periods

	Cost to Maintain Conditions and Performance (Billions of 1997 Dollars)			Cost to Improve Conditions and Performance (Billions of 1997 Dollars)		
Period	5-Year Total	Annual Average	Percent of 20-Year Total	5-Year Total	Annual Average	Percent of 20-Year Total
1998-2002	52.5	10.5	24.4%	83.4	16.7	26.0%
2003-2007	46.5	9.3	21.6%	72.8	14.6	22.7%
2008-2012	58.1	11.6	27.0%	81.4	16.3	25.4%
2013-2017	58.2	11.6	27.0%	83.4	16.7	26.0%
Total	**215.3**	**10.8**	**100.0%**	**321.0**	**16.0**	**100.0%**

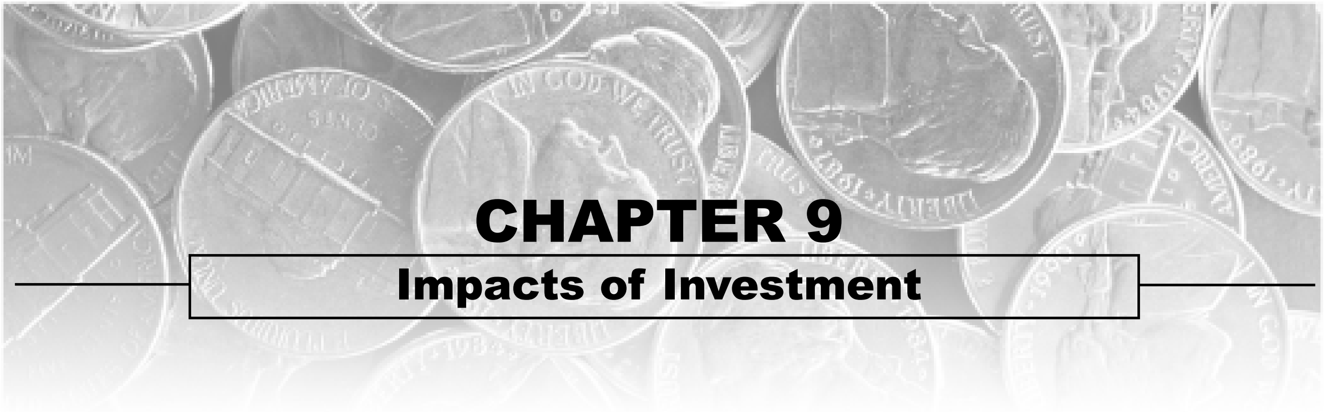
Comparison with Previous Reports

Exhibit 8-14 compares the percent difference between current spending and investment requirements to the same differences calculated in the 1995 and 1997 Conditions and Performance Reports. Due to changes in methodology, especially between 1995 and 1997, estimated investment requirements are not directly comparable. However, the figures here do indicate that the investment requirements relative to spending have remained relatively constant under both scenarios, with investment needs to maintain conditions and performance roughly 40 percent above spending, and investment needs to improve conditions and performance between 100 and 125 percent above actual spending. As noted above, if the increases in funding authorized by TEA-21 are realized, and states continue to match the federal transit capital funding, expenditures on transit capital should increase sharply. Thus, it is expected that future reports will show considerable improvement toward closing the investment gaps.

Exhibit 8-14

Average Annual Transit Investment Requirements Versus Current Spending: 1995, 1997 and 1999 Conditions and Performance Reports

			Percent Above Current Spending	
Report Year	Spending Year	Investment Requirements Forecast Years	Cost to Maintain Conditions and Performance	Cost to Improve Conditions and Performance
1995	1993	1994-2013	37.6%	124.4%
1997	1995	1996-2015	38.3%	102.9%
1999	1997	1998-2017	41.0%	110.2%



CHAPTER 9

Impacts of Investment

Introduction

This chapter serves two major purposes. The first is to discuss the impacts of historic investment, relating the condition and performance trends reported in Chapters 3 and 4 with the financial trends reported in Chapter 6. The second purpose 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.

This chapter is a new addition to the C&P report. In this edition, the chapter focuses on a limited number of topics. Future versions of the report will expand on this analysis, and address other related topics.

The highway portion of this chapter begins by discussing the impacts that future investment patterns would be expected to have on future highway travel growth, travel time costs, vehicle operating costs and crash costs. The section then examines the impacts that recent funding patterns have had on highway conditions and performance. The section concludes with a discussion of innovative means to increase future investment.

The transit portion addresses the projected increase in transit travel that would be accommodated by the estimated investment requirement levels. The recent stability of most condition and performance measures is discussed, and some possible reasons for this phenomenon in the face of estimates of current funding gaps are proposed.

Impact of Highway and Bridge Investment on Conditions and Performance

This section explores some of the impacts that future levels of investment would be expected to have on future travel growth and on future highway user costs. This analysis moves beyond the investment requirements and scenarios defined in Chapter 7, to explore a variety of different investment levels.

This chapter also 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. This section concludes with a discussion of innovative means to increase the resources available for future highway and bridge investment.

Impact of Investment Levels on Future Travel Growth

As discussed in Chapter 7, HERS predicts that the level of future investment on highways will have an impact on 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 (travel time costs, vehicle operating costs, and crash costs) on a facility will induce additional traffic on that route that would not otherwise have occurred. Future pavement and widening improvements will tend to reduce highway user costs, and induce additional travel. If a highway section is not improved, highway user costs on that section will tend to rise over time due to pavement deterioration and/or increased congestion, which will tend to suppress travel.

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 that 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.

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 is 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.

Projected Average Annual Travel Growth

Exhibit 9-1 shows how the effective VMT growth rates in HERS are influenced by the total amount invested in highways, and the location of highway improvements. The highway investment levels shown in the table line up with those in Exhibit 7-3, which defined the highway scenarios and benchmarks used in this report. Each row represents a different minimum benefit-cost ratio (BCR) cutoff point in HERS, as discussed in Chapter 7. The italicized bridge values shown in the second column are interpolated or extrapolated from the $5.8 billion bridge component of the Cost to Maintain Highways and Bridges, and the $10.6 billion Cost to Improve Highways and Bridges. Only these two values are directly obtained from the Bridge Needs and Investment Process (BNIP) model. The remaining bridge values are included in this table to facilitate comparisons with the combined highway and bridge spending projections from Chapter 8. As discussed in Chapters 7 and 8, investment requirements for new bridges are included as "Highway" rather than "Bridge" since BNIP only considers existing bridges.

Exhibit 9-1

Projected Average Annual VMT Growth Rates, 1998-2017, for Different Possible Funding Levels

Average Annual Investment (Billions of 1997 Dollars)			Average Annual VMT Growth			
Highway	Bridge	Total	Rural	Urban	Urbanized > 1 Million Population	Funding Level Description
$83.4	$10.6	**$94.0**	3.03%	2.22%	2.06%	**Cost to Improve Highways & Bridges**
$76.5	*$9.6*	$86.1	3.01%	2.19%	2.03%	
$70.7	*$8.7*	$79.4	2.98%	2.15%	2.01%	
$67.9	*$8.3*	$76.3	2.97%	2.13%	1.99%	**Maintain Travel Time Benchmark**
$65.4	*$7.9*	$73.3	2.95%	2.11%	1.97%	
$60.8	*$7.3*	$68.1	2.92%	2.06%	1.92%	
$56.6	*$6.7*	$63.3	2.88%	2.01%	1.88%	
$53.9	*$6.3*	$60.1	2.85%	1.97%	1.84%	**Maintain User Costs Benchmark**
$52.9	*$6.1*	$59.0	2.85%	1.96%	1.83%	
$50.8	$5.8	**$56.6**	2.82%	1.93%	1.80%	**Cost to Maintain Highways & Bridges**
$49.8	*$5.7*	$55.4	2.80%	1.92%	1.79%	
$46.9	*$5.3*	$52.2	2.76%	1.87%	1.74%	
$44.2	*$4.9*	$49.0	2.72%	1.83%	1.70%	
$41.8	*$4.5*	$46.3	2.68%	1.78%	1.66%	
			2.35%	2.04%	1.86%	**HPMS Baseline**

The weighted average annual growth rate for all HPMS sample sections in rural areas is 2.35 percent. At all levels of investment shown in the table, the travel demand elasticity features in HERS cause additional travel to be induced in rural areas. A new safety module has been added to HERS that has improved the models ability to evaluate the safety impacts of highway improvements, particularly in rural areas (See Appendix G). The model now recommends a larger number of widening and alignment improvements in rural areas to reduce crashes, fatalities, and injuries. By reducing crash costs, these improvements reduce the overall cost of using rural highways, which has the side effect of encouraging additional travel.

The weighted average annual growth rate for all HPMS sample sections in urban areas is 2.04 percent. If average annual highway capital outlay rose to $53.9 billion ($60.1 billion for highways and bridges combined) in constant 1997 dollars, HERS predicts that overall highway user costs would be maintained at 1997 levels. However, at this funding level, the improvements recommended by HERS would reduce user costs on rural highways, while allowing costs on urban highways to rise. The Maintain User Costs Benchmark derived from HERS attempts to maintain the weighted average user costs for all highway sections, but user costs can vary on individual functional classes, and on individual highway sections. Due to the travel demand elasticity features in HERS, the model projects that the increase in user costs in urban areas would limit average annual urban VMT growth to 1.97 percent, below the baseline forecasts in HPMS.

In 1997, all levels of government spent $42.6 billion for highway capital outlay (excluding bridge preservation expenditures), falling between the values in the first column of the last two rows in Exhibit 9-1. If average annual investment remains at this level in constant dollar terms over the next 20 years, urban VMT would be expected to grow at an average annual rate between 1.78 percent and 1.83 percent.

As indicated in Chapter 8, average annual capital investment on highways and bridges by all levels of government from 1998–2003 is expected to grow to $53.6 billion in constant 1997 dollars. Reading down the third column, this amount falls between the $55.4 billion and the $52.2 billion shown in the third and fourth rows from the bottom. Reading across these rows to the average annual urban VMT growth rate in the fifth column, Exhibit 9-1 indicates that if this level of investment were sustained for 20 years, and used in the manner recommended by HERS, the model projects urban VMT growth would rise at an average annual rate between 1.87 percent and 1.92 percent.

Projected Average Annual Travel Growth in Large Urbanized Areas

Exhibit 9-1 shows that the weighted average annual growth rate for all HPMS sample sections in urbanized areas with population over 1 million is 1.86 percent. A separate survey of metropolitan planning organizations (MPOs) indicates that they are projecting average annual VMT growth of only 1.68 percent. The source of the differences between these two sets of forecasts appear to stem from their underlying assumptions. The MPO forecasts incorporate the effects of actions the MPOs are proposing to shape demand in their areas to attain air quality and other development goals. The MPO plans may include transit expansion, congestion pricing, parking constraints, capacity limits, and other local policy options. The forecasts in HPMS may not similarly account for these effects.

As discussed in Chapter 7, the travel demand elasticity features in HERS mimic the effects that these types of Transportation Demand Management (TDM) programs would have. ***(See the Q&A box on page 7-13)***. As shown in Exhibit 9-1, HERS predicts that if current funding levels were sustained, user costs in large urbanized areas would increase, reducing VMT growth from the 1.86 percent rate projected in HPMS to an average annual growth rate between 1.66 percent and 1.70 percent. The 1.68 percent growth rate obtained from the MPO survey falls within this range. This appears to be logical since the MPO forecasts have to factor in funding availability, while HERS assumes HPMS forecasts are not funding-constrained, and that they represent the level of travel that would occur only if investment is high enough to maintain a constant level of service.

Prior to the addition of travel demand elasticity features into the HERS, the HPMS forecasts for sections in large urbanized areas were manually reduced to make them consistent with the MPO projections. This adjustment was necessary, since the model could not simulate the effects that TDM policies would be likely to have on future travel growth. Since travel demand elasticity has been added to HERS, this adjustment is no longer required, and has been discontinued in this report. This change is discussed in more detail in Appendix G. Chapter 10 explores the effect that reducing the projected VMT growth rate in large urbanized areas would have on the overall investment requirements.

> ***Q.*** **What are the implications of the higher VMT growth rates under the Cost to Improve Highways and Bridges?**
>
> ***A.*** The HERS analysis suggests that the MPO travel projections are consistent with current funding levels. If highway investment were to rise substantially, VMT growth could be higher than the MPOs are accounting for in their plans to meet Clean Air Act requirements. This might require States and MPOs to invest a greater share of resources in congestion mitigation and air quality programs, and/or to take more aggressive measures in regulating emissions from vehicular and non-vehicular sources with what would occur If total investment requirements rose.

Historic Travel Growth

Exhibit 9-2 shows annual VMT growth rates for the 20-year period from 1977 to 1997. The average annual VMT growth rate over this period was 2.84 percent. Travel growth varied significantly in individual years, ranging from a decline of 1.01 percent in 1979 to an increase of 5.45 percent in 1988. Highway travel growth is typically lower during recessions, or periods of slow economic growth, and higher during periods of economic expansion. VMT growth was below average during the 1980, 1981–1982 and the 1990–1991 recessions. From 1983 through 1989, annual VMT growth was higher than 3 percent every year. Exhibit 9-2 shows that travel has grown more slowly during the current economic expansion, than in the 1980s, reflecting a long term trend towards lower VMT growth rates.

Exhibit 9-2

VMT Growth Rates, 1977-1997

Year	Growth Rate	Year	Growth Rate	Year	Growth Rate	Year	Growth Rate
1978	5.29%	1983	3.62%	1988	5.45%	1993	2.19%
1979	-1.01%	1984	4.08%	1989	3.48%	1994	2.67%
1980	-0.12%	1985	3.17%	1990	2.28%	1995	3.43%
1981	1.83%	1986	3.38%	1991	1.29%	1996	2.59%
1982	2.55%	1987	4.71%	1992	3.46%	1997	2.61%
avg. annual 1977-1982	1.69%	avg. annual 1982-1987	3.79%	avg. annual 1987-1992	3.18%	avg. annual 1992-1997	2.70%

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 2.16 percent overall average annual projected travel growth derived from HPMS is well below the 1997 growth rate of 2.61 percent, or the 2.84 percent average annual VMT growth rate from 1977 to 1997. Rather than assuming that VMT growth will suddenly drop to 2.16 percent in 1998, and remain constant for the next 20 years, the HERS model now assumes that VMT growth rates will gradually decline over the 1997 to 2017 period. The model accomplishes this by assuming that VMT growth will be linear, and will grow by a constant amount annually, rather than growing by a constant rate. For example, if travel grows at an average annual rate of 2.16 percent, this would result in an increase in travel between 1997 and 2017 of 1.37 trillion vehicle miles. The HERS model would assume that VMT will increase by 1/20 of this amount, 68.4 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.

Q. If future travel growth doesn't slow as quickly as the forecasts assume, how would this affect future investment requirements?

A. If travel growth is higher than expected, additional investment would be required to maintain and improve highways and bridges. Chapter 10 shows what would happen to the investment requirements if average annual VMT growth for the next 20 years matched the 2.84 percent rate observed over the last 20 years.

Exhibit 9-3 shows projected year-by-year VMT derived from HERS for five 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 4.2 trillion in 2017. If average annual investment remains at 1997 levels in constant dollar terms, VMT would grow to only 3.9 trillion.

Note that projected travel growth for each of these funding levels is well below the historic growth rate over the last 20 years.

Exhibit 9-3

Annual Projected Highway VMT at Different Funding Levels (VMT in Millions; Funding in Billions of 1997 Dollars)

Funding Level Description		Cost to Improve Highways and Bridges	Highway Maintain Travel Time Benchmark	Highway Maintain User Costs Benchmark	Cost to Maintain Highways and Bridges	Actual 1997 Capital Outlay
Funding Level $ Billions	**Highway**	**$83.4**	**$67.9**	**$53.9**	**$50.8**	**$42.6**
	Bridge	$10.6	*$8.3*	*$6.3*	$5.8	$6.1
	Combined	$94.0	*$76.3*	*$60.1*	$56.6	$48.7
Projected Annual VMT By Year	**1997**	**2,566,958**	**2,566,958**	**2,566,958**	**2,566,958**	**2,566,958**
	1998	2,650,942	2,647,620	2,642,104	2,640,562	2,634,928
	1999	2,734,925	2,728,283	2,717,251	2,714,167	2,702,898
	2000	2,818,909	2,808,945	2,792,397	2,787,771	2,770,867
	2001	2,902,893	2,889,607	2,867,544	2,861,375	2,838,837
	2002	2,986,876	2,970,269	2,942,690	2,934,980	2,906,807
	2003	3,070,860	3,050,932	3,017,836	3,008,584	2,974,777
	2004	3,154,844	3,131,594	3,092,983	3,082,188	3,042,747
	2005	3,238,827	3,212,256	3,168,129	3,155,793	3,110,717
	2006	3,322,811	3,292,918	3,243,276	3,229,397	3,178,686
	2007	3,406,795	3,373,581	3,318,422	3,303,001	3,246,656
	2008	3,490,778	3,454,243	3,393,568	3,376,605	3,314,626
	2009	3,574,762	3,534,905	3,468,715	3,450,210	3,382,596
	2010	3,658,745	3,615,567	3,543,861	3,523,814	3,450,566
	2011	3,742,729	3,696,230	3,619,007	3,597,418	3,518,535
	2012	3,826,713	3,776,892	3,694,154	3,671,023	3,586,505
	2013	3,910,696	3,857,554	3,769,300	3,744,627	3,654,475
	2014	3,994,680	3,938,217	3,844,447	3,818,231	3,722,445
	2015	4,078,664	4,018,879	3,919,593	3,891,836	3,790,415
	2016	4,162,647	4,099,541	3,994,739	3,965,440	3,858,385
	2017	**4,246,631**	**4,180,203**	**4,069,886**	**4,039,044**	**3,926,354**

Impact of Investment Levels 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 benefits are defined as reductions in travel time costs, crashes, and vehicle operating costs. Chapter 7 defined a highway Maintain User Cost benchmark, indicating that an average annual investment of $53.9 billion would be required to maintain highway user costs at their baseline 1997 levels. The highway Maintain Travel Time benchmark, defined as the average annual investment required to maintain travel time costs at current levels, was projected to be $67.9 billion.

Exhibit 9-4 describes how travel time costs, vehicle operating costs and crash costs are influenced by the total amount invested in highways. The highway investment levels shown in the table line up with those in Exhibit 7-3, which defined the highway scenarios and benchmarks used in this report. Each row represents a different minimum BCR cutoff point in HERS, as discussed in Chapter 7. As in Exhibit 9-1, the italicized bridge values shown in the second column are interpolated or extrapolated from the two bridge investment requirement scenarios to facilitate comparisons with the combined highway and bridge spending projections from Chapter 8.

Exhibit 9-4

Projected Changes in Highway User Costs Compared to 1997 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 1997 Dollars)			Percent Change in User Costs				
Highway	Bridge	Total	Travel Time Costs	Vehicle Operating Costs	Crash Costs	Total User Costs	Funding Level Description
$83.4	$10.6	**$94.0**	-0.9%	-3.2%	-2.3%	-1.8%	**Cost to Improve Highways & Bridges**
$76.5	*$9.6*	$86.1	-0.7%	-2.8%	-2.3%	-1.6%	
$70.7	*$8.7*	$79.4	-0.2%	-2.4%	-2.0%	-1.3%	
$67.9	*$8.3*	$76.3	**0.0%**	-2.4%	-2.0%	-1.1%	**Maintain Travel Time Benchmark**
$65.4	*$7.9*	$73.3	0.2%	-2.0%	-2.0%	-1.0%	
$60.8	*$7.3*	$68.1	0.7%	-1.6%	-2.0%	-0.6%	
$56.6	*$6.7*	$63.3	1.1%	-1.2%	-1.6%	-0.3%	
$53.9	*$6.3*	$60.1	1.5%	-1.2%	-1.6%	**0.0%**	**Maintain User Costs Benchmark**
$52.9	*$6.1*	$59.0	1.8%	-0.8%	-1.6%	0.1%	
$50.8	$5.8	**$56.6**	2.0%	-0.8%	-1.6%	0.4%	**Cost to Maintain Highways & Bridges**
$49.8	*$5.7*	$55.4	2.2%	-0.4%	-1.3%	0.5%	
$46.9	*$5.3*	$52.2	2.6%	0.0%	-1.3%	0.9%	
$44.2	*$4.9*	$49.0	3.1%	0.4%	-1.0%	1.3%	
$41.8	*$4.5*	$46.3	3.5%	0.8%	-1.0%	1.6%	

As shown in Exhibit 9-4, while an average annual highway investment of $53.9 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would rise 1.5 percent, while vehicle operating costs and crash costs would fall by 1.2 percent and 1.6 percent respectively. This indicates that at this investment level, HERS predicts that there would be a relatively greater rate of return on improvements aimed at reducing crashes rather than those aimed at reducing congestion.

The improvements recommended by HERS would reduce crash costs at all levels of investment shown in Exhibit 9-4. Vehicle operating costs would be maintained if average annual investment reached $46.9 billion for highways. Combined with projected bridge investment requirements (extrapolated from the two scenarios derived from BNIP), total highway and bridge investment of $52.2 billion would be required to maintain vehicle operating costs. This is above the $48.7 billion level of 1997 highway and bridge capital outlay, but below the $53.6 billion average annual capital outlay projected for 1998–2003 in Chapter 8. As indicated earlier, maintaining travel time costs would be significantly more expensive.

The percent change in user costs shown in Exhibit 9-4 are 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.

Recent Condition and Performance Trends Versus Spending Trends

Chapter 6 indicated that there has been a change in the types of highway capital improvements being made in recent years. The percentage of total highway capital outlay used for the construction of new roads and bridges dropped from 22.8 percent in 1993 to 15.2 percent in 1995, rising back to 15.6 percent in 1997. The percentage used for system preservation rose from 44.7 percent to 50.0 percent in 1995, falling back to 47.6 percent in 1997. Over this 4-year period, highway capital outlay has grown 2.2 percent in constant dollar terms.

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. As indicated in Chapter 8, bridge spending has exceeded the investment requirements for the bridge component of the Cost to Maintain in recent years. This is consistent with the recent decline in the percent of deficient bridges.

Recent highway spending has been below the investment requirements for the highway component of the Cost to Maintain. Average IRI and the percent of pavement in poor condition have both worsened since 1995, though they have improved since 1993.

Chapter 7 discussed the existence of a backlog of pavement improvements that would currently be cost-beneficial to address. As indicated in Chapter 8, some of these deficiencies could be addressed relatively inexpensively in the short term, but will become much more expensive to correct if they are deferred. While current funding levels have been adequate to gradually improve pavement ride quality, continuing this level of investment indefinitely would not allow some pavement deficiencies to be addressed, and would ultimately be expected to drive up the long term cost of keeping average conditions at 1997 levels.

Conditions

The improved highway and bridge conditions reported in Chapter 3 reflect the effects of this shift toward system preservation, and the constant dollar increase in investment. From 1993 to 1995, the percentage of all road miles in poor condition fell from 8.6 percent to 6.4 percent. From 1995, as the percentage of resources devoted to system preservation dipped, the percentage of all road miles in poor condition rose from 6.4 percent to 6.6 percent. The percent of deficient bridges has been reduced each year during this 4-year period, falling from 32.5 percent to 29.6 percent.

Operational Performance

Highway operational performance since 1993 has been mixed, depending on which indicator is used. As indicated in Chapter 4, from 1993 to 1995, average delay in urbanized areas greater than

200,000 in population increased from 11.9 hours to 13.7 hours per thousand VMT. From 1995 to 1997, average delay in urbanized areas fell to 13.0 hours per thousand VMT. The percentage of urban Interstate travel on segments with a V/SF>=0.80 increased from 52.6 percent in 1993 to 53.3 percent in 1997. However, congested travel on other urban principal arterials declined. Traffic density, measured as DVMT per Lane-Mile, increased on all functional systems between 1993 and 1997.

Between 1993 and 1997, the percentage of capital outlay used for system expansion (including new roads, new bridges, and new lanes on existing roads and bridges) fell from 49.4 percent to 44.4 percent. At the same time, spending for traffic operational improvements increased. System expansion and traffic operational improvements both tend to increase capacity and reduce congestion. Since traffic density measured by DVMT per Lane-Mile has been increasing steadily, but overall delay and the V/SF ratios have not gotten substantially worse, this implies that existing roadways are being utilized more effectively. Part of this is the result of increased investment in traffic operational improvements, which add capacity without adding additional lane-miles. Some of this is also the result of changes in driver behavior.

Q. **How do the conditions and performance of Interstate routes with heavy truck traffic compare to those with fewer trucks?**

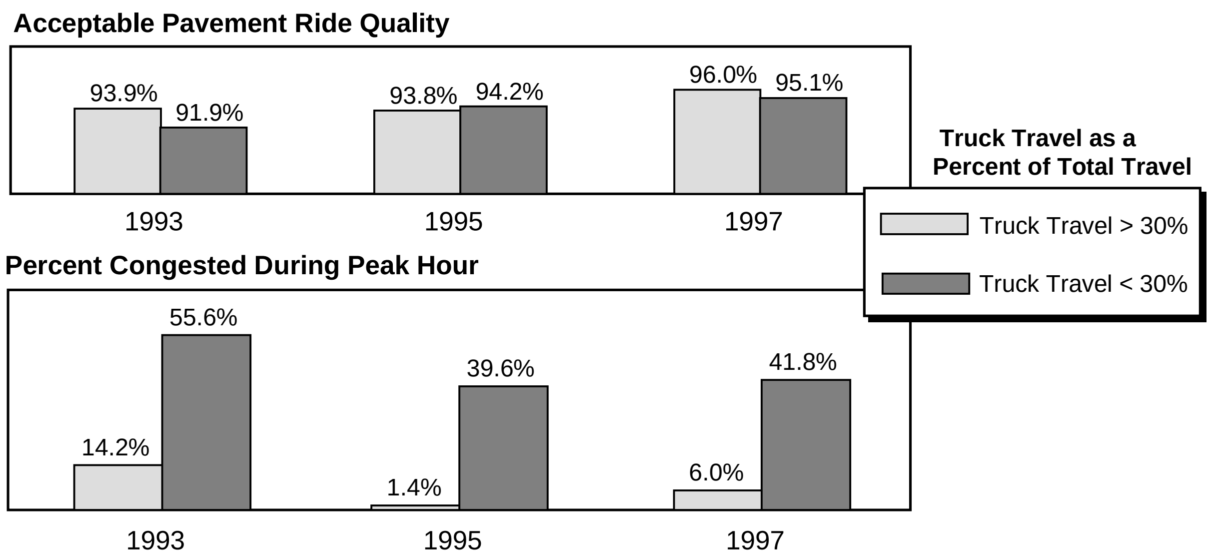
A. Approximately 20 percent of Interstate mileage has truck traffic that exceeds 30 percent of total traffic on these routes. Exhibit 9-5 compares the percent of pavement with acceptable ride quality and the percent of congested travel for Interstate routes with 30 percent or more trucks with those with lighter truck traffic. As indicated in Chapter 3, to meet the FHWA Strategic Plan standard for acceptable ride quality, pavement must have an IRI value of 170 or less. In this exhibit, congested travel includes sections with a V/SF ratio of 0.80 or higher.

This exhibit shows that on the Interstate pavement is in better condition on routes with high truck travel than on those with fewer trucks, and the portion of miles with smooth pavement increased from 1993 to 1997. While heaver vehicles cause more damage to pavement than lighter vehicles, routes most used by trucks are typically those with pavement with a higher strength than average, and that receive more than average attention from the appropriate jurisdictions for rehabilitation and maintenance.

The exhibit also shows that there is less congestion on routes with a high percentage of truck travel, but that the congestion varies from year to year. Truck drivers chose routes with less congestion when feasible. (See Exhibit 9-5)

Exhibit 9-5

Conditions and Performance of Interstate Routes with Heavy Truck Traffic



Transit Investment Impacts

Unlike HERS, TERM does not model transit demand responses to infrastructure investments and the reduction in user costs which they provide (see Appendix I). Accordingly, it is impossible to determine how achieving the investment levels targeted by TERM and discussed in Chapter 7 would affect transit ridership and user costs. Instead, the causality runs the other direction: at the forecast annual transit PMT growth rate of 1.9 percent, the asset expansion investments would accommodate an increase in annual transit passenger miles from 40.2 billion in 1997 to 58.7 billion in 2017 while maintaining the same level of performance that existed in 1997.

Transit Investment and Historical Trends

The forecast travel growth rate of 1.9 percent is well above the average growth rate in transit PMT of 1.0 percent that was observed between 1987 and 1997. However, it is below the average growth rates in the most recent years, between 1993 and 1997 (2.6 percent) and 1995–1997 (2.9 percent). The metropolitan planning organizations appear to be predicting that future transit growth will be faster than recent long-term growth, but slower than the sharp increase observed most recently.

As indicated in Chapter 3, the average condition of bus vehicles has been relatively constant over the last several years, while the average condition of the aging rail vehicle fleet (particularly the heavy rail vehicle fleet) has declined. As Exhibit 8-15 indicates, previous reports have estimated that then-current capital spending levels would fall well short of the amount required to maintain both conditions and performance. However, these amounts have been slightly higher than the pure replacement and rehabilitation levels, as shown in Exhibit 9-6. Over the same 10-year period (1987–1997), the two primary system performance measures, average speed and vehicle utilization rates, have also been relatively constant (see Chapter 4). Thus, actual conditions and performance (with the possible exception of heavy rail vehicles) do not appear to have been strongly affected by the funding gap.

Exhibit 9-6

Current Capital Spending Levels versus Rehabilitation and Replacement Needs, 1993-1997

	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

Future Analyses of Spending Impacts

This is the second reporting cycle that has used TERM to model asset conditions and forecast investment needs. Several important modifications and additions have been made to TERM during its early development, and it is anticipated that many more such improvements will continue to be made in the future. Of particular interest would be additions to TERM that would allow a more complete analysis of investment impacts. For example, it would be helpful to be able to quantify the year-to-year performance improvements that are made and changes in conditions that occur over the analysis period. Another effort will be made to incorporate demand elasticity into PMT growth, and to allow for some degree of interaction between the HERS and TERM models. One additional effort currently underway is to adapt TERM to allow for annual spending caps to be imposed. This would allow for an analysis of how asset conditions would change if funding levels were held at some particular value (such as current spending).

Q. **Why haven't transit conditions and performance diminished substantially if there has been a capital investment gap?**

A. There are several possible reasons for this. One is the simple fact that the investment requirements are forward-looking, rather than historical. Their intention is to forecast future investment needs, rather than to describe past patterns of investment and its impact. As a result, while past and current spending levels may be sufficient to have maintained the condition and performance levels currently observed, they may not be adequate to continue to do so in the future.

It is also possible, as surmised in the highway section of this chapter, that recent investments have provided short-term maintenance fixes while larger, more expensive replacement needs have simply been deferred to the future. TEA-21 attempts to address this possibility by eliminating most operating costs from eligibility for Section 5307 Urbanized Area Formula funding in large cities (i.e., urbanized areas over 200,000 in population), while specifically allowing preventative maintenance costs as an eligible expense. It is hoped that this change may result in a more-optimal allocation of capital funds by transit agencies.

Another possibility for the perceived insensitivity of conditions to the funding gap is that capital funds have been sufficient to cover pure rehabilitation and replacement needs, while not allowing for capacity expansion to maintain current performance levels. However, this assumes that all capital funds are being used on rehab and replacement. In actuality, much of this funding has gone toward new vehicles for system expansion and new, performance-improving rail systems. The performance measures have also stayed relatively constant.

Two features of the data and modeling in TERM should also be noted. First, for many transit systems, increases in vehicle utilization may be a sign of improved system efficiency, rather than a stress on system capacity. If current vehicles are being underutilized (as may especially be the case for new rail systems in their start-up periods), then there will be excess capacity in the system, and travel growth can easily be handled by existing assets, so long as they are properly rehabilitated and replaced. Second, the Rehabilitation and Replacement module in TERM (see Appendix I) invests sufficient amounts to maintain conditions on the existing asset base. As new assets for system expansion are purchased, the average condition of all assets will increase, even if the condition of existing assets remains constant. Some of this may be reflected in the stability of bus vehicle conditions even as investment appears to be inadequate to do so.

Methods for Increasing Future Investment for Transportation Projects

Chapter 6 describes the broad revenue categories that have traditionally provided most funding for highways. Buried within these numbers are a variety of new financing mechanisms that have come on line in recent years. These innovative finance strategies leverage existing Federal, State, and local transportation funds, and draw on the resources of the private sector as well. Innovative finance is a broadly defined term that refers to methods of financing transportation infrastructure other than relying on conventional highway user fees and taxes.

The TEA-21 provides new grants, management flexibility, and project financing opportunities to State DOTs and other project sponsors. Major finance provisions include:

- TIFIA: The Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) established a new Federal credit program under which the Department of Transportation (DOT) may provide $10.6 billion via three forms of credit assistance – secured (direct) loans, loan guarantees and standby lines of credit – for surface transportation projects of national or regional significance. The program's fundamental goal is to leverage Federal funds by attracting substantial private and other non-Federal co-investment in critical improvements to the Nation's surface transportation system.
- SIBs: A State Infrastructure Bank (SIB) pilot program was established under the 1995 National Highway System Designation Act (Section 350) and expanded upon in the 1997 DOT Appropriations Act. Designed to complement traditional transportation funding programs, SIBs can give States significantly increased flexibility in project financing. Much like a private bank, a SIB uses seed capitalization funds to get started and offers customers a range of loans and credit enhancement products. The SIBs can be used to finance eligible surface transportation projects, including both highway construction and transit capital projects. As of September 30, 1999, $516.5 million in Federal funds had been deposited into the highway and transit accounts of the 39 approved State banks. The TEA-21 authorized only four states to use TEA-21 funds to capitalize the SIBs.
- GARVEE: Grant Anticipation Revenue Vehicle, or GARVEE Bond, refers to any financing instrument for which principal and/or interest is repaid with future Federal-aid highway funds. In essence, the debt is issued in anticipation of the receipt of Federal apportionments in subsequent years.

The following are innovative finance concepts and strategies that can be used to increase the state and local transportation revenue streams. It is important to note that controversy surrounds each. For example, questions have been raised about whether some of the strategies listed below are equitable.

- Congestion pricing ("peak hour tolls"): Motorists pay a fee to use congested roadways during peak hour traffic. The fee assessed is reflective of the amount of delay and congestion present on the roadway. The user pays a higher fee during peak hour traffic, when delay is heaviest, and a lower or no fee during less congested non-peak hour traffic. The fee is based on estimated costs and other externalities (e.g., air pollution).
- Value pricing: In contrast to congestion pricing, motorists pay a fee to use "uncongested" roadways, such as existing high-occupancy vehicle (HOV) lanes. A recent concept referred to

as High-Occupancy Toll (HOT) Lanes allows lower occupancy vehicles or solo drivers to pay a fee to use HOV lanes during peak hour traffic. The HOT toll is based on traffic volume and time of day and is set to maintain free flow in the express lane. Motorists have a "choice," that is if they are in a hurry, they may elect to pay in order to have less delay and improved level-of-service compared to the free general purpose travel lanes.

- VMT fee: A fee based on the number of miles a vehicle travels. Unlike fuel taxes, VMT fees measure overall road use. Some say VMT fees are superior to fuel taxes because of the wide differences in the fuel-efficiency of vehicles. A potential problem is the discouragement of owning fuel-efficient cars.
- Emission fees: A fee based on the air pollution produced by a vehicle.
- Parking charges: A fee collected to offset the costs of providing parking and externalities related to automobile driving. Currently, many employers offer free parking to employees.
- Pay-at-the-pump insurance: Instead of paying set premiums directly to an insurance agent for vehicle liability coverage, a motorist pays a surcharge per gallon of gasoline purchased. This insurance program would not necessarily generate revenue, but it would change insurance payment from a lump sum to an out-of-pocket cost. Lump sum payments lead to the perception that driving an automobile is cheaper than it really is because there is not a frequent reminder of the actual associated cost. A driver would achieve lower insurance rates if he/she drives less or uses a fuel-efficient vehicle.
- Development Impact Fees: States are using Development Impact Fees (DIFs) to finance transportation projects. The DIFs are assessed on new development, and are normally used to improve an area's infrastructure, such as schools, sewers or roads. Georgia law allows local governments to establish DIFs. In the case of the Foothill/Easterns Toll Road in Orange County, California, DIFs have raised $178 million.

Q. **Have any of these innovative funding strategies been implemented?**

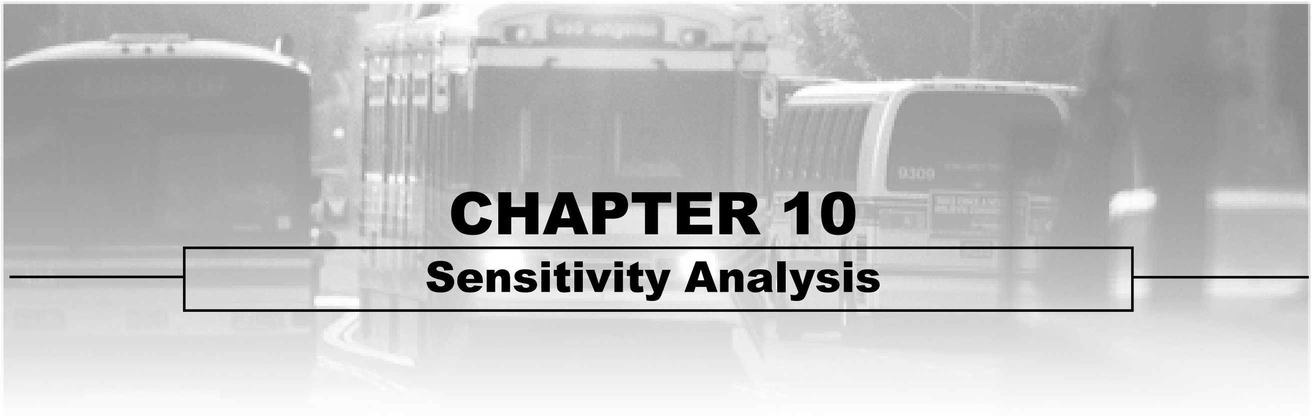
A. Yes. The following is a sample of some of the innovative financing measures that have been implemented.

Federal Government Sponsored

- TIFIA: An example of TIFIA funding project is the Miami Intermodal Center, estimated at $1.349 billion. Two Federal TIFIA direct loans will be provided: one in the amount of $269 million, secured by State fuel tax revenues, and the other, for the Rental Car Facility (RCF), in the amount of $167 million, secured by rental car fees.
- SIBs: As of September 30, 1999, $516.5 million in Federal funds had been deposited into the highway and transit accounts of the 39 approved State banks. Although States are limited in expanding Federal capitalization of their SIBs (with the exception of the four TEA-21 pilot States), some States are enhancing capitalization with non-Federal revenue sources.
- GARVEEs: Three States – New Mexico, Ohio, and Massachusetts – have already taken advantage of the GARVEE bond issue, by issuing debt backed by pledges of Federal aid. On the transit side, the New Jersey Transit Corporation issued $151.5 million in debt backed solely by a pledge of future Federal Transit Administration (FTA) funding. The debt, which was sold in March 1999, and insured by AMBAC Corporation, will be used to purchase 500 new buses for the mass transit agency.

State Sponsored

- A HOT lane was opened on State Route 91 in Orange County, California. A private company built the lanes and will operate and maintain the facility. After 35 years the lanes revert back to California. Other operational HOT lane projects include the I-15 HOV lanes in San Diego, CA, and the I-10 (Katy) HOV lane in Houston, TX.



CHAPTER 10
Sensitivity Analysis

Introduction

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 of Highway Economic Requirements System (HERS) and Transit Economic Requirements Model (TERM) are strongly affected by the values they are supplied for certain key variables. This chapter was added to the 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. The highway section of this chapter also explores a number of other variables, in part to show the impacts of some of the assumptions that were modified for this version of the report. The changes in the highway investment requirement methodology are discussed more fully in Appendix G.

One of the key parameters used in projecting investment requirements is the forecast rate of transit travel growth. The sensitivity of the estimated 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).

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 Maintain Highways and Bridges and the Cost to Improve 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

The States provide forecasts of future VMT for each individual HPMS sample highway section. As indicated in Chapter 7, the HERS model 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 1997 levels. If HERS predicts that highway-user costs will deviate from baseline 1997 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, particularly in large urban areas. This concept is discussed in more detail in Appendix G.

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 accurately predict 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. This section explores the impacts of modifying the HPMS forecasts. This is the equivalent of assuming that the HPMS forecasts don't actually predict the VMT that would occur at a constant level of service.

Increasing VMT Growth Projections

As indicated in Chapter 9, the State-supplied VMT growth projections in HPMS for 1997 to 2017 average 2.16 percent per year, well below the 2.84 average annual VMT growth rate observed from 1977 to 1997. The HERS model assumes that the 2.16 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 10-1 shows the impact on investment requirements of assuming that the VMT growth that would occur at a constant level of services will be 2.84 percent annually (matching the actual growth rate over the last 20 years), rather than the 2.16 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 31.5 percent. Modifying the travel growth projections in this fashion would increase the Cost to Maintain Highway and Bridges by 15.5 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. Both these factors would tend to increase the investment required to maintain condition at 1997 levels. The Cost to Improve Highways and Bridges would increase by 14.1 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.

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	**56.6**		**94.0**	
Overall VMT Growth Rates increased from 2.16% to 2.84%	65.4	15.5%	107.3	14.1%
VMT Growth Rates in Urbanized Areas>1,000,000				
Decreased 10% from 1.86 to 1.68%	55.7	-1.6%	92.9	-1.1%
Decreased 20% from 1.86 to 1.49%	55.3	-2.4%	92.1	-2.0%
Decreased 50% from 1.86 to 0.93%	53.5	-5.6%	89.5	-4.7%
Decreased 100% from 1.86 to 0%	50.4	-11.0%	86.1	-8.3%

Source: Highway Economic Requirements System (HERS).

Reducing VMT Growth Projections in Large Urbanized Areas

Exhibit 10-1 also shows the effects of reducing the initial travel growth projections for all HPMS sections in areas over 1 million in population by 10 percent, 20 percent, 50 percent, and 100 percent. As indicated in Chapter 9, the average annual VMT growth rate for HPMS sections in large urbanized areas is 1.86 percent. If this value actually represents the travel growth that would occur at a rising level of service, factoring down the VMT growth rates could reduce them to the level that would occur at a constant level of service, which HERS needs to properly perform its travel demand elasticity adjustments.

Factoring down the initial travel projections for all HPMS sections in large urbanized areas by 10 percent would reduce the average annual VMT growth projection from 1.86 percent to 1.68 percent. This would reduce the Cost to Maintain Highways and Bridges by 1.6 percent, and reduce the Cost to Improve Highways and Bridges by 1.1 percent. A 20 percent reduction would change the average annual VMT growth projection in large urbanized areas to 1.49 percent, and would reduce the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges by 2.4 percent and 2.0 percent respectively. If it is assumed that no travel growth will occur in large urbanized areas at all, unless user costs decline, then the Cost to Maintain Highways and Bridges would be 11.0 percent lower and the Cost to Improve Highways and Bridges would be 8.3 percent lower. (Note that investment in large urbanized areas only would be much more heavily affected than overall investment in all areas, and would decline 37.9 percent and 29.2 percent respectively.)

If reductions in highway travel growth coincided with increases in transit PMT growth, this would increase overall transit investment requirements, offsetting to some extent the lowered highway investment requirements. The effects of changing transit travel growth assumptions are discussed later in this chapter.

Q. **Why does reducing VMT growth rates in urbanized areas over 1 million in population have a smaller impact on investment requirements than raising the VMT growth rates for all highway sections?**

A. Of the total investment requirements for the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges, only 28.5 percent and 29.1 percent respectively are for highway improvements in urbanized areas over 1 million. Therefore, over 70 percent of the baseline investment requirements would not be affected by a reduction in VMT growth rates that applies only to highway sections in large urbanized areas.

Other Alternative Assumptions

As in the case with travel growth projections, changing other key variables can have a significant impact on the investment requirement results. Exhibit 10-2 shows the impact that changing certain variables would have on the Cost to Maintain Highways and Bridges and the Cost to Improve Highways and Bridges. The individual changes are discussed in more detail below.

Exhibit 10-2

Impact of Other Alternate Assumptions on Investment Requirements

	Cost to Maintain Highways & Bridges		Cost to Improve Highways & Bridges	
	($ Billions)	Percent Change	($ Billions)	Percent Change
Chapter 7 Baseline	**56.6**		**94.0**	
Turn on High Cost Lane Feature	72.9	28.7%	129.7	38.0%
Change Elasticity Values to 1997 C&P Levels	59.4	4.9%	93.2	-0.8%
Turn off Emissions Module	56.7	0.1%	95.0	1.1%
Value of time: Increase 100 percent	60.4	6.6%	98.5	4.9%
Value of time: Reduce 50 percent	56.8	0.3%	90.4	-3.8%
Value of life: Increase 100 percent	57.8	2.1%	94.4	0.5%
Value of life: Reduce 50 percent	56.5	-0.2%	93.8	-0.2%

Source: Highway Economic Requirements System (HERS).

High Cost Lanes

For each highway section in HPMS, States code a Widening Feasibility rating. In this report, it has been assumed that highway sections cannot be widened beyond the width specified as feasible by the States. However, the investment requirement analysis in previous C&P reports treated the widening feasibility rating as a measure of the number of lanes that could be added at "normal" cost. In previous reports, it was assumed that if adding additional lanes was justified, they could be added at "high" cost, representing the cost required to double-deck a freeway, build a parallel route, or acquire expensive right-of-way. The decision to turn off the high-cost lane feature in HERS for this report is explained in Appendix G.

Turning on the high-cost lane feature would increase the Cost to Improve Highways and Bridges by 38.0 percent. This feature allows HERS to add additional lanes in congested areas. While these lanes are expensive, the model would consider them to be cost-beneficial in many situations.

Turning on high-cost lanes would increase the Cost to Maintain Highways and Bridges by 28.7 percent. This occurs because the model would shift a greater percentage of investment towards capacity improvements, since there would be more attractive widening projects to choose from. As explained in Chapter 7, the Highway Maintain Conditions scenario represents a cost-beneficial mix of investments that is expected to maintain average IRI, but also includes capacity projects that meet the same minimum BCR cutoff point.

Elasticity Values

The travel demand elasticity values were increased in this report to -1.0 for short term elasticity with an additional -0.6 (total -1.6) for long term elasticity. [See the discussion of elasticity in Chapter 7]. In the 1997 C&P report, values of -0.8 and -0.2 (total -1.0) were used. The rationale behind this change is explained in Appendix G.

Setting the elasticity values back to the levels used to develop the 1997 C&P report would increase the Cost to Maintain Highways and Bridges by 4.9 percent. As indicated in Chapter 7, highway-user costs are projected to increase overall under the Highway Maintain Conditions scenario. Therefore, the elasticity procedures in HERS tend to suppress travel growth at this level of investment. Reducing the elasticity values back to the levels used in the 1997 C&P report would allow additional travel to occur, thus boosting the investment requirements.

The opposite effect can be observed in the Cost to Improve Highways and Bridges. Under the Highway Maximum Economic Investment scenario, highway users are projected to decline. At this level of investment, the elasticity procedures in HERS tend to induce travel growth. Therefore, reducing the elasticity values back to the levels used in the 1997 C&P report would reduce the amount of induced travel, and reduce the investment requirements.

Emissions Module

The HERS model now factors in the societal costs of emissions into its benefit-cost analysis of highway improvements. As discussed in Appendix G, the emissions module in HERS is based on older research. The impact of emissions costs on the investment requirements may change in the future, as the HERS emissions equations are enhanced.

Turning off the emissions module in HERS would increase the Cost to Maintain Highways and Bridges by 0.1 percent and increase the Cost to Improve Highways and Bridges by 1.1 percent. When the model doesn't consider the societal costs of emissions, it finds more potential improvements to be cost beneficial.

Value of Time

The value of time in HERS was developed using a standard methodology adopted by the Department of Transportation. This methodology provides consistency between 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 time in HERS would increase the Cost to Maintain Highways and Bridges by 6.6 percent and increase the Cost to Improve Highways and Bridges by 4.9 percent. Increasing the value of time causes HERS to consider more widening projects that reduce travel time costs cost beneficial. The proportion of capacity projects implemented as a percentage of total projects would increase, causing the Cost to Maintain Highways to rise also.

Reducing the value of time by 50 percent would cause a slight 0.3 percent increase in the Cost to Maintain Highways and Bridges, and a 3.8 percent reduction in the Cost to Improve Highways and Bridges. The slight increase in the Cost to Maintain Highways and Bridges is caused by the change in the mix of projects that are implemented.

Value of Life

HERS uses $2.7 million for the value of life, which is the Department of Transportation'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 of life in HERS would increase the Cost to Maintain Highways and Bridges by 2.1 percent and increase the Cost to Improve Highways and Bridges by 0.5 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. HERS would also change the mix of recommended improvements, favoring those that reduce crash costs over those that primarily gain their benefits by improving pavement quality. This effect tends to cause the Cost to Maintain Highways and Bridges to increase.

Reducing the value of life by 50 percent would reduce the Cost to Maintain Highways and Bridges by 0.2 percent and reduce the Cost to Improve Highways and Bridges by 0.2 percent. Some marginal projects that were justified based on potential reductions in crash rates they would cause would not be implemented if the value of life was reduced.

Transit Sensitivity Analysis

One of the most important parameters used by TERM in forecasting transit investment needs is the projected growth rate in transit passenger miles traveled (PMT). This forecast is obtained from metropolitan planning organizations (MPOs) in large urbanized areas, most of which make forecasts about transit PMT and auto VMT growth as part of the regional transportation planning process. The average annual growth rate in PMT from the most recently available MPO forecasts, used in this report, is 1.90 percent.

The assumed passenger travel growth rate has several important effects on the estimates of investment requirements. The effect is most important for Asset Expansion. The forecast travel growth rate is the primary factor in determining the need for system expansion in order to accommodate increased transit usage while maintaining a constant degree of vehicle utilization. A larger growth rate also affects the degree to which crowded systems become even more so, requiring even more investment to achieve Performance Improvement. On the other hand, the growth rate does not affect the need for the replacement and rehabilitation of the existing capital stock as it wears out.

In order to examine the sensitivity of the estimated transit investment requirements to forecast transit growth rates, TERM was run using the following three alternative scenarios:

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.

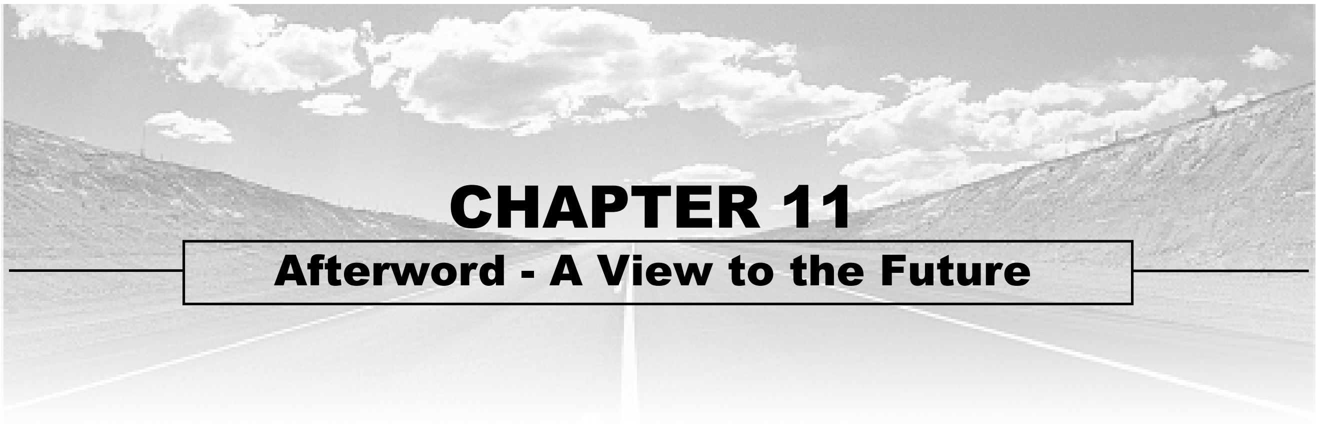
The effect of varying the growth rate is shown in Exhibit 10-3. Adjusting the growth rate has a significant effect on the estimated investment requirements, though the effect is greater under the **Maintain Conditions and Performance** scenario. Under the Maintain scenario, each 1 percent change in the growth rate causes a 35 to 40 percent change in investment requirements, while the same change in the growth rate changes the Improve scenario investment requirements by 25 to 30 percent. The smaller sensitivity under the Improve scenario is due to the greater replacement and rehabilitation expenditures which are necessary for condition improvements. Note that even under conditions of no growth in passenger miles, major investment would still be required in order to maintain the current system, with still greater expenditures to improve conditions and performance relative to current levels.

Exhibit 10-3

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 $)	Percent Change	(Billions of $)	Percent Change
Baseline (1.90%)	**10.8**	**---**	**16.0**	**---**
Increased 50% (to 2.85%)	13.0	20.7%	18.4	14.7%
Decreased 50% (to 0.95%)	8.8	-18.0%	14.1	-12.4%
Decreased 100% (to 0%)	7.0	-34.8%	12.2	-24.0%

Source: Transit Economic Requirements Model.



CHAPTER 11

Afterword - A View to the Future

Introduction

Since the earliest editions of this report were prepared, the original engineering standards perspective on transportation needs have evolved and matured along with the industries and institutions which attempt to address them. With those increasing capabilities come even greater expectations on the part of the traveling public, whether they be users of highways and transit for shopping, commuting, touring, or commercial purposes. The purpose of this chapter, in what might be considered as almost an appendage to the Conditions and Performance Report, is to raise those issues which the authors feel give an indication of the shortcomings and future advances in this endeavor to articulate for the American people the state of the Nation's highways, bridges, and transit systems.

Over time, we have continued to look at whether a more reliable, comprehensive, and useful assessment of these systems is a function of the tools that are available to assess them or the data that is collected for analysis or both. The resulting critiques have led us to new tools, refinement of tools and techniques, new questions, and new data needs. This chapter continues in that tradition to ask whether there are issues that this report should address more specifically, whether better tools should be developed to address these issues and whether additional data needs to collected.

Some of these aspects can also be considered limitations of the current report and therefore readers are well served to understand them so that the findings can be properly applied to answer questions of concern. We understand these limitations in the context of a "work in progress" and therefore encourage constructive dialogue as to how to address the limitations of the analyses presented in the future.

The issues are presented under the strategic planning framework adopted by the U.S. Department of Transportation, with implementation responsibility related to the highway and transit networks primarily facing the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Federal Motor Carrier Safety Administration (FMCSA).

The analyses results presented in this report are based on the data available to FHWA and FTA and on the analytical tools that have been developed to analyze these data. Analyses beyond the limits of the data and the capabilities of the analytical tools cannot be performed without further data collection and/or the development of more sophisticated analytical tools. This chapter addresses several issues that relate to the limitations imposed on this report by the current state of the practice in data collection and in the development of suitable tools for analysis of the data.

Safety

As the foremost goal, safety is clearly of great importance to the Department of Transportation, as it is to all of us. Safety is the first goal listed in the FHWA strategic plan, and with good reason. Fatalities and injuries on the nation's highways are not something for which we as a nation can be complacent. We are always striving to reduce injuries, including fatalities, the most serious form of injury. Safety initiatives have been developed on a number of fronts. Safer highways, safer vehicles, and safer drivers are all important achievements and all have contributed to greater safety on the highways than in the past. Fatality rates have been reduced significantly even while highway travel has increased dramatically. For example, from 1966 to 1997 the fatality rate per 100 million vehicles miles of travel has declined from 5.5 to 1.6. This occurred while travel increased from 926 billion to 2,576 billion vehicle miles.

Indicators of the safety aspects of performance are relatively easy to identify but difficult to isolate because of the many different influences on the causation. Safer vehicles (transit cars, buses, trucks, autos) are one aspect. Safer infrastructure contributes a more forgiving environment. Safer operation of the vehicles by professionals and amateurs alike yield the benefits of fewer crashes. The net effects of all of these facets are reflected in fatalities and injuries both in total numbers and rates of occurrence.

What metrics serve to help us evaluate that net result? What method of forecasting can enlighten us as to the potential safety impacts of various future situations? Since safety is imbedded in project design and program operation aspects of all transportation agencies, it is reflected in the Highway Economic Requirements System (HERS) mechanism used to evaluate various alternative investment scenarios. HERS incorporates a crash model that predicts future numbers of crashes based on the information available in the Highway Performance Monitoring System (HPMS) database and on projected highway capital improvements. This crash model has been recently upgraded to be more sensitive to changes in geometrics, such as lane width, shoulder width, and horizontal and vertical alignment. Crash costs, including the costs of injuries and fatalities, are included in the user costs estimated by HERS and are used to evaluate potential highway improvement actions.

These crash costs are evaluated along with other user costs such as the time costs of delay and vehicle operating costs. Therefore the dollar benefits of reduced crashes are included in the benefit/cost analysis by HERS when analyzing the relative benefits of alternative highway improvements. Highway improvements that would be expected to reduce the number of crashes will reduce the costs of crashes, and this reduction is part of the benefits of the improvement. If benefits exceed costs over the life of the improvement, the action is deemed beneficial.

The HPMS database on which the analysis is based includes data on roadway geometrics, travel volumes, vehicle speeds, etc., but it does not include data on the number of accidents that occur on the sample highway sections. Such data were included for several years in the 1980s, but the data were too sparse to be statistically significant. Currently the HPMS contains no data on specific roadway locations regarding number of accidents. Therefore the HERS analysis has no way to address specific high accident locations.

The question asked here is whether the current form of analysis is sufficient to address safety concerns at the national level. HERS can be adjusted to assign a higher value to crash costs than to other user costs. Crash costs could, for example, be doubled with respect to other user costs. This would give crash costs more weight in the benefit/cost analysis than other costs. But such a procedure, it can be argued, would invalidate the premise of basing the analysis results on values that are assigned as fairly as possible for all costs. If different weights are arbitrarily assigned to different components of user costs, that could be construed as predetermining the results of the analysis. If we wish to claim that a dollar in crash costs is worth more than a dollar of delay, sensitivity analysis can be done to determine how much change in investment strategy would result.

How can transit safety be related to the overall analysis? The safety of bus transit may be related to overall highway safety, but to what degree? The safety of rail transit, whether light or heavy rail, would typically be a separate issue from highway safety.

There is no intent implied here for FHWA to develop a specific program of highway safety projects for the States. Instead the concern is whether safety is adequately addressed in the national level analysis for this report. In other words, does the analysis that we perform for this report adequately address concerns about highway crashes? If more attention were paid to highway improvements that enhance safety more than capacity or pavement condition, what would the scenario look like? Would it be very different from what HERS now recommends? Should more attention be paid to facilities that are substandard from a safety standpoint–width, alignment, shoulders, etc?

The national investment analysis that we now perform is not intended to dictate what highway improvements the States will accomplish. The analyses are rather intended to demonstrate what can be accomplished with given investment levels, with user costs and agency costs being minimized for each scenario. Safety is one of the major inputs to each scenario, and this may be the way to continue.

Mobility

By most measures the United States is the most mobile nation on earth. Most of us have the opportunity to be selective of the location where we work, where we live (even at some distance from our job), and where we shop, yet there are sectors of the population which have less than the average mobility. Traffic congestion is a problem that faces almost everyone who lives in the larger cities in this nation, and to some degree in smaller cities as well. Do we really know how much congestion exists and what it is costing us? Is there a better way to analyze the need for highway improvements that are intended to reduce congestion and to determine which improvements are best?

Personal Mobility

According to Chapter 1 of this report, certain population groups are not accommodated as well as the average person by our transportation systems, both highways and transit. The major factor affecting the use of our transportation systems is economic. For example, if one cannot afford to buy and operate a car, one’s opportunity to travel becomes limited to other modes. Population groups categorized by age, gender, or ethnic origin may also be at a disadvantage. Part of this is because these groups have a lower income than average. But even those within the group who receive an average income may not receive average service. This may be because of reduced personal mobility, as with the elderly, or it may have a geographic component, as may be the case with ethnic groups. Working mothers may need to go by the grocery store and the day care center on the way home from work. People that need to do trip chaining may find the use of a car a necessity and for them the use of transit may not be practicable.

Why are some groups or subgroups at a disadvantage in the transportation system even when they are not economically disadvantaged? Is it geography? Do they live in an area not well served by transportation systems? Does transit provide the service they need? Does it provide a reasonable service between where they live and where they could work, shop, or participate in other activities? Are these questions relevant at the national level, or are these matters best left to the local level?

Congestion

Everyone claims to know what traffic congestion is but a precise quantification is difficult. Measures of the operational performance of our nation's streets and highways can be difficult to obtain or define. Congestion in one city is not necessarily perceived the same as in another. In some cities commuters struggle with an hour of congestion in morning and again in the afternoon. In other cities, congestion occurs for 8 or 10 hours a day.

In some cities transit plays a significant role in travel, and therefore reduces highway congestion compared to what it would be without transit. We can hardly imagine New York City without its subway system. An analysis of the trade-offs between transit and automobile travel would include the role of transit in reducing highway travel and therefore highway congestion. While this type of analysis may be done at the local level to establish the need for new or expanded transit systems, how can this impact be addressed at the national level?

The Volume/Capacity (V/C) ratio has long been used in this report as a measure of congestion, but it has weaknesses. It only addresses the peak hour, which may be the only congested time or may be only one of many congested hours of the typical day. Also, a V/C ratio of less than 1.0 (say 0.9) may describe a facility approaching capacity (Level of Service E) or a facility that has been reduced below capacity by congestion (LOS F). Delay as a measure of congestion has recently come into some prominence; however, it has been difficult to measure and apply.

Chapter 4 of this report cites two sources of calculated delay. One is delay based directly on HPMS data, and calculated from recently formulated travel speed equations. This delay includes delay at traffic signals and stop signs. The other measure reported by the Texas Transportation Institute is based less directly on HPMS data and uses travel per lane as a surrogate for congestion. Their procedures are based on rather simple assumptions, but do include an estimate of delay caused by roadway incidents, such as accidents. Two other measures that have been proposed are travel speed and reliability. The average traveler, whether commuter or shopper, would like to travel at a speed not slowed by congestion or frequent "red" traffic signals. Industries which depend on transportation need a reliable system that can guarantee a given level of performance, providing for "just in time" deliveries. A trip that takes one hour one day and one and a half hours the next day does not provide that service.

Today, the variety of congestion measures creates uncertainty and confusion about how much congestion exists and whether it is getting worse, better, or is about the same as last year. When a measure of congestion is tied to the agency performance measure or goal, a defensible and reliable measure is needed. We need accepted, easily understood measures for which data can be readily collected.

Life Cycle Cost Analysis

The FHWA encourages the States to use Life Cycle Cost Analysis (LCCA) in their determination of pavement types and designs. This type of analysis can be used to evaluate a total stream of costs and benefits over a significant period of time, say 40 years, to compare alternative highway improvement actions. It can include the cost of delay to the user of pavement actions, maintenance and capital improvements. It can be a useful tool to evaluate alternative pavement investment strategies.

If FHWA is to promote the use of LCCA to the States, should FHWA also use LCCA in its own analyses of current and future highway capital investment requirements? The HERS process currently does look ahead at costs and benefits of potential highway capital investment actions. However, HERS does not compare resurfacing with reconstruction on a fully implemented LCCA basis. It does not consider the cost of delay to the user of improvement actions proposed, now or in the future. It does not compare a 20-year pavement design with a 40-year design. Should these elements be considered at the national level? If so, would the national analysis be making a false assumption about what the States will do in their stewardship of the highway systems? Would such analytical capabilities be useful and informative at the national level?

Productivity

It is the conventional wisdom, at least among highway advocates, that improvements in the highway systems positively affect the productivity and economy of the nation. A healthy transportation system is important to the manufacturing and service industries of the nation, as well as to personal users. It is not trivial to measure the effects of the highway systems, or improvements to the system, on the economy. It is not trivial to determine the effect of highway improvements on the economy of the nation. Do currently available tools, such as HERS, adequately consider the costs of industrial users of highways? HERS does consider user costs in its decision process, but is it skewed toward the private automobile user? While the value of time for trucks is calculated differently from passenger cars, is that sufficient to adequately address the full costs and benefits to the industrial user? How can recent or future research improve the analysis to better address the effects on industry and the economy?

A number of highway routes in this country are considered trade corridors, because of their importance to international trade. Many of them connect to international borders or to major ports. If we as a nation wish to give prominence to international trade, we need to know whether these corridors are adequate to accommodate this trade. Do we know the conditions of highways that accommodate border trade flows? What is the strength of the pavement on these facilities? What is the capacity of these facilities, and are they adequate to accommodate the expected loads travel? Are we providing adequate service at our international border crossings to facilitate trade? Should we evaluate these corridors separately from the rest of the highway system to determine the condition of these facilities relative to the condition of similar facilities nationwide?

Human and Natural Environment

The environment is important to all of us, indeed to life on this planet. Improvements to transportation systems must acknowledge this importance and tread softly where environmental concerns are high. But how can the environmental concerns be addressed in a national level analysis of highway conditions and performance, and capital investment? While it is routine for an assessment to be made of pavement conditions nationwide, how is it possible to make a similar assessment of the effects of highways or highway construction on the environment? For example, can wetland mitigation be addressed? Most environmental concerns are addressed at the local level. A highway project may be altered or canceled to address environmental concerns. Increased use of transit may reduce the negative impact of highways on the environment. How can these types of actions be subsumed in a national analysis of highway investment strategies? Can a national analytical process be used to address these environmental costs or trade-offs?

The HERS does have the capability to recognize vehicle emissions and to estimate at the national level the costs to the populace of these emissions. Since this is a nationwide analysis, it does not delve into the local situation, but makes general assumptions and applies them nationwide, segmented only by rural/urban location and by highway type. Is there any reason to attempt to develop a more local approach for national analysis?

National Security

This report does not attempt to address conditions, performance, or investment requirements separately for those highways of particular importance to the military, such as the strategic highway network (STRAHNET). Since all public roads eligible for Federal-aid highway funds are represented in the report, such highways are covered in their respective functional system analysis. Is this coverage sufficient, or can the FHWA better address national security in our national analysis of the highway systems? STRAHNET routes are identified in the HPMS database, but the sampling for this database does not use STRAHNET as basis for sampling. There is a FHWA/Military Traffic Management Command (MTMC) working group that meets periodically to address military interest in the highway system. Is there a national analysis that would better serve the goals of this group? Are the pavement and bridge data adequate for DOD purposes? Does the C&P report need to have a specific focus on military requirements?

Conclusion

The purpose of this chapter is to raise certain issues regarding the analysis of our highway and transit systems, and the results of these analyses as reported in the biennial Conditions and Performance Report. If sufficient importance is attached to further analyses, beyond the scope supported by available data and the capabilities of the current models, additional resources would need to be applied. This chapter does not promise a resolution to these issues, either now or in the future. Some of these issues may be faced for a number of years, as efforts are made toward obtaining more comprehensive data and more capable analytical tools. If raising these issues results in a broader discussion of the problems, with a view toward eventual improved analysis and reporting, the purpose will have been achieved.

APPENDIX A

Interstate Needs

Introduction

This edition of the C&P report includes the results of a study on Interstate Needs required by Section 1107(c) of the Transportation Equity Act for the 21^{st} Century (TEA-21). The three required elements of the study contained in this Appendix are: First, to determine the expected condition of the Interstate System over the next 10 years and the needs of States and Metropolitan Planning Organizations to reconstruct and improve the Interstate System; second, to determine the resources necessary to maintain and improve the Interstate System; and third, to determine the means to ensure that the Nation's surface transportation program can address the needs identified in this Appendix, and to allow for States to address any extraordinary needs.

This appendix begins with a brief description of the current conditions and performance of Interstate Highways and Bridges based on 1997 data. This is followed by a discussion of the analytical processes used to project expected Interstate conditions in 2007. Rural and Urban Interstate Highways are examined separately, to show the impact that different levels of highway reconstruction and 3R (restoration, rehabilitation, and resurfacing) would have on average pavement roughness, and on the miles of pavement in poor condition. The analysis then expands to also consider the impact of widening improvements, and evaluates the impacts that different levels of investment would have on both Interstate pavement condition and operational performance. An analysis of Rural and Urban Interstate Bridges identifies the level of investment for bridge replacement and bridge rehabilitation required to maintain and improve bridge conditions. This section of the report concludes by combining the results of the highway and bridge analyses.

The third section of this appendix identifies the resources needed to Maintain and Improve the Interstate System over the next 10 years, and compares these needs with projected spending levels from 1998 through 2007. This is followed by an analysis examining how the structure and funding levels for the components of the Federal-aid Highway Program align with Interstate System needs.

Background

The Dwight D. Eisenhower System of Interstate and Defense highways, from its inception to its fulfillment as the foundation for the national Highway system, has more than achieved its founders' expectations. It has provided a rapid and efficient means of travel to the American public, allowed the growth of a highly efficient trucking industry, and formed a transport infrastructure foundation for the nation's economic growth and development.

It has been more than 40 years since the establishment of the Highway Trust Fund for financing of the nation's highways, in particular the Interstate system. What better time to look at the condition and performance of this system, the core of the more recently enacted National Highway System. It is also a good time to look at the investment requirements to maintain and improve this system.

The Interstate system has served its purposes well. In many instances, anticipated usage levels of the system were reached as much as a decade earlier than expected by the planners. America's reliance on the Interstate system creates major challenges for transportation agencies. The system has provided a reliable basis for long distance surface movement and has been fully integrated into the freight logistics of major producers and suppliers. Consequently, the reliability of the system and the preservation of its physical assets are key policy and programmatic concerns for the entire transportation community.

For long- and medium-distance travel by automobile and for freight movement by truck, the system is aiding the mobility and productivity of the nation. In spite of congestion in the larger metropolitan areas, travel on the Interstate system is usually faster than on the alternative street systems.

Much of the pavement on the Interstate system was constructed 20 to 40 years ago. However, some highways with even older pavements—mostly in the Northeast—were incorporated into the system to provide logical connectivity without increasing the cost of the system for highway users. Some of the pavements have been completely reconstructed over the years. Some are still fairly new. Some have been resurfaced one or more times. Most have undergone some form of rehabilitation, restoration, resurfacing, or reconstruction since the original construction.

Interstate pavement condition and congestion data used in this study are taken from the Highway Performance Monitoring System (HPMS), a database that has been in place since 1978. The States furnish data annually for all of the Interstate and other arterial systems and most of the collector roads. This is a sample section database that provides a statistically valid sample of each of the categories of highway in the data system. More that half of all Interstate mileage is included in the sample sections. Thus, the Interstate is well represented in the HPMS database.

The National Bridge Inventory (NBI) contains data for each public road bridge in the nation. This database is updated on a continuing basis by the States. Most bridges are inspected every two years, and the data from these inspections are reported to the Federal Highway Administration and incorporated into the NBI. Deficient bridges are classified as structurally deficient or functionally obsolete. A structurally deficient bridge is one that has been restricted to light vehicles (no heavy trucks), one that requires immediate rehabilitation to remain open, or is closed. A functionally obsolete bridge has 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, in this case the Interstate system.

For many years congestion has been a growing problem on urban Interstates and on Interstate routes approaching and connecting major metropolitan areas. However, congestion is difficult to measure. Historically the ratio of the volume of traffic to the capacity of the roadway to accommodate that volume has been used as a measure of the severity of congestion. This measure addresses only the peak hour of travel. Delay to the user of the system is now being used in an effort to measure the effects of congestion throughout the day. However, it is difficult to measure delay. The current procedures are based on modeling of speed and delay, and are subject to revisions in the future. Other measures, such as reliability, have been proposed. Reliability is the consistency of the travel time between any two points. This is also difficult to measure, and is not included in this report. The volume of travel per lane, such as VMT per lane-mile, is a measure of the density of travel and is information that is readily available. While it is not directly a measure of congestion, it does provide a valuable indication of travel density on the system.

This study evaluates current conditions and performance of the Interstate system roadways and bridges, and analyzes these data to project the investment requirements for the next 10 years to maintain and improve the system.

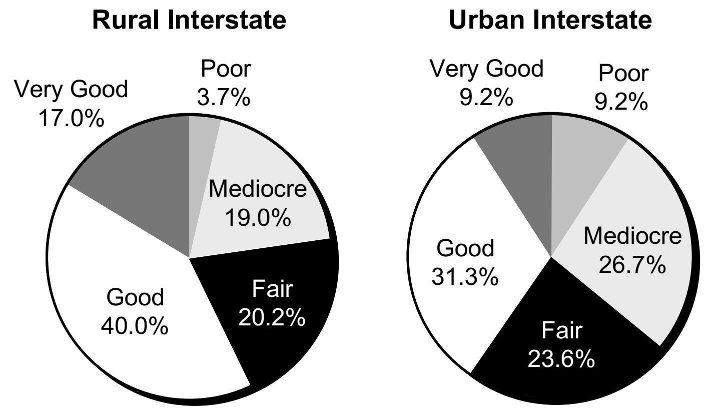
Highway Conditions

Chapter 3 discusses the current highway and bridge conditions for all functional systems, including Interstate highways. Exhibits 3-9 and 3-10 show trends in pavement condition for Rural Interstates and Urban Interstates from 1993 to 1997. The 1997 data are highlighted in Exhibit A-1.

In 1997, 96.3 percent of rural Interstate mileage met the *Federal Highway Administration 1998 National Strategic Plan* standard for "acceptable ride quality" having an International Roughness Index (IRI) value of less than or equal to 170 inches per mile. The remaining 3.7 percent of rural mileage is identified as having "poor" pavement in Exhibit A-1. Of urban Interstate mileage, 90.8 percent was classified as having "acceptable ride quality" and the remaining 9.2 percent is identified as "poor" pavement in Exhibit A-1. The percentage of Interstate pavement with acceptable ride quality has increased in recent years.

Exhibit A-1

Interstate Pavement Condition, by Percent Total Miles, 1997



Condition Term	Very Good	Good	Fair	Mediocre	Poor
IRI Rating (inches/mile)	<60	60 - 94	95 - 119	120 - 170	> 170

The average IRI reported for HPMS sample sections on rural Interstates was 93 inches per mile, which falls in the "good" range in Exhibit A-1. The average IRI for urban Interstate sections was 114, which would be classified as "fair."

Lane Widths, Curves, Grades, and Access Control

Chapter 3 also discusses other factors that affect the level of service and safety of the highway system. *[See Exhibits 3-14, 3-15, 3-17, and 3-18.]* Rural and Urban Interstate Lane Width are shown in Exhibit A-2. In 1997, 99.8 percent of rural interstate mileage had lane widths of 12 feet or wider. For urban Interstate mileage, 99.4 percent met or exceeded the 12 foot standard.

Exhibit A-2

Rural and Urban Interstate Lane Width, 1997

Rural Lane Width			Urban Lane Width		
10 foot	11 foot	12 foot+	10 foot	11 foot	12 foot+
0.0%	0.2%	99.8%	0.1%	0.5%	99.4%

Exhibit A-3 shows the horizontal and vertical alignment adequacy for rural Interstate highways. Of total rural Interstate highways mileage, 95.5 percent is rated as "Code 1" for horizontal alignment, meaning that all curves meet appropriate design standards. The remaining 4.5 percent are below design standards. For vertical alignment, 93.0 percent of rural Interstate mileage is rated as "Code 1," meaning that all grades meet appropriate design standards. The remaining 7.0 percent are below design standards.

Exhibit A-3

Rural Interstate Horizontal and Vertical Alignment, 1997

Rating	Horizontal Alignment	Vertical Alignment	Description
Code 1	95.5%	93.0%	All curves and grades meet appropriate design standards.
Code 2	2.4%	6.4%	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	0.7%	0.2%	Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits.
Code 4	1.4%	0.4%	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 speeds of the curves.

The vast majority of Interstate mileage consists of divided highways with at least four lanes and full access control. However, in 1997 there were 1,100 miles of rural interstate that did not meet this standard, concentrated mainly in Alaska. None of Alaska's 1,034 rural Interstate miles meet this criteria. For urban Interstates, 104 miles do not meet the criteria specified; 53 of these miles are in Puerto Rico.

Highway Operational Performance

Chapter 4 includes data for several operational performance indicators. *[See Exhibits 4-3, 4-5, 4-6, 4-7 and 4-9.]* Daily Vehicle Miles of Travel (DVMT) per Lane-Mile is a basic measure of traffic density. Since 1993, rural Interstate DVMT per Lane-Mile has increased an average annual rate of 3.4 percent per year, from 3,530 to 4,952. Over the same period, urban Interstate DVMT per Lane-Mile has grown at an average annual rate of 2.0 percent, from 11,230 to 13,696.

The Volume/Service Flow (V/SF) ratio measures the volume of traffic using a highway during the peak hour and the theoretical capacity of the highway to accommodate traffic. Sections with a V/SF ratio above 0.80 are traditionally considered to be congested. In 1997, 53.3 percent of urban Interstate highways had a V/C ratio greater than or equal to 0.80, up from 52.6 percent in 1993.

Delay is another calculated measure of operational performance. In 1997, average delay on rural Interstates was 2.313 hours per 1000 vehicle miles traveled (VMT). Delay has been increasing on rural Interstates in recent years. Average delay on Interstates in small urban areas was 0.496 hours per 1000 VMT. In urbanized areas under 200,000 in population, average delay per 1000 VMT on Interstates was 0.909 hours. In urbanized areas over 200,000 in population, delay was much higher, at 2.533 hours per 1000 VMT. Delay on urban interstates has fluctuated in recent years, but 1997 delay is smaller than delay calculated using 1993 data.

Bridge Conditions

Chapter 3 also discusses the bridge deficiencies for all functional systems, including Interstate highways. Exhibit 3-29 show trends for rural Interstates and urban Interstates from 1993 to 1997. The 1997 data are highlighted in Exhibit A-4.

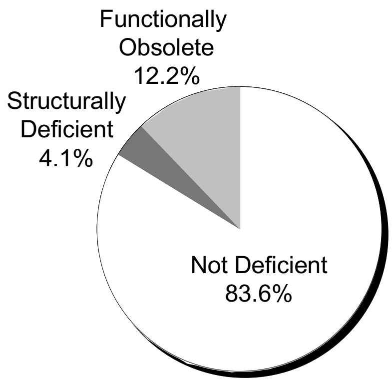
In 1998 there were 55,010 bridges on the Interstate Highway System. The number of rural and urban Interstate bridges is virtually equal, as approximately 50.0 percent of the total are in rural areas. Of the total number of rural Interstate bridges, 16.4 percent were classified as deficient, including 4.1 percent that were structurally deficient, and 12.2 percent that were functionally obsolete. In urban areas, 26.8 percent of Interstate bridges were deficient in 1998, including 6.7 percent classified as structurally deficient and 20.1 percent classified as functionally obsolete.

The percentage of deficient Interstate bridges has declined in recent years in both rural and urban areas, and for both structural and functional deficiencies. Since 1992, the number of deficient Interstate bridges has fallen from 13,725 to 11,880.

Exhibit A-4

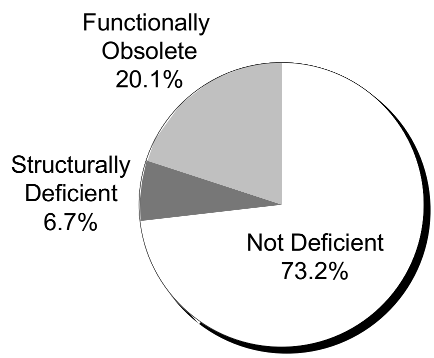
Interstate Bridge Condition, 1998

Rural Interstate



	Number	Percent
Rural Bridges	27,530	
Deficient Bridges	4,504	16.4%
Structural	1,135	4.1%
Functional	3,369	12.2%

Urban Interstate



	Number	Percent
Urban Bridges	27,480	
Deficient Bridges	7,376	26.8%
Structural	1,850	6.7%
Functional	5,526	20.1%

Projected Conditions and Performance in 2007

The future condition of the Interstate system is a function of several factors, including the current condition of the system, projected travel growth, and the level of future investment. This study uses current condition data, performance data, and travel growth projections from the Highway Performance Monitoring System (HPMS) database to predict what impact different levels of investment over the 10-year period from 1998 through 2007 would have on the Interstate system. Data from the National Bridge Inventory are used to project future Interstate Bridge conditions.

Since rural and urban Interstate data are available, and the characteristics of rural and urban Interstate routes are different, this study examines them separately. Investment requirements for highway preservation, bridge preservation and system expansion are separately identified, to facilitate more detailed analysis of physical conditions separate from operational performance. This section includes nine analyses of projected Interstate conditions and performance. The first examines the impact that different levels of investment for highway reconstruction and 3R (restoration, rehabilitation, and resurfacing) would be expected to have on rural Interstate pavement conditions. The second analysis adds widening improvements, and describes the combined effect that pavement improvements and widening improvements would be expected to have on the operational performance of rural Interstate highways. The third and fourth analyses contain comparable material for urban Interstate highways. The fifth and sixth analyses combine the earlier analyses, and examine rural/urban tradeoffs. The seventh and eighth analyses project future rural and urban bridge conditions. The ninth analysis combines the separate highway and bridge analyses and serves as the starting point for the identification of the resources required to maintain and improve the Interstate system, which is discussed in the next section.

Each separate analysis includes a table and chart showing the potential impacts of a range of different investment levels. Each table identifies the effects of continuing to invest at 1997 levels in constant dollar terms over the next 10 years, and the investment required to achieve certain performance targets. Since highway capital spending is expected to grow in constant dollar terms as TEA-21 is implemented, this section includes a simple forecast of 10-year funding levels, which is referenced in each of the analyses of future conditions and performance.

The highway condition and performance forecasts utilize the Highway Economic Requirements System (HERS), while the bridge analysis is based on the Bridge Needs and Investment Process (BNIP). These models were generally utilized in this analysis in the same manner as was used to develop the investment requirements in Chapter 7. There are differences in the results however, since Chapter 7 presents average annual values for a 20-year analysis, while this study is based on a 10-year analysis. Note that all dollar values cited in this section are stated in constant 1997 dollars.

Projected 10-Year Funding Levels for Interstate Highways and Bridges

Chapter 8 contained a projection of constant dollar highway capital spending by all levels of government for 1998-2003. This study extended this projection out to 2007 using the same basic methodology. **Note that Federal funding levels can not be accurately predicted beyond 2003, the final year covered by TEA-21.** For the purposes of this analysis, a simplifying assumption was made that Federal-aid highway obligations after 2003 would increase to keep pace with inflation, remaining at the same level as in 2003 in constant dollar terms. State and local spending was projected to increase approximately 2.8 to 3.0 percent annually in constant dollar terms from 2003 to 2007. Based on these assumptions, total highway capital expenditures by all levels of government for all functional systems for the 10 years from 1998 to 2007 were projected to be $555.7 billion stated in constant 1997 dollars.

Current Expenditure Patterns

All levels of government spent $11.0 billion for capital improvements to Interstate highways and bridges in 1997, which constituted 22.6 percent of the $48.7 billion of capital outlay on all functional classes. Exhibit A-5 breaks down this total by type of improvement. Only the $8.4 billion expended for the preservation and widening of existing Interstate highways and bridges corresponds to the analyses included in this section. Expenditures for new construction and for system enhancements (including traffic operational improvements, safety improvements and environmental enhancements) are not modeled by HERS or BNIP, and are not discussed in this section.

Exhibit A-5

Interstate Capital Expenditures, 1997

	Total Invested (Billions of Dollars)			Percent of Total	Percent of Total for all Functional Classes		
	Rural	Urban	Total	Interstate	Rural	Urban	Total
Highway/Bridge Preservation & Widening							
Work on Existing Highways							
Highway Preservation	1.6	2.5	4.0	36.7%	3.2%	5.1%	8.3%
Widening	0.6	2.1	2.6	23.9%	1.2%	4.2%	5.4%
Subtotal, Existing Highways	2.1	4.5	6.7	60.6%	4.4%	9.3%	13.7%
Bridge Work	0.4	1.3	1.7	15.6%	0.8%	2.7%	3.5%
Subtotal Work on Existing Highways & Bridges	**2.5**	**5.9**	**8.4**	**76.3%**	**5.2%**	**12.0%**	**17.2%**
New Construction	0.4	1.2	1.6	14.4%	0.7%	2.5%	3.3%
System Enhancements	0.3	0.7	1.0	9.3%	0.6%	1.5%	2.1%
Total Investment	**3.2**	**7.8**	**11.0**	**100.0%**	**6.5%**	**16.0%**	**22.6%**

Projected Interstate Funding

Exhibit A-6 applies the percentages from Exhibit A-5 to the $555.7 billion projected spending level on all functional classes. Assuming the 1997 pattern of expenditures remains unchanged, and expenditures grow at the rate predicted, approximately $126.0 billion would be used for capital improvements to Interstate highways and bridges over the 10-year period 1998 through 2007.

Exhibit A-6

Projected 10-Year Capital Expenditures on Interstates

	1997 Percent of Total for all Functional Classes			Projected 10-Year Spending (Billions of 1997 Dollars)		
	Rural	Urban	Total	Rural	Urban	Total
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	3.2%	5.1%	8.3%	17.8	28.4	46.2
Widening	1.2%	4.2%	5.4%	6.6	23.5	30.1
Subtotal, Existing Highways	4.4%	9.3%	13.7%	24.4	51.9	76.4
Bridge Work	0.8%	2.7%	3.5%	4.6	15.2	19.7
Subtotal Work on Existing Highways & Bridges	**5.2%**	**12.0%**	**17.2%**	**29.0**	**67.1**	**96.1**
New Construction	0.7%	2.5%	3.3%	4.2	14.0	18.2
System Enhancements	0.6%	1.5%	2.1%	3.3	8.4	11.7
Total Investment	**6.5%**	**16.0%**	**22.6%**	**36.5**	**89.5**	**126.0**

Expected Rural Interstate Pavement Condition in 2007

Exhibit A-7 shows the impact that different levels of highway reconstruction and 3R investment would have on average rural interstate IRI. Note that all dollar values cited in this analysis are stated in constant 1997 dollars.

As indicated in Exhibit A-5, in 1997, all levels of government spent approximately $1.6 billion for rural Interstate roadway preservation. If this type of investment grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998-2007 period would be $15.5 billion. As shown in Exhibit A-7, at this level of investment, average IRI would be expected to worsen by 23.7 percent, increasing from 93 to 115 inches per mile. This would represent a shift in average pavement condition from "good" to "fair," using the verbal descriptions shown in Exhibit A-1. Note that the average IRI values shown in Exhibit A-7 and in subsequent exhibits are weighted by VMT rather than by mileage. This approach emphasizes the impact that pavement conditions have on highway users, who bear the costs of driving on poor pavement, rather than on highway agencies, who bear the costs of repairing poor pavement. The current average IRI of 93 represents the pavement roughness that the average vehicle traveling on rural Interstate highways experiences. If current levels of investment are maintained in constant dollar terms, the percent of VMT occurring on roads with an IRI greater than or equal to 122 would increase from 18.9 percent to 37.9 percent.

As shown in Exhibit A-7, system preservation investment on rural Interstates would need to reach $21.2 billion over 10 years in order to maintain average IRI at 93 inches per mile. To prevent an increase in the percentage of VMT on roads with an IRI greater than or equal to 122 would require a cumulative investment from 1998 through 2007 of $20.2 billion. The $25.0 billion on the first line of the table represents the maximum amount that could be economically invested for rural Interstate system preservation.

Projected Pavement Conditions at Forecast Funding Levels for 1998-2007

As indicated earlier, this study projects that highway capital outlay on all functional systems will total $557.5 billion (1997 dollars) for the 10-year period from 1998 through 2007. In 1997, 3.2 percent of total highway capital outlay by all

Q. **How does the projected split between reconstruction and 3R compare with current spending patterns on rural Interstates?**

A. In 1997, 11 percent of rural Interstate highway system preservation spending went for reconstruction. The pattern of investment derived from HERS shown in Exhibit A-7 suggests that if current spending levels are maintained for 10 years, only 5 percent will be needed for reconstruction. The exhibit also shows that at higher levels of investment, less reconstruction would be needed, presumably because performing needed 3R work in a timely fashion reduces the need for major reconstruction.

Part of the difference between the values shown in Exhibit A-7 and current spending data provided by States may be the result of differences in the way States distinguish between reconstruction and 3R, versus the approach HERS uses.

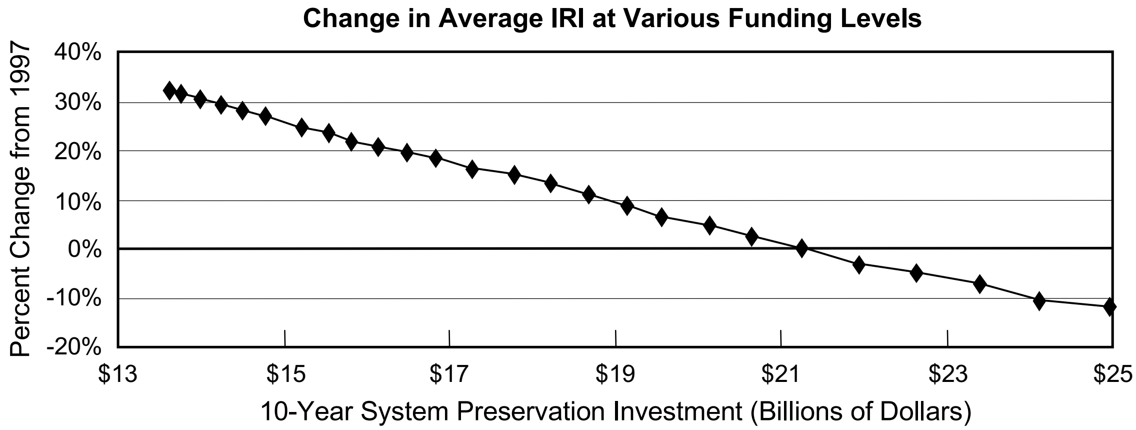
Q. **Does the IRI threshold of 122 shown in Exhibit A-7 have any special significance?**

A. No. As part of its internal calculations, HERS utilizes a PSR threshold value roughly equivalent to an IRI of 122 and shows the percentage of pavement that does not meet this threshold as part of its standard output. However, this value has no special significance in terms of the verbal descriptions of pavement shown in Exhibit A-1. This threshold includes all of the pavement identified as "poor" in Exhibit A-1 and most of the pavement identified as "mediocre".

This percentage was included in Exhibit A-7 to show the impacts of various levels of investment on one end of the IRI scale, and provide a broader perspective than could be obtained by looking at average IRI alone.

Exhibit A-7

Projected Rural Interstate Pavement Condition in 2007, for Different Possible Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI (Weighted by VMT)		Percent of VMT on Roads with IRI>=122		Funding Level Description: Investment Required to Maintain…
Total	Recon-struction	3R	IRI in Inches per Mile	Percent Change from 1997	Percent	Change from 1997	
25.0	0.5	24.4	82	-11.8%	1.8%	-18.6%	
24.1	0.6	23.5	83	-10.8%	3.3%	-17.1%	
23.4	0.6	22.8	86	-7.5%	5.7%	-14.8%	
22.6	0.7	22.0	88	-5.4%	8.2%	-12.2%	
21.9	0.7	21.3	90	-3.2%	10.7%	-9.8%	
21.2	0.6	20.6	93	**0.0%**	13.9%	-6.6%	...Average IRI
20.7	0.7	20.0	95	2.2%	16.5%	-4.0%	
20.2	0.7	19.4	97	4.3%	18.9%	**-1.6%**	…VMT with IRI>=122
19.6	0.7	18.8	99	6.5%	21.4%	0.9%	
19.1	0.7	18.4	101	8.6%	23.6%	3.1%	
18.7	0.7	18.0	103	10.8%	25.1%	4.6%	
18.2	0.7	17.5	105	12.9%	27.7%	7.3%	
17.8	0.7	17.1	107	15.1%	29.9%	9.4%	
17.3	0.7	16.6	108	16.1%	31.4%	10.9%	
16.8	0.7	16.1	110	18.3%	32.7%	12.3%	
16.5	0.7	15.8	111	19.4%	33.9%	13.5%	
16.1	0.7	15.5	112	20.4%	35.3%	14.8%	
15.8	0.6	15.2	113	21.5%	36.7%	16.2%	
15.5	0.7	14.9	115	23.7%	37.9%	17.5%	…Spending at 1997 Level
15.2	0.7	14.5	116	24.7%	39.6%	19.1%	
14.8	0.7	14.1	118	26.9%	41.0%	20.5%	
14.5	0.7	13.8	119	28.0%	42.1%	21.6%	
14.2	0.7	13.5	120	29.0%	43.7%	23.2%	
14.0	0.8	13.2	121	30.1%	45.1%	24.6%	
13.8	0.8	13.0	122	31.2%	46.0%	25.6%	
13.6	0.8	12.8	123	32.3%	46.7%	26.3%	
			93		20.5%		1997 Values

levels of government was used for system preservation on rural Interstates. If this percentage is maintained in the future, approximately $17.8 billion would be spent for rural interstate system over the next 10 years, as shown in Exhibit A-6. Based on Exhibit A-7, this level of investment would be expected to result in average IRI increasing (worsening) by 15.1 percent from 93 to 107 inches per mile, moving from the "good" to the "fair" range. The percent of VMT on roads with IRI>122 would be expected to increase to 29.9 percent. Note that the projections of 10-year capital outlay by all levels of government are based on certain simplifying assumptions about future Federal, State and local funding patterns. Federal funding beyond 2003 has yet to be determined.

Expected Rural Interstate Pavement Condition and Performance in 2007

Exhibit A-8 combines the investment requirements shown for system preservation in Exhibit A-7 with widening improvements that have a comparable rate of return according to the benefit-cost analysis performed by HERS. The second and fourth columns in Exhibit A-8, showing preservation investment and percent change in average IRI respectively, duplicate information provided in the first and fifth column of Exhibit A-7 and are included as reference points to relate the two analyses together. All values shown in this analysis are stated in constant 1997 dollars.

Exhibit A-5 shows that in addition to the $1.6 billion spent by all levels of government on rural Interstate system preservation in 1997, another $0.6 billion was used for widening existing Interstate routes. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $21.4 (stated in 1997 dollars). Exhibit A-8 does not have a row that exactly corresponds to this level of investment. The closest one is for $21.8 billion.

Effects of Investing at 1997 Spending Levels

If highway investment for the 10-year period though 2007 remains constant at 1997 levels, HERS would recommend a change in the distribution of funding between system preservation and widening. Reading across the "$21.8 billion" row in Exhibit A-8, shows that if a cumulative $21.8 billion were invested on existing rural Interstates over 10 years, the HERS analysis recommends that $19.6 billion be invested in system preservation improvements, and $2.3 billion be invested in additional lanes. However, if 1997 spending patterns were continued for 10 years, only $15.5 billion would be invested in system preservation improvements, and $6.3 billion would be invested in adding lanes. In Exhibit A-8, the row containing widening spending of $6.3 billion is much higher on the table than the row containing preservation spending of $15.5 billion. The implication of this difference is that current rural Interstate spending patterns do a much better job addressing investment requirements for widening than investment requirements for pavement, and that a greater share of future increases in funding should be directed towards system preservation. (Note that the system preservation figures cited above would include reconstruction or resurfacing of existing lanes of an Interstate route that was done in conjunction with a widening improvement.)

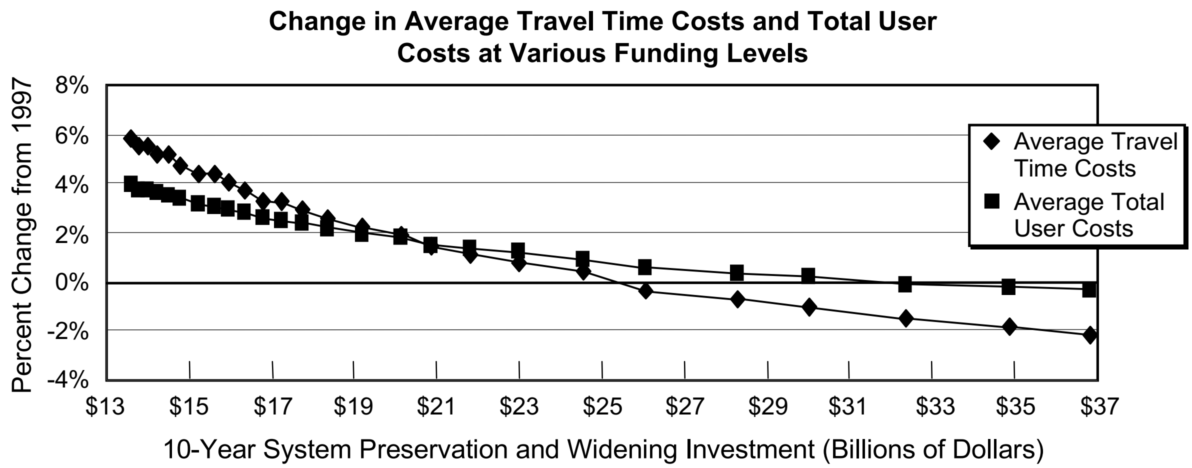
Assuming the $21.8 billion were invested in the manner recommended by HERS, average IRI would be expected to increase by 6.5 percent by 2007. Average travel time costs per VMT would rise 1.1 percent, and average total user costs would rise 1.3 percent. The percentage of VMT occurring on rural Interstate routes with a (V/SF) ratio greater than or equal to 0.80 would be expected to increase from 12.5 percent in 1997 to 23.3 percent in 2007.

Q. **Does the V/SF ratio threshold of 0.80 shown in Exhibit A-8 have any special significance?**

A. Yes. At V/SF ratios above 0.80, travelers on the road experience significant interference with free travel flow. This is the traditional cut-off point used in the C&P report to describe congestion.

Exhibit A-8

Projected Rural Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997			Percent of VMT on Roads with V/SF>=0.80		
Total	Preser-vation	Widening	Average IRI	Average Travel Time Costs	Average Total User Costs	%	Change from 1997	Funding Level Description: Investment Required to Maintain…
36.8	25.0	11.8	-11.8%	-2.2%	-0.4%	13.5%	3.1%	
34.9	24.1	10.7	-10.8%	-1.8%	-0.3%	14.1%	3.7%	
32.4	23.4	9.0	-7.5%	-1.5%	**-0.1%**	16.0%	5.6%	...Total User Costs
30.0	22.6	7.4	-5.4%	-1.1%	0.1%	17.4%	7.0%	
28.3	21.9	**6.3**	-3.2%	-0.7%	0.3%	18.5%	8.2%	…Widening at 1997 Level
26.1	21.2	4.8	**0.0%**	**-0.4%**	0.6%	20.5%	10.1%	…IRI & Travel Time Costs
24.6	20.7	3.9	2.2%	0.4%	0.9%	21.8%	11.4%	
23.0	20.2	2.8	4.3%	0.7%	1.2%	23.0%	12.7%	
21.8	19.6	2.3	6.5%	1.1%	1.3%	23.3%	13.0%	…Spending at 1997 Level
20.9	19.1	1.7	8.6%	1.5%	1.4%	23.7%	13.3%	
20.2	18.7	1.5	10.8%	1.8%	1.7%	24.0%	13.6%	
19.2	18.2	1.0	12.9%	2.2%	1.9%	24.7%	14.3%	
18.4	17.8	0.6	15.1%	2.6%	2.2%	25.0%	14.6%	
17.7	17.3	0.4	16.1%	2.9%	2.3%	25.1%	14.7%	
17.3	16.8	0.4	18.3%	3.3%	2.4%	25.3%	14.9%	
16.8	16.5	0.3	19.4%	3.3%	2.6%	25.6%	15.2%	
16.4	16.1	0.2	20.4%	3.7%	2.7%	25.6%	15.2%	
15.9	15.8	0.1	21.5%	4.0%	2.9%	25.7%	15.3%	
15.6	**15.5**	0.1	23.7%	4.4%	3.0%	25.8%	15.4%	…Preservation at 1997 Level
15.2	15.2	0.0	24.7%	4.4%	3.2%	26.0%	15.6%	
14.8	14.8	0.0	26.9%	4.8%	3.3%	26.5%	16.1%	
14.5	14.5	0.0	28.0%	5.1%	3.5%	26.4%	16.0%	
14.2	14.2	0.0	29.0%	5.1%	3.6%	26.3%	15.9%	
14.0	14.0	0.0	30.1%	5.5%	3.7%	26.2%	15.8%	
13.8	13.8	0.0	31.2%	5.5%	3.7%	26.2%	15.8%	
13.6	13.6	0.0	32.3%	5.9%	3.9%	26.2%	15.8%	
						12.5%		1997 Percentage

Investment Required to Achieve Certain Performance Targets

As shown in Exhibit A-8, combined system preservation and widening investment on rural Interstates would need to reach $26.1 billion over 10 years in order to maintain average IRI at 93 inches per mile. Coincidentally, this same level of investment would also be expected to keep average travel time costs from increasing. To prevent average total user costs (including travel time costs, vehicle operating costs, and crash costs) from increasing would require a cumulative investment from 1998–2007 of $32.4 billion. Since the slope of the total user costs line in the graph in Exhibit A-8 is flatter than the slope of the travel time costs line, this implies that on rural Interstates, vehicle operating costs and crash costs are less sensitive to changes in the level of investment than travel time costs are.

The $36.8 billion shown on the top row of Exhibit A-8 represents the maximum amount that could be economically invested for rural Interstate system preservation and widening. Even at this level of investment the percentage of rural Interstate VMT on routes with a V/SF ratio greater than or equal to 0.80 would still increase. This implies that it is not economically efficient to try to address rural congestion problems through the widening of existing routes alone.

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, 4.4 percent of total highway capital outlay by all levels of government in 1997 was used for system preservation or widening of existing rural Interstate routes. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $24.4 billion would be spent for rural interstate system preservation or widening over the next 10 years. Exhibit A-8 does not have a row that exactly corresponds to this level of investment. The closest one is for $24.6 billion.

This level of investment would be expected to result in average IRI increasing (worsening) by 2.2 percent. In constant dollar terms, average travel time costs would be expected to increase by 0.4 percent while average total user costs would increase by 0.9 percent over 1997 levels. The percent of VMT on roads with a V/SF ratio greater than or equal to 0.80 would increase to 21.8 percent.

Expected Urban Interstate Pavement Condition in 2007

Exhibit A-9 is the urban Interstate equivalent of Exhibit A-7. Exhibit A-9 shows the impact that different levels of highway reconstruction and 3R investment would have on urban interstate IRI. All values cited in this analysis are stated in constant 1997 dollars.

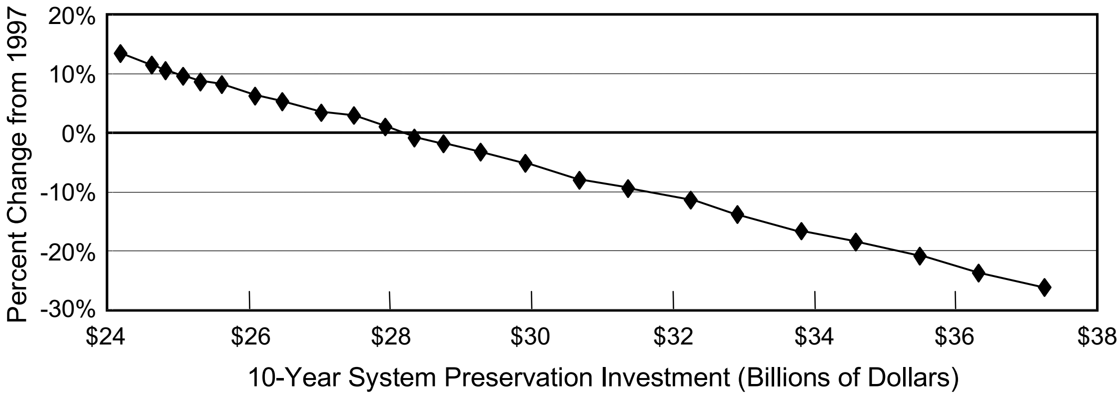
Exhibit A-5 shows that in 1997, all levels of government spent approximately $2.5 billion for urban Interstate roadway preservation. If this type of investment grows at the rate of inflation over the next 10 years, cumulative investment for the 1998-2007 period would be $24.8 billion (stated in 1997 dollars). Exhibit A-9 shows that at this level of investment, average IRI would be expected to increase (worsen) by 10.5 percent, increasing from 114 to 126 inches per mile. This would represent a shift in average pavement condition from "fair" to "mediocre," using the verbal descriptions shown in Exhibit A-1. If

> ***Q.*** **How does the projected split between reconstruction and 3R compare with current spending patterns on urban Interstates?**
>
> ***A.*** In 1997, 29 percent of urban Interstate highway system preservation spending went for reconstruction. The pattern of investment derived from HERS shown in Exhibit A-9 suggests that if current spending levels are maintained for 10 years, 33 percent will be needed for reconstruction.

Exhibit A-9

Projected Urban Interstate Pavement Condition in 2007, for Different Possible Funding Levels

Change in Average IRI at Various Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI (Weighted by VMT)		Percent of VMT on Roads with IRI>=101		Funding Level Description: Investment Required to Maintain…
Total	Recon-struction	3R	IRI in Inches per Mile	Percent Change from 1997	Percent	Change from 1997	
37.3	8.4	28.9	84	-26.3%	14.1%	-40.4%	
36.3	8.4	27.9	87	-23.7%	17.7%	-36.9%	
35.5	8.4	27.1	90	-21.1%	21.0%	-33.6%	
34.6	8.5	26.1	93	-18.4%	24.1%	-30.4%	
33.8	8.5	25.3	95	-16.7%	26.0%	-28.5%	
32.9	8.4	24.5	98	-14.0%	28.9%	-25.7%	
32.2	8.5	23.7	101	-11.4%	31.4%	-23.2%	
31.4	8.5	22.9	103	-9.6%	34.3%	-20.3%	
30.7	8.4	22.2	105	-7.9%	36.6%	-18.0%	
29.9	8.3	21.6	108	-5.3%	39.3%	-15.3%	
29.3	8.4	20.9	110	-3.5%	41.0%	-13.5%	
28.8	8.3	20.4	112	-1.8%	43.5%	-11.1%	
28.4	8.5	19.9	113	**-0.9%**	45.5%	-9.1%	...Average IRI
27.9	8.5	19.4	115	**0.9%**	47.2%	-7.3%	
27.5	8.4	19.1	117	2.6%	48.8%	-5.7%	
27.0	8.3	18.7	118	3.5%	50.3%	-4.3%	
26.5	8.3	18.2	120	5.3%	52.1%	-2.4%	
26.1	8.2	17.8	121	6.1%	53.4%	-1.1%	
25.6	8.1	17.5	123	7.9%	54.5%	**-0.1%**	…VMT with IRI>=101
25.3	8.1	17.2	124	8.8%	55.5%	1.0%	
25.1	8.2	16.9	125	9.6%	56.4%	1.9%	
24.8	8.2	16.6	126	10.5%	57.0%	2.4%	…Spending at 1997 Level
24.6	8.3	16.4	127	11.4%	57.6%	3.0%	
24.2	8.2	16.0	129	13.2%	59.0%	4.4%	
23.8	8.1	15.8	130	14.0%	59.8%	5.3%	
23.5	8.1	15.4	131	14.9%	61.3%	6.7%	
			114		54.6%		1997 Values

current levels of investment are maintained in constant dollar terms, the percent of VMT occurring on roads with an IRI greater than or equal to 101 would increase from 54.6 percent to 57.0 percent.

> ***Q.*** **Does the IRI threshold of 101 shown in Exhibit A-9 have any special significance?**
>
> ***A.*** No. As part of its internal calculations, HERS utilizes a PSR threshold value roughly equivalent to an IRI of 101 and shows the percentage of pavement that does not meet this threshold as part of its standard output. However, this value has no special significance in terms of the verbal descriptions of pavement shown in Exhibit A-1. This threshold includes all of the pavement identified as "poor" and "mediocre" in Exhibit A-1 and much of the pavement identified as "fair".

Exhibit A-9 shows that system preservation investment on urban Interstates would need to reach between \$27.9 billion and \$28.4 billion over 10 years in order to maintain average IRI at 114 inches per mile. To prevent an increase in the percentage of VMT on roads with an IRI greater than or equal to 101 would require a cumulative investment from 1998 to 2007 of \$25.6 billion. The \$37.3 billion on the first line of the table represents the maximum amount that could be economically invested for urban Interstate system preservation.

Projected Pavement Conditions at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, highway capital outlay on all functional systems is projected to total \$557.5 billion (1997 dollars) for the 10-year period from 1998 to 2007, based on certain assumptions made about future Federal, State and local funding. In 1997, 5.1 percent of total highway capital outlay by all levels of government was used for system preservation on urban Interstates. If this percentage is maintained in the future, approximately \$28.4 billion will be spent for urban interstate system over the next 10 years. Exhibit A-9, shows that this level of investment would be expected to result in average IRI improving by 0.9 percent, declining from 114 to 113 inches per mile. The percent of VMT on roads with IRI>101 would decline from 54.6 percent to 45.5 percent.

Expected Urban Interstate Pavement Condition and Performance in 2007

Exhibit A-10 combines the investment requirements shown for system preservation in Exhibit A-9 with widening improvements that have a comparable rate of return according to the benefit-cost analysis performed by HERS. The columns in Exhibit A-10 showing preservation investment and percent change in average IRI duplicate information provided in Exhibit A-9, and are included as reference points to relate the two analyses together. All values shown in this analysis are stated in constant 1997 dollars.

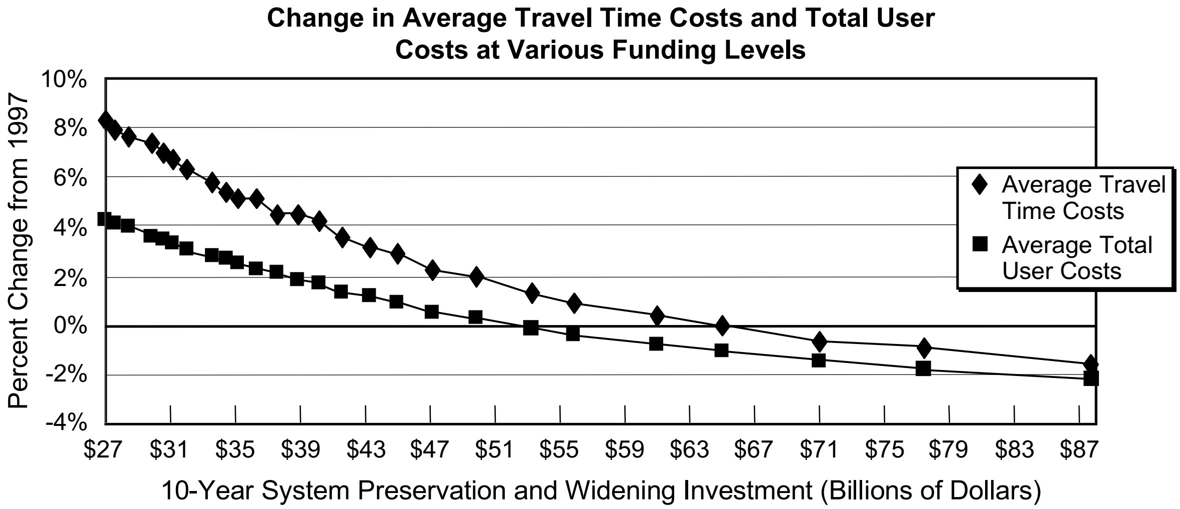
As shown in Exhibit A-5, in addition to the \$2.5 billion spent by all levels of government on urban Interstate system preservation in 1997, \$2.1 billion was used for widening existing Interstate routes. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately \$45.4 (stated in 1997 dollars). Exhibit A-10 does not have a row that exactly corresponds to this level of investment. The closest one is for \$45.0 billion.

Effects of Investing at 1997 Spending Levels

If highway investment for the 10-year period though 2007 remains constant at 1997 levels, HERS would recommend a change in the distribution of funding between system preservation and widening. Reading across the "\$45.0 billion" row in Exhibit A-10, shows that if a cumulative \$45.0 billion were to be invested on existing urban Interstates over 10 years, the HERS analysis recommends that

Exhibit A-10

Projected Urban Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997			Percent of VMT on Roads with V/SF>=0.95		Funding Level Description: Investment Required to Maintain…
Total	Preser-vation	Widening	Average IRI	Average Travel Time Costs	Average Total User Costs	Percent	Change from 1997	
87.7	37.3	50.5	-26.3%	-1.6%	-2.2%	29.9%	**-0.4%**	…% VMT with V/C>=0.95
77.4	36.3	41.0	-23.7%	-1.0%	-1.8%	32.8%	2.5%	
71.0	35.5	35.5	-21.1%	-0.6%	-1.4%	35.0%	4.7%	…Total User Costs
65.0	34.6	30.4	-18.4%	**0.0%**	-1.1%	36.9%	6.6%	…Average Travel Time Costs
61.0	33.8	27.2	-16.7%	0.3%	-0.8%	38.1%	7.8%	
55.8	32.9	22.9	-14.0%	1.0%	-0.4%	39.8%	9.5%	
53.2	32.2	**21.0**	-11.4%	1.3%	**-0.1%**	40.7%	10.5%	...User Costs & 97 Widening $
49.9	31.4	18.5	-9.6%	1.9%	0.3%	41.9%	11.6%	
47.1	30.7	16.4	-7.9%	2.2%	0.5%	42.8%	12.5%	
45.0	29.9	15.1	-5.3%	2.9%	0.9%	43.4%	13.1%	…1997 Total Spending
43.2	29.3	14.0	-3.5%	3.2%	1.2%	43.8%	13.6%	
41.6	28.8	12.8	-1.8%	3.5%	1.3%	44.6%	14.3%	
40.1	28.4	11.8	**-0.9%**	4.1%	1.7%	45.1%	14.8%	...Average IRI
38.8	27.9	10.9	**0.9%**	4.4%	1.8%	45.7%	15.4%	
37.5	27.5	10.0	2.6%	4.4%	2.1%	45.3%	15.0%	
36.3	27.0	9.3	3.5%	5.1%	2.2%	45.6%	15.3%	
35.1	26.5	8.6	5.3%	5.1%	2.5%	45.4%	15.1%	
34.5	26.1	8.4	6.1%	5.4%	2.6%	45.4%	15.1%	
33.6	25.6	8.0	7.9%	5.7%	2.8%	45.5%	15.2%	
32.1	25.3	6.7	8.8%	6.3%	3.0%	45.6%	15.4%	
31.2	25.1	6.1	9.6%	6.7%	3.3%	45.4%	15.1%	
30.6	**24.8**	5.7	10.5%	7.0%	3.4%	45.5%	15.2%	..1997 Preservation Spending
29.9	24.6	5.2	11.4%	7.3%	3.6%	45.5%	15.3%	
28.4	24.2	4.2	13.2%	7.6%	4.0%	45.7%	15.5%	
27.6	23.8	3.8	14.0%	7.9%	4.1%	45.6%	15.3%	
27.0	23.5	3.5	14.9%	8.3%	4.2%	45.6%	15.3%	
						30.3%		1997 Percentage

$29.9 billion be invested in system preservation improvements, and $15.1 billion be invested in additional lanes. However, if actual 1997 spending patterns were continued for 10 years, only $24.8 billion would be invested in system preservation improve-ments, and $21.0 billion would be invested in adding lanes. The row containing widening spending of $21.0 billion is much higher in the table in Exhibit A-10 than the row containing preservation spending of $24.8 billion. The implication of this difference is that current urban Interstate spending patterns do a much better job addressing investment requirements for widening than investment requirements for pavement, and that a greater share of future increases in funding should be directed towards system preservation. (Note that the system preservation figures cited above would include reconstruction or resurfacing of existing lanes of an Interstate route that was done in conjunction with a widening improvement.)

Q. **Does the V/SF ratio threshold of 0.95 shown in Exhibit A-10 have any special significance?**

A. Yes. At V/SF ratios above 0.95, travelers on the road are likely to experience stop and go traffic. Any incident can be expected to produce a serious breakdown of traffic flow, with exces-sive queuing. This is the traditional cut-off point used in the C&P report to describe severe congestion.

Assuming the $45.0 billion were invested in the manner recommended by HERS, average IRI would be expected to decrease (improve) by 5.3 percent by 2007. Average travel time costs per VMT would rise 2.9 percent, and average total user costs would rise 0.9 percent. The percentage of VMT occurring on urban Interstate routes with a (V/SF) ratio greater than or equal to 0.95 would be expected to increase from 30.3 percent in 1997 to 43.4 percent in 2007.

Investment Required to Achieve Certain Performance Targets

Exhibit A-10 shows that combined system preservation and widening investment on urban Interstates would need to reach between $38.8 billion and $40.1 billion over 10 years in order to maintain average IRI at 114 inches per mile. To prevent average total user costs (including travel time costs, vehicle operating costs, and crash costs) from increasing would require a cumulative investment from 1998–2007 of $53.2 billion. Maintaining the travel time costs component alone would require a 10-year investment of $65.0 billion. The average travel time costs line in the graph in Exhibit A-8 is always higher then the average total user costs line, which implies that on urban Interstates, it is easier to maintain vehicle operating costs and crash costs than travel time costs.

The $87.7 billion shown on the top row of Exhibit A-10 represents the maximum amount that could be economically invested for urban Interstate system preservation and widening. Only at this level of investment would there be a decline in the percentage of urban Interstate VMT on routes with a V/SF ratio greater than or equal to 0.95.

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

Exhibit A-6 shows that in 1997, 9.3 percent of total highway capital outlay by all levels of government was used for system preservation or widening of existing urban Interstate routes. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $51.9 billion would be spent for urban interstate system preservation or widening over the next 10 years. In Exhibit A-10, this would fall between the $49.9 billion and the $53.2 billion rows.

This level of investment is close to the amount required to maintain user costs, though average travel time costs would be expected to rise by 1.3 to 1.9 percent. The percent of VMT on roads with a V/SF ratio greater than or equal to 0.95 would increase from 30.3 percent to between 40.7 and 41.9 percent. Average IRI would be expected to improve by 9.6 to 11.4 percent.

Expected Rural and Urban Interstate Pavement Condition in 2007

The total 10-year investment levels for each row in Exhibits A-7 and A-9 were selected to have a comparable rate of return according to the benefit-cost analysis performed by HERS. (See Exhibit 7-3 in Chapter 7 for a graphical illustration of how different minimum benefit-cost ratio cutoff points in HERS correspond to different levels of investment). Therefore the values in each row for these two exhibits can be combined directly into the same row in Exhibit A-11, which compares the impacts of different levels of investment on rural and urban pavement condition. Some columns in Exhibit A-11 duplicate those in Exhibits A-7 and A-9, to facilitate comparisons with the more detailed condition information provided in these exhibits. The second and third columns of Exhibit A-11, showing rural and urban system preservation investment, match the first column in Exhibits A-7 and A-9, respectively. The sixth and seventh columns in Exhibit A-11, showing the percent change in rural and urban average IRI, correspond to the fourth column in Exhibits A-7 and A-9. Note that all dollar values cited in this analysis are stated in constant 1997 dollars.

As indicated in Exhibit A-5, all levels of government spent approximately $4.0 billion for Interstate roadway preservation in rural and urban areas combined in 1997. If this type of investment grows at the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be about $40.5 billion (stated in 1997 dollars). Exhibit A-11 shows that at this level of investment, average IRI would be expected to increase (worsen) by 15.2 percent, increasing from 105 to 121 inches per mile. This would represent a shift in average pavement condition from “fair” to “mediocre,” using the verbal descriptions shown in Exhibit A-1. Based on the pattern of investment recommended by HERS, average IRI for rural Interstates would increase by 24.7 percent, while average IRI for urban Interstates would only get 8.8 percent worse. (Note that average IRI for rural Interstates would still be lower for rural Interstates than for urban Interstates in 2007, since rural Interstate IRI is currently about 22 percent lower than urban Interstate IRI.)

Rural/Urban Tradeoffs

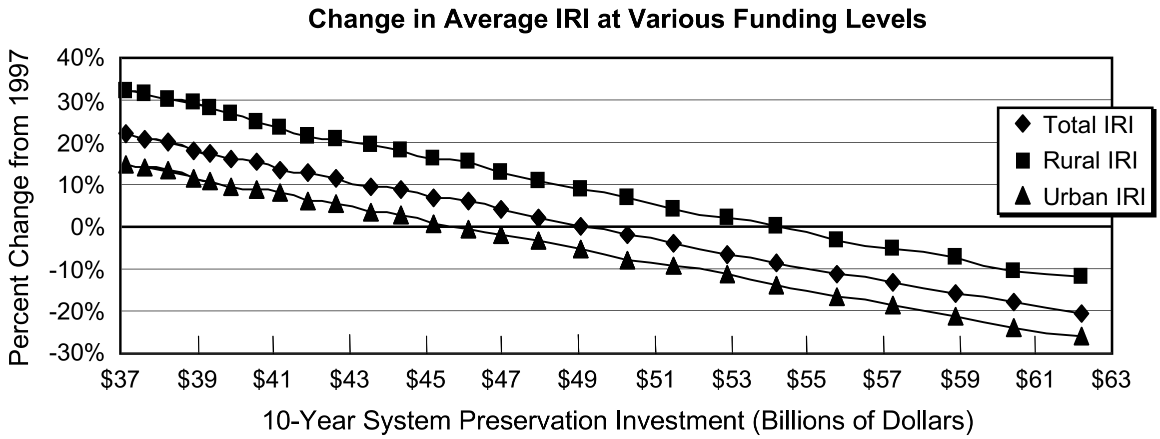
At a 10-year Interstate system preservation investment level of $40.5 billion, HERS would recommend spending slightly more in urban areas, and slightly less (about 2 percent) in rural areas. This can be seen in Exhibit A-11, as the row containing current rural Interstate system preservation of $15.5 billion is higher than the row containing total Interstate system preservation of $40.5 billion.

The graph in Exhibit A-11, shows that based on the pattern of investment recommended by HERS, urban Interstate IRI would fare better than rural Interstate IRI at all levels of investment. The exhibit shows that a combined rural and urban system preservation investment of $49.1 billion over 10 years would maintain overall average IRI, but that average rural IRI would get 8.6 percent worse, which would be offset by a 5.3 percent improvement in urban IRI.

At a combined rural and urban system preservation level of $54.2 billion, average rural Interstate IRI would be maintained, while urban Interstate IRI would improve by 14.0 percent. Urban IRI could be maintained if 10-year investment is approximately $45.2 to $46.1 billion. At this level of investment rural Interstate IRI would be expected to increase (worsen) by 5.7 to 6.7 percent.

Exhibit A-11

Projected Rural and Urban Interstate Pavement Condition in 2007, for Different Possible Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI				Funding Level Description: Investment Required to Maintain…
			Total in Inches per Mile	Percent Change from 1997			
Total	Rural	Urban		Total	Rural	Urban	
62.2	25.0	37.3	83	-21.0%	-11.8%	-26.3%	
60.4	24.1	36.3	86	-18.1%	-10.8%	-23.7%	
58.9	23.4	35.5	88	-16.2%	-7.5%	-21.1%	
57.2	22.6	34.6	91	-13.3%	-5.4%	-18.4%	
55.8	21.9	33.8	93	-11.4%	-3.2%	-16.7%	
54.2	21.2	32.9	96	-8.6%	**0.0%**	-14.0%	...Average Rural IRI
52.9	20.7	32.2	98	-6.7%	2.2%	-11.4%	
51.5	20.2	31.4	101	-3.8%	4.3%	-9.6%	
50.3	19.6	30.7	103	-1.9%	6.5%	-7.9%	
49.1	19.1	29.9	105	**0.0%**	8.6%	-5.3%	...Average IRI
48.0	18.7	29.3	107	1.9%	10.8%	-3.5%	
47.0	18.2	28.8	109	3.8%	12.9%	-1.8%	
46.1	17.8	28.4	111	5.7%	15.1%	**-0.9%**	…Average Urban IRI
45.2	17.3	27.9	112	6.7%	16.1%	**0.9%**	
44.3	16.8	27.5	114	8.6%	18.3%	2.6%	
43.5	16.5	27.0	115	9.5%	19.4%	3.5%	
42.6	16.1	26.5	117	11.4%	20.4%	5.3%	
41.9	15.8	26.1	118	12.4%	21.5%	6.1%	
41.2	**15.5**	25.6	119	13.3%	23.7%	7.9%	…Rural Spending at 1997 Level
40.5	15.2	25.3	121	15.2%	24.7%	8.8%	…Total Spending at 1997 Level
39.9	14.8	25.1	122	16.2%	26.9%	9.6%	
39.3	14.5	**24.8**	123	17.1%	28.0%	10.5%	...Urban Spending at 1997 Level
38.9	14.2	24.6	124	18.1%	29.0%	11.4%	
38.2	14.0	24.2	126	20.0%	30.1%	13.2%	
37.6	13.8	23.8	127	21.0%	31.2%	14.0%	
37.1	13.6	23.5	128	21.9%	32.3%	14.9%	
			105				1997 Values

Projected Pavement Conditions at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, highway capital outlay on all functional systems is projected to total $557.5 billion (1997 dollars) for the 10-year period from 1998 to 2007, based on certain assumptions about future Federal, State and local funding levels. In 1997, 8.3 percent of total highway capital outlay by all levels of government was used for system preservation on urban Interstates. If this percentage is maintained in the future, approximately $46.2 billion will be spent for urban interstate system over the next 10 years. This level of investment would be sufficient to maintain urban Interstate IRI at 1997 levels, though rural Interstate IRI would increase.

Expected Rural and Urban Interstate Pavement Condition and Performance in 2007

Exhibit A-12 combines the rural and urban pavement condition and performance results shown separately in Exhibits A-8 and A-10. This table incorporates the system preservation investments included in Exhibit A-11 as well as rural and urban widening improvements with a comparable benefit-cost ratio. The second and third column in Exhibit A-12 showing rural and urban 10-year preservation and widening investment duplicate the first column of Exhibits A-8 and A-10. The fourth column with the percent change in average IRI data matches the fifth column in Exhibit A-11. The seventh and eighth columns covering the percent change in rural and urban average highway user costs match the sixth column in Exhibits A-8 and A-10, respectively. These duplicate columns are included to serve as reference points to relate this analysis back to the more detailed analyses developed earlier. All values shown in this analysis are stated in constant 1997 dollars.

Effects of Investing at 1997 Spending Levels

In addition to the $4.0 billion spent by all levels of government on rural and urban Interstate system preservation in 1997, $2.6 billion was used for widening existing Interstate routes, as shown in Exhibit A-5. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $66.7 (stated in 1997 dollars). Exhibit A-12 does not have a row that exactly corresponds to this level of investment. The closest one is for $65.9 billion.

As discussed earlier, HERS would recommend that a greater share of both rural and urban Interstate spending be devoted to system preservation than is currently the case. If this shift in expenditure patterns were to occur and highway investment remained constant at 1997 levels over 10 years, then average IRI would be maintained at current levels. At this level of investment, average travel time costs would be expected to increase by 2.0 percent. Overall average highway user costs would increase by 1.0 percent, while highway user costs on rural Interstates would increase by 1.4 percent.

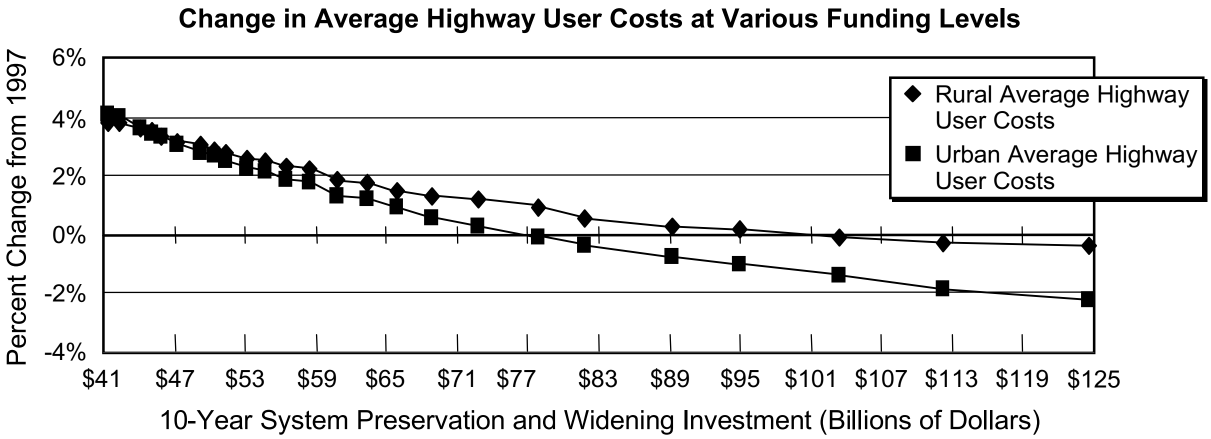
Investment Required to Achieve Certain Performance Targets

As shown in Exhibit A-12, combined system preservation and widening investment on rural and urban Interstates would need to reach $89.3 billion over 10 years in order to maintain average travel time costs. Maintaining total highway user costs would require a cumulative investment from 1998–2007 of $81.9 billion. At this level of investment, urban highway user costs would decrease by 0.4 percent while rural highway user costs would increase by 0.6 percent.

At higher funding levels, the investment pattern recommended by HERS has more of an impact on reducing urban highway user costs than rural highway user costs. However, the lines in the graph in Exhibit A-12 do cross, indicating that at lower funding levels, the investments recommended by HERS would allow urban highway user costs to grow more quickly than rural highway user costs.

Exhibit A-12

Projected Rural and Urban Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997					Funding Level Description: Investment Required to Maintain…
				Average Travel Time Costs	Average Highway User Costs			
Total	Rural	Urban	Average IRI		Total	Rural	Urban	
124.5	36.8	87.7	-21.0%	-2.0%	-1.6%	-0.4%	-2.2%	
112.2	34.9	77.4	-18.1%	-1.3%	-1.2%	-0.3%	-1.8%	
103.4	32.4	71.0	-16.2%	-1.0%	-1.0%	**-0.1%**	-1.4%	…Rural User Costs
95.1	30.0	65.0	-13.3%	-0.7%	-0.7%	0.1%	-1.1%	
89.3	28.3	61.0	-11.4%	**-0.3%**	-0.4%	0.3%	-0.8%	…Travel Time Costs
81.9	26.1	55.8	-8.6%	0.3%	**-0.1%**	0.6%	-0.4%	...Total User Costs
77.8	24.6	53.2	-6.7%	0.7%	0.1%	0.9%	**-0.1%**	…Urban User Costs
72.9	23.0	49.9	-3.8%	1.3%	0.5%	1.2%	0.3%	
68.9	**21.8**	47.1	-1.9%	1.7%	0.7%	1.3%	0.5%	…Rural Spending at 1997 Level
65.9	20.9	**45.0**	**0.0%**	2.0%	1.0%	1.4%	0.9%	…Urban/Total Spending, & IRI
63.4	20.2	43.2	1.9%	2.7%	1.2%	1.7%	1.2%	
60.8	19.2	41.6	3.8%	3.0%	1.5%	1.9%	1.3%	
58.5	18.4	40.1	5.7%	3.4%	1.8%	2.2%	1.7%	
56.6	17.7	38.8	6.7%	3.7%	1.9%	2.3%	1.8%	
54.8	17.3	37.5	8.6%	4.0%	2.0%	2.4%	2.1%	
53.1	16.8	36.3	9.5%	4.4%	2.2%	2.6%	2.2%	
51.5	16.4	35.1	11.4%	4.4%	2.5%	2.7%	2.5%	
50.4	15.9	34.5	12.4%	4.7%	2.6%	2.9%	2.6%	
49.2	15.6	33.6	13.3%	5.0%	2.7%	3.0%	2.8%	
47.3	15.2	32.1	15.2%	5.4%	2.9%	3.2%	3.0%	
46.0	14.8	31.2	16.2%	5.7%	3.1%	3.3%	3.3%	
45.1	14.5	30.6	17.1%	6.0%	3.3%	3.5%	3.4%	
44.1	14.2	29.9	18.1%	6.4%	3.4%	3.6%	3.6%	
42.4	14.0	28.4	20.0%	6.7%	3.7%	3.7%	4.0%	
41.4	13.8	27.6	21.0%	7.0%	3.8%	3.7%	4.1%	
40.7	13.6	27.0	21.9%	7.0%	4.0%	3.9%	4.2%	

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

In 1997, 13.7 percent of total highway capital outlay by all levels of government was used for system preservation or widening of existing rural and urban Interstate routes. As shown in Exhibit A-6, if this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $76.4 billion would be spent for rural and urban interstate system preservation or widening over the next 10 years. In Exhibit A-12, this would fall between the $72.9 billion and the $77.8 billion rows.

This level of investment is close to the amount required to maintain urban highway user costs, though rural highway user costs would be expected to rise about 0.9 to 1.2 percent. Average travel time costs would be expected to rise by 0.7 to 1.3 percent. Average IRI would be expected to improve by 3.8 to 6.7 percent.

Expected Rural Interstate Bridge Conditions in 2007

Chapter 7 defined the bridge investment backlog as the cost of improving all bridges that are currently deficient. The current investment requirement backlog includes the costs to repair or replace all bridges identified as functionally obsolete or structurally deficient in Exhibit A-4, as well as the costs of additional repairs or partial replacements required to correct less severe problems with individual bridge components. (These less severe problems are described in BNIP as "condition deficiencies," and includes such items as bridge decks in need of rehabilitation. However, this term is not widely utilized, and is not referenced elsewhere in this study to avoid confusion with the common definition of "bridge deficiencies" which includes only structural and functional deficiencies.)

The BNIP model estimates that the current investment backlog on rural Interstate bridges is $6.3 billion. This section examines the effect that different levels of investment would be expected to have on the size of this backlog. All dollar values cited in this analysis are stated in constant 1997 dollars.

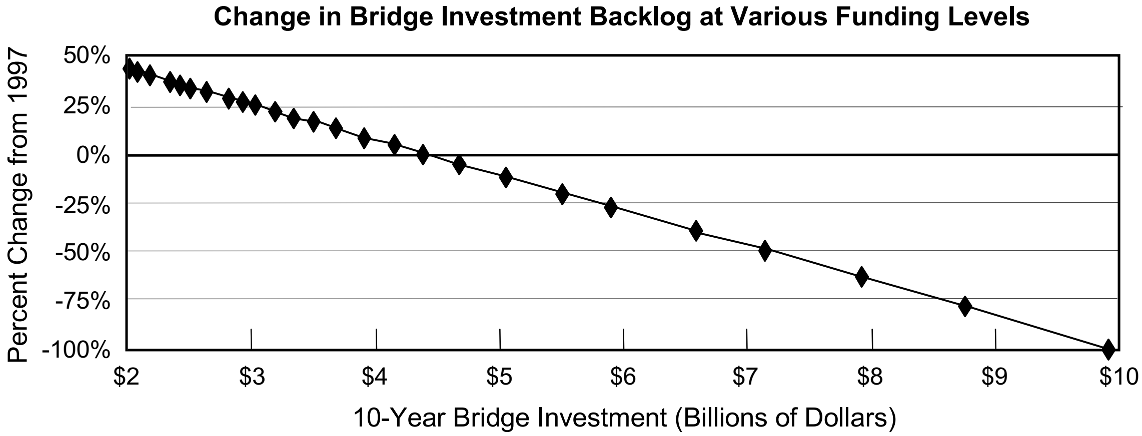
Exhibit A-13 projects the percent of rural Interstate bridges that would be deficient in 2007, the total percent of rural Interstate bridges needing to be repaired or replaced in 2007, and the cost to address these structural deficiencies, functional deficiencies, and other bridge needs. Exhibit A-5 shows that all levels of government spent approximately $0.4 billion for the repair, rehabilitation and replacement of existing rural Interstate bridges in 1997. If this level of investment were sustained over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $3.9 billion (stated in 1997 dollars).

Effects of Investing at 1997 Spending Levels

The pattern of investments recommended by BNIP is intended to minimize the investment requirement backlog, rather than the number of deficient bridges or the total number of bridges needing repairs. If current funding levels were sustained in constant dollar terms over the next 10 years, and $3.9 billion were invested in bridges, the model predicts the bridge investment backlog would increase from $6.3 billion to $6.8 billion. The percent of bridges that are deficient would fall from 16.4 percent to 10.6 percent. However, the total percent of bridges needing repairs (including deficient bridges as well as bridges with less severe problems) would rise from 30.9 percent to 47.5 percent. These results suggest that the BNIP model is choosing to address a smaller number of severe deficiencies that are expensive to correct, while it is letting a number of less severe problems to continue to accrue.

Exhibit A-13

Projected Rural Interstate Bridge Investment Backlog in 2007, for Different Possible Funding Levels



10-Year Bridge Investment (Billions of 1997 Dollars)	Percent of Bridges That Would be Deficient in 2007: Structural	Functional	Total	Change from 1997	Bridge Investment Backlog in 2007: (Deficiencies & Other): Percent of Bridges Needing Repairs	Cost to Address: Billions of 1997 Dollars	Cost to Address: Percent Change from 1997	Funding Level Description: Investment Required to Maintain…
$9.9	0.0%	0.0%	0.0%	-16.4%	0.0%	$0.0	**-100.0%**	
$8.8	0.7%	0.6%	1.3%	-15.1%	11.1%	$1.4	-78.4%	
$7.9	1.2%	1.7%	2.9%	-13.5%	17.4%	$2.3	-63.4%	
$7.1	1.7%	2.7%	4.4%	-12.0%	23.2%	$3.2	-49.4%	
$6.6	2.0%	3.4%	5.4%	-10.9%	27.3%	$3.8	-39.6%	
$5.9	2.5%	4.3%	6.8%	-9.6%	32.6%	$4.6	-27.1%	
$5.5	2.7%	4.8%	7.5%	-8.8%	35.5%	$5.0	-20.2%	
$5.0	3.0%	5.4%	8.4%	-7.9%	38.9%	$5.6	-11.8%	
$4.7	3.2%	5.9%	9.1%	-7.2%	41.8%	$6.0	-5.1%	
$4.4	3.4%	6.3%	9.7%	-6.7%	43.9%	$6.3	**0.0%**	...Backlog at 1997 Level
$4.2	3.6%	6.6%	10.1%	-6.2%	45.7%	$6.6	4.2%	
$3.9	3.7%	6.9%	10.6%	-5.8%	47.5%	$6.8	8.6%	…Spending at 1997 Level
$3.7	3.9%	7.2%	11.0%	-5.3%	49.1%	$7.1	12.5%	
$3.5	4.0%	7.4%	11.4%	-5.0%	50.5%	$7.3	15.8%	
$3.3	4.1%	7.6%	11.7%	-4.7%	51.8%	$7.5	18.8%	
$3.2	4.2%	7.8%	12.0%	-4.4%	52.9%	$7.7	21.6%	
$3.0	4.3%	8.0%	12.3%	-4.1%	54.1%	$7.8	24.4%	
$2.9	4.3%	8.2%	12.5%	-3.9%	54.9%	$7.9	26.2%	
$2.8	4.4%	8.3%	12.7%	-3.7%	55.7%	$8.1	28.2%	
$2.6	4.5%	8.5%	13.0%	-3.3%	57.1%	$8.3	31.5%	
$2.5	4.6%	8.7%	13.3%	-3.1%	58.0%	$8.4	33.7%	
$2.4	4.6%	8.8%	13.4%	-2.9%	58.7%	$8.5	35.2%	
$2.3	4.7%	8.9%	13.6%	-2.7%	59.3%	$8.6	36.8%	
$2.2	4.8%	9.1%	13.9%	-2.4%	60.5%	$8.8	39.7%	
$2.1	4.9%	9.3%	14.1%	-2.2%	61.3%	$8.9	41.5%	
$2.0	4.9%	9.3%	14.2%	-2.1%	61.8%	$9.0	42.7%	
	4.1%	12.2%	16.4%		30.9%	$6.3		1997 Values

Investment Required to Eliminate or Maintain the Bridge Investment Backlog

The top row in the table in Exhibit A-13 represents the cost to eliminate the rural Interstate bridge investment backlog by 2007. To achieve this would require a cumulative 10-year investment of $9.9 billion on rural Interstate highways. This level of investment would address all structural deficiencies, functional deficiencies, and all other less severe bridge condition problems identified by BNIP.

> ***Q.*** **How does the pattern of investments recommended by BNIP compare with current spending patterns on Interstate bridges?**
>
> ***A.*** The expenditure data available does not distinguish between amounts spent to correct structural and functional deficiencies versus other bridge expenditures. However, since 1996, the percent of deficient Interstate bridges has declined, while the number of bridges with less severe problems with individual bridge components has risen. This implies that current spending patterns are consistent with those recommended by BNIP, in broad terms.

To maintain the bridge investment backlog at its 1997 level would require a 10-year investment of $4.4 billion. Based on the pattern of investment recommended by BNIP, this level of investment would reduce the percent of deficient bridges from 16.4 percent to 9.7 percent. The percent of bridges with condition problems that eventually would need to be repaired would rise to 43.9 percent.

Projected Bridge Investment Backlog at Forecast Funding Levels for 1998–2007

Exhibit A-6 shows that 0.8 percent of total highway capital outlay by all levels of government was used for rural Interstate bridge repair, rehabilitation, or replacement in 1997. If this percentage remains constant, and total highway and bridge capital outlay for 1998–2007 on all functional systems reaches $557.5 billion in constant 1997 dollars, approximately $4.6 billion would be spent on rural Interstate bridges. At this level of investment, the rural Interstate bridge investment backlog in 2007 would be expected to be between 0.0 and 5.1 percent lower than the current level.

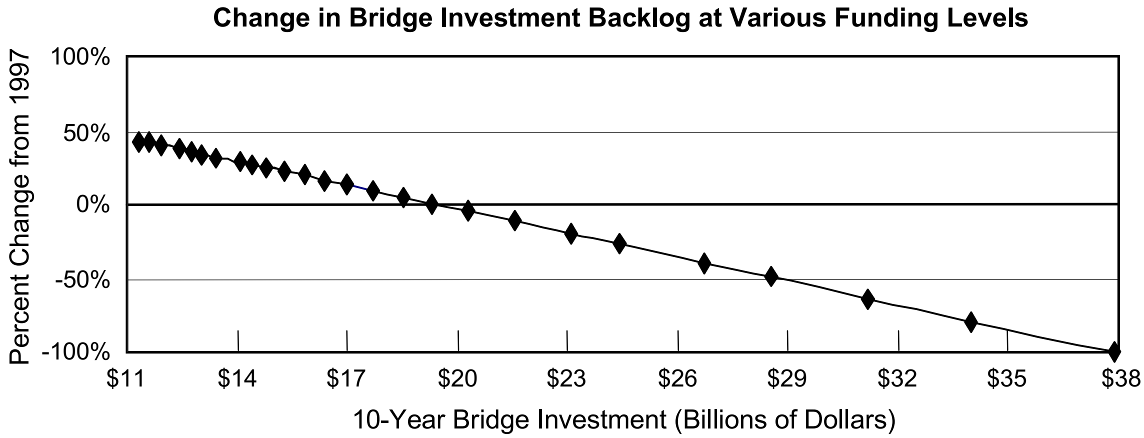
Expected Urban Interstate Bridge Conditions in 2007

The BNIP model estimates that the current investment backlog on urban Interstate bridges is $18.7 billion. This includes the costs to repair or replace all bridges identified as functionally obsolete or structurally deficient in Exhibit A-4, as well as the costs of additional repairs or partial replacements required to correct less severe problems with individual bridge components. This section examines the effect that different levels of investment would be expected to have on the size of this backlog. All dollar values cited in this analysis are stated in 1997 dollars.

Exhibit A-5 shows that all levels of government spent approximately $1.3 billion for capital improvements to urban Interstate bridges in 1997. If this level of investment were sustained over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $13.4 billion (stated in 1997 dollars). As indicated in Exhibit A-14, if this level of investment was utilized in the manner recommended by BNIP, the bridge investment backlog would increase from $18.7 billion to $24.6 billion. The total percent of bridges needing repairs (including deficient bridges as well as bridges with less severe problems) would rise from 35.6 percent to 74.3 percent, and the percent of urban Interstate bridges that are structurally deficient would rise from 6.7 percent to 9.8 percent. The percent of functionally obsolete bridges would decline sharply, as BNIP appears to emphasize addressing them.

Exhibit A-14

Projected Urban Interstate Bridge Investment Backlog in 2007, for Different Possible Funding Levels



10-Year Bridge Investment (Billions of 1997 Dollars)	Percent of Bridges That Would be Deficient in 2007: Structural	Functional	Total	Change from 1997	Bridge Investment Backlog in 2007: (Deficiencies & Other): Percent of Bridges Needing Repairs	Cost to Address: Billions of 1997 Dollars	Cost to Address: Percent Change from 1997	Funding Level Description: Investment Required to Maintain…
$37.9	0.0%	0.0%	0.0%	-26.8%	0.0%	$0.0	**-100.0%**	
$34.0	1.3%	1.2%	2.5%	-24.4%	13.3%	$3.9	-79.4%	
$31.2	2.5%	2.0%	4.5%	-22.4%	21.6%	$6.7	-64.2%	
$28.6	3.6%	2.8%	6.3%	-20.5%	29.4%	$9.3	-50.0%	
$26.7	4.3%	3.3%	7.6%	-19.2%	34.8%	$11.2	-40.1%	
$24.4	5.3%	4.0%	9.3%	-17.6%	41.7%	$13.5	-27.5%	
$23.1	5.8%	4.4%	10.2%	-16.6%	45.6%	$14.9	-20.4%	
$21.5	6.5%	4.9%	11.3%	-15.5%	50.2%	$16.4	-12.0%	
$20.3	7.0%	5.2%	12.2%	-14.6%	54.0%	$17.7	-5.2%	
$19.3	7.4%	5.5%	12.9%	-13.9%	56.8%	$18.7	**0.0%**	...Backlog at 1997 Level
$18.5	7.7%	5.8%	13.5%	-13.4%	59.1%	$19.5	4.2%	
$17.7	8.0%	6.0%	14.0%	-12.8%	61.6%	$20.3	8.8%	
$17.0	8.3%	6.2%	14.6%	-12.3%	63.8%	$21.0	12.7%	
$16.4	8.6%	6.4%	15.0%	-11.9%	65.6%	$21.7	16.0%	
$15.8	8.8%	6.6%	15.4%	-11.4%	67.2%	$22.2	19.0%	
$15.3	9.0%	6.7%	15.8%	-11.1%	68.8%	$22.8	21.8%	
$14.8	9.3%	6.9%	16.1%	-10.7%	70.3%	$23.3	24.7%	
$14.4	9.4%	7.0%	16.4%	-10.5%	71.3%	$23.6	26.5%	
$14.1	9.5%	7.1%	16.6%	-10.2%	72.4%	$24.0	28.5%	
$13.4	9.8%	7.3%	17.1%	-9.8%	74.3%	$24.6	31.9%	…Spending at 1997 Level
$13.0	10.0%	7.4%	17.4%	-9.5%	75.5%	$25.0	34.1%	
$12.7	10.1%	7.5%	17.6%	-9.3%	76.4%	$25.3	35.7%	
$12.5	10.2%	7.6%	17.8%	-9.1%	77.2%	$25.6	37.3%	
$11.9	10.4%	7.7%	18.2%	-8.7%	78.8%	$26.2	40.2%	
$11.6	10.6%	7.8%	18.4%	-8.4%	79.8%	$26.5	42.0%	
$11.4	10.7%	7.9%	18.6%	-8.3%	80.5%	$26.7	43.2%	
	6.7%	20.1%	26.8%		35.6%	$18.7		1997 Values

Investment Required to Eliminate or Maintain the Bridge Investment Backlog

The top row in the table in Exhibit A-14 indicates that eliminating the urban Interstate bridge investment backlog by 2007 would require a cumulative 10-year investment of $37.9 billion. This level of investment would address all structural deficiencies, functional deficiencies, and all other less severe bridge condition problems identified by BNIP.

> **Q. Why might BNIP correct a higher percentage of functional deficiencies than structural deficiencies?**
>
> **A.** Correcting structural deficiencies frequently requires the replacement of the bridge, while correcting functional deficiencies may be possible by modifying the existing structure, which would be less expensive.

To maintain the bridge investment at its 1997 level would require a 10-year investment of $19.3 billion. Based on the pattern of investment recommended by BNIP, this level of investment would reduce the percent of deficient bridges from 26.8 percent to 12.9 percent. However, the percent of structurally deficient bridges would rise from 6.7 percent to 7.4 percent. The total percent of bridges with condition problems that eventually would need to be repaired would also rise, from 35.6 percent to 56.8 percent.

Projected Bridge Investment Backlog at Forecast Funding Levels for 1998–2007

In 1997, 2.7 percent of total highway capital outlay by all levels of government was used for urban Interstate bridge repair, rehabilitation, or replacement. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 billion in constant 1997 dollars as projected in Exhibit A-6, approximately $15.2 billion would be spent on urban Interstate bridges over the next 10 years. At this level of investment, the urban Interstate bridge investment backlog in 2007 would be expected to grow by about 21.8 percent, from $18.7 billion to $22.8 billion. Note that the projections of 10-year capital outlay by all levels of government are based on certain simplifying assumptions about future Federal, State and local funding patterns. Federal funding beyond 2003 has yet to be determined.

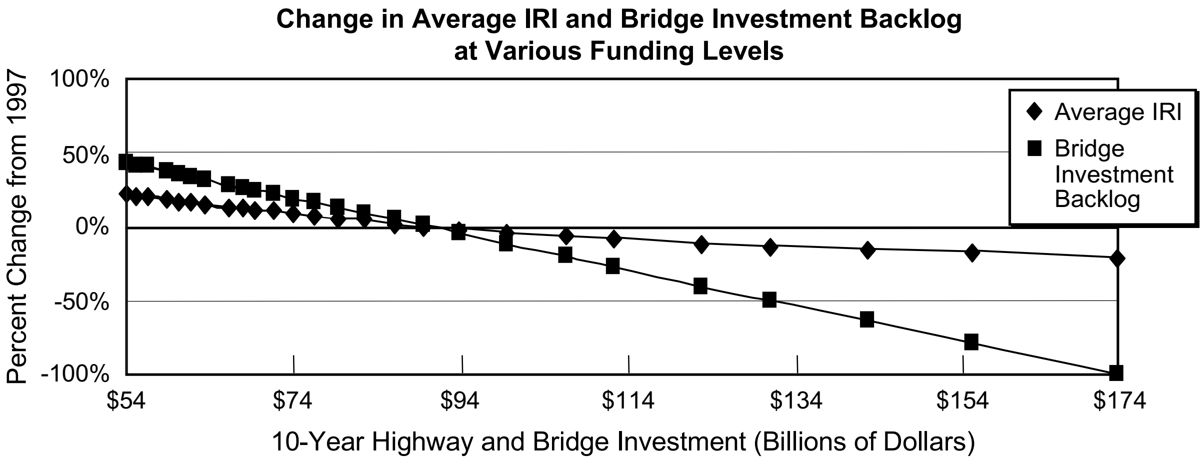
Expected Rural and Urban Interstate Highway and Bridge Conditions and Performance in 2007

The total 10-year bridge investment levels for the rows of Exhibits A-13 and A-14 were selected to line up with their highway investment counterparts for the rows in Exhibit A-12. The top rows in Exhibits A-13 and A-14 represent the level of investment required to eliminate the current investment backlog for rural and urban Interstate bridges respectively, while the top row in Exhibit A-12 represents the maximum level of rural and urban Interstate highway investment that can be economically justified. The levels of investment required to maintain the current Interstate bridge investment backlog for rural and urban Interstates respectively were assigned to the tenth row of Exhibits A-13 and A-14 in order to line up with the tenth row of Exhibit A-12, which contains the level of investment required to maintain average IRI on rural and urban Interstates at current levels. The bridge investment levels for the remaining rows in Exhibits A-13 and A-14 were selected to be consistent with the slope of the highway investment requirement levels for the rows in Exhibit A-12.

Exhibit A-15 combines Exhibits A-12, A-13 and A-14. As described above, the rows in this table were intentionally lined up to demonstrate the relative differences between current investment levels and investment requirements for Interstate highways, rural Interstate bridges, and urban Interstate bridges. However, no analysis was performed to determine the relative benefits of Interstate highway

Exhibit A-15

Projected Interstate Highway and Bridge Conditions and Performance in 2007, for Different Possible Funding Levels



Total 10-Year Highway and Bridge Preservation and Widening (Billions of 1997 Dollars)				Percent Change from 1997				Funding Level Description: Investment Required to Maintain...
		Bridge						
Total	Highway	Rural	Urban	Average IRI	Average Travel Time Costs	Average Highway User Costs	Cost to Address Bridge Backlog	
172.3	124.5	9.9	37.9	-21.0%	-2.0%	-1.6%	-100.0%	
154.9	112.2	8.8	34.0	-18.1%	-1.3%	-1.2%	-79.1%	
142.5	103.4	7.9	31.2	-16.2%	-1.0%	-1.0%	-64.0%	
130.8	95.1	7.1	28.6	-13.3%	-0.7%	-0.7%	-49.8%	
122.6	89.3	6.6	26.7	-11.4%	**-0.3%**	-0.4%	-40.0%	…Average Travel Time Costs
112.2	81.9	5.9	24.4	-8.6%	0.3%	**-0.1%**	-27.4%	…Average Highway User Costs
106.4	77.8	5.5	23.1	-6.7%	0.7%	0.1%	-20.4%	
99.5	72.9	5.0	21.5	-3.8%	1.3%	0.5%	-12.0%	
93.9	68.9	4.7	20.3	-1.9%	1.7%	0.7%	-5.2%	
89.6	**65.9**	4.4	19.3	**0.0%**	2.0%	1.0%	**0.0%**	…Average IRI, Bridge Backlog, and 1997 Highway Spending
86.1	63.4	4.2	18.5	1.9%	2.7%	1.2%	4.2%	
82.4	60.8	**3.9**	17.7	3.8%	3.0%	1.5%	8.7%	…1997 Rural Bridge Spending
79.2	58.5	3.7	17.0	5.7%	3.4%	1.8%	12.6%	
76.4	56.6	3.5	16.4	6.7%	3.7%	1.9%	15.9%	
73.9	54.8	3.3	15.8	8.6%	4.0%	2.0%	19.0%	
71.6	53.1	3.2	15.3	9.5%	4.4%	2.2%	21.8%	
69.3	51.5	3.0	14.8	11.4%	4.4%	2.5%	24.6%	
67.8	50.4	2.9	14.4	12.4%	4.7%	2.6%	26.4%	
66.1	49.2	2.8	14.1	13.3%	5.0%	2.7%	28.4%	
63.4	47.3	2.6	**13.4**	15.2%	5.4%	2.9%	31.8%	…1997 Urban Bridge Spending
61.5	46.0	2.5	13.0	16.2%	5.7%	3.1%	34.0%	
60.2	45.1	2.4	12.7	17.1%	6.0%	3.3%	35.6%	
58.9	44.1	2.3	12.5	18.1%	6.4%	3.4%	37.2%	
56.5	42.4	2.2	11.9	20.0%	6.7%	3.7%	40.1%	
55.0	41.4	2.1	11.6	21.0%	7.0%	3.8%	41.8%	
54.0	40.7	2.0	11.4	21.9%	7.0%	4.0%	43.1%	
								1997 Percentage

improvements compared to Interstate bridge investments, or of rural Interstate bridge improvements compared to urban Interstate bridge improvements. Therefore, this exhibit is not intended to identify direct highway/bridge investment tradeoffs, or rural bridge/urban bridge tradeoffs.

Exhibit A-15 indicates that if current levels of Interstate highway investment were sustained over 10 years in constant dollar terms, and utilized in the manner recommended by HERS, average IRI could be maintained at current levels. However, if Interstate bridge investment remained constant, the Interstate bridge investment backlog would increase, especially in the case of urban Interstate bridges. Other implications of this exhibit are discussed in the next section of this study.

Resources Needed to Maintain and Improve the Interstate System

The preceding portion of this report projected the conditions and performance of Interstate highways and bridges based on a variety of funding levels. This section looks in more detail at the level of investment required to "maintain" the Interstate system (corresponding to the tenth row in Exhibit A-15), and the level of investment required to "improve" the Interstate system (corresponding to the first row in Exhibit A-15). This analysis determines where there are "gaps" between the estimated investment requirements and the projected level of available resources identified in Exhibit A-6.

Cost to Maintain and Improve the Interstate System

The funding levels shown in Exhibit A-15 consider only Interstate highway and bridge preservation and widening improvements. This analysis did not factor in expenditures for new Interstate construction, or for Interstate system enhancements, which are not modeled in HERS or BNIP. As indicated earlier in Exhibit A-6, 14.4 percent of Interstate capital expenditures went for new construction in 1997, and 9.3 percent went for system enhancements. Assuming these non-modeled items continued to receive the same percentage of total Interstate funding, the total investment required to maintain and improve the Interstate system would need to be factored up to accommodate them.

Exhibit A-15 indicated that an investment of $89.6 billion in Interstate highway and bridge preservation and widening over 10 years on the Interstate and the backlog of Interstate bridge investments at their respective 1997 levels. As shown in Exhibit A-16, factoring up this projection to include new construction and system enhancements results in an overall Cost to Maintain Interstate Highways and Bridges of $117.5 billion over 10 years.

Q. **Would the operational performance of the Interstate system be maintained if investment reached the Cost to Maintain level?**

A. No. The tenth row in Exhibit A-15 shows that this level of investment would maintain the physical conditions of Interstate highways and bridges, but that travel time costs would rise by 2.0 percent, and highway user costs would rise by 1.0 percent. Maintaining operational performance would be significantly more expensive than simply maintaining physical conditions.

Exhibit A-16

1998-2007 Cost to Maintain and Cost to Improve the Interstate System

	10-Year Cost to Maintain (Billions of 1997 Dollars)			10-Year Cost to Improve (Billions of 1997 Dollars)		
	Rural	Urban	Total	Rural	Urban	Total
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	19.1	29.9	49.1	25.0	37.3	62.2
Widening	1.7	15.1	16.8	11.8	50.5	62.3
Subtotal, Existing Highways	20.9	45.0	65.9	36.8	87.7	124.5
Bridge Work	4.4	19.3	23.7	9.9	37.9	47.8
Subtotal Work on Existing Highways & Bridges	**25.2**	**64.4**	**89.6**	**46.7**	**125.6**	**172.3**
New Construction	*3.6*	*13.3*	*17.0*	*6.7*	*25.9*	*32.6*
System Enhancements	*2.9*	*8.0*	*10.9*	*5.4*	*15.6*	*21.0*
Total Investment	***31.8***	***85.7***	***117.5***	***58.8***	***167.1***	***226.0***

The top row of Exhibit A-15 shows a maximum investment level recommended by HERS and BNIP of $172.3 billion over 10 years. Factoring up this total to account for new construction and system enhancements would increase this amount to $226.0 billion. Exhibit A-16 identifies this value as the Cost to Improve Highways and Bridges.

Q. **What effect would investing at the Cost to Improve Interstate Highways and Bridges level have on conditions and performance?**

A. The highway portion represents the maximum level of investment that can be economically justified. The bridge portion represents the investment required to eliminate all deficiencies. As shown in Exhibit A-15, investing at this level would be expected to result in a 21.0 percent improvement in average IRI, a 2.0 percent decline in average travel time costs and a 1.6 percent reduction in average highway-user costs. The backlog of bridge deficiencies would be eliminated.

Cost to Maintain Conditions Compared to Projected Spending

Exhibit A-17 compares the Cost to Maintain Interstate Highways and Bridges identified in Exhibit A-16 with the projected 10-year capital expenditures on Interstates identified in Exhibit A-6. **Note that these projected expenditures are estimates based on simplifying assumptions about future Federal, State and local funding patterns.** Positive values in the last two columns of Exhibit A-17 indicate that where is a "gap" between projected spending and investment requirements. Negative values indicate that projected spending exceeds the investment requirements for that category.

Exhibit A-17

1998-2007 Cost to Maintain Interstates Compared to Projected Interstate Spending

	Cost to Maintain Cumulative 10-Year Investment Required (Billions of 1997 Dollars)			Projected 1998-2007 Interstate Spending	Cost to Maintain Compared to Projected Spending	
	Rural	Urban	Total	($Billions)	Difference ($Billions)	Percent Difference
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	19.1	29.9	49.1	46.2	2.8	6.1%
Widening	1.7	15.1	16.8	30.1	-13.3	-44.2%
Subtotal, Existing Highways	20.9	45.0	65.9	76.4	-10.5	-13.7%
Bridge Work	4.4	19.3	23.7	19.7	4.0	20.3%
Subtotal Work on Existing Highways & Bridges	25.2	64.4	**89.6**	**96.1**	-6.5	**-6.7%**
New Construction	3.6	13.3	17.0	18.2	-1.2	-6.7%
System Enhancements	2.9	8.0	10.9	11.7	-0.8	-6.7%
Total Investment	31.8	85.7	117.5	126.0	-8.5	-6.7%

The table shows a $2.8 billion gap between the investment required for highway preservation and projected spending over 10 years, as well as a $4.0 billion gap between investment requirements and spending for bridges over 10 years. However, if current expenditure patterns continue, investment for widening would be $13.3 billion above the Cost to Maintain level over 10 years. If a portion of these resources were redirected toward highway and bridge preservation, IRI and the backlog of bridge investments could be maintained at this funding level.

In 1997, 14.4 percent of Interstate spending went for new construction. Exhibits A-6, A-16, and A-17 all assumed that this percentage would remain unchanged in the future. If instead, this percentage was reduced, additional resources would be available to put into other types of Interstate improvements. Based on the assumptions used to develop Exhibit A-6, projected 10-year new Interstate construction totals $11.7 billion. This funding would be more than adequate to close the highway preservation and bridge preservation gaps identified above.

As indicated earlier, the Cost to Maintain Interstate Highways and Bridges represents the level of investment required to maintain physical conditions. Maintaining travel time costs or highway user costs would require a significantly higher level of investment.

Cost to Improve Compared to Projected Spending

Exhibit A-18 compares the Cost to Improve Interstate Highways and Bridges identified in Exhibit A-16 with the projected 10-year capital expenditures on Interstates identified in Exhibit A-6. The gaps between projected spending and this level of investment are identified in the second to last column, while the last column shows the additional resources above projected levels that would be required to close the gaps.

Exhibit A-18

1998-2007 Cost to Improve Interstates Compared to Projected Interstate Spending

	Cost to Improve Cumulative 10-Year Investment Required (Billions of 1997 Dollars)			Projected 1998-2007 Interstate Spending	Cost to Improve Compared to Projected Spending	
	Rural	Urban	Total	($Billions)	Difference ($Billions)	Percent Difference
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	25.0	37.3	62.2	46.2	16.0	34.7%
Widening	11.8	50.5	62.3	30.1	32.2	106.7%
Subtotal, Existing Highways	36.8	87.7	124.5	76.4	48.2	63.1%
Bridge Work	9.9	37.9	47.8	19.7	28.1	142.4%
Subtotal Work on Existing Highways & Bridges	46.7	125.6	**172.3**	**96.1**	76.3	**79.4%**
New Construction	6.7	25.9	32.6	18.2	14.4	79.4%
System Enhancements	5.4	15.6	21.0	11.7	9.3	79.4%
Total Investment	58.8	167.1	226.0	126.0	100.0	79.4%

Overall, the Cost to Improve Interstate Highways and Bridges is 79.4 percent ($100.0 billion over 10 years) above the level of projected Interstate spending. As in the case for the Cost to Maintain, bridge spending would need to increase by a larger percentage than highway spending in order to close the gap. However, unlike the Cost to Maintain, the gap for widening ($32.2 billion over 10 years) is larger than the gap for highway preservation (16.0 billion over 10 years). The implication of this is that at lower levels of funding, the HERS model would recommend investing a greater share of available resources in system preservation, rather than widening. However, if funding levels increased, there are a significant number of cost-beneficial widening projects that HERS would recommend funding.

Implications

The Cost to Maintain Interstate highways and bridges can be viewed as a "floor." This is the level of investment required to maintain the physical conditions of the Interstate assets already in place. However, operational performance would be expected to decline at this level of investment. The Cost to Improve Interstate highways and bridges can be viewed as a "ceiling." This level of investment would address all cost-beneficial highway investments and correct all bridge deficiencies. Investments above this level would not be expected to have a positive rate of return.

If current highway and bridge spending patterns remain constant, and the overall level of highway and bridge spending increases as predicted in this report, $126.0 billion (in constant 1997 dollars) will be expended for capital improvements to Interstate highways and bridges over the next 10 years. This level of investment would be 6.7 percent above the $117.5 billion Cost to Maintain level, but would need to rise 79.4 percent to reach the $226.0 billion Cost to Improve level. Using the analogy introduced above, this level of investment would lift us a little ways off the floor, but we would still be far away from the ceiling.

This study shows that if additional resources become available for capital improvements to the Interstate system, they could be utilized in a productive fashion. There is substantial room for improvement to highway and bridge conditions and performance in terms of improving pavement conditions, reducing bridge deficiencies, reducing congestion, and reducing the overall costs experienced by highway users traveling Interstate routes. Additional investment may also tend to have favorable impacts that are not modeled, such as improved system reliability and economic productivity.

Addressing Interstate System Needs

Much of the analysis in this appendix compares the needs identified in the two scenarios to projected spending on the Interstate System. Those projections of spending are based on the assumption that States will spend on the Interstate System the same proportion of the funds available to them in future years as they did in 1997. These comparisons provide a benchmark measure of the ability and willingness of States to apply the resources required to meet the scenario goals.

The following analysis examines how the structure and funding levels for the components of the Federal-aid Highway Program (FAHP) align with Interstate System needs: Would the level and categories of Federal funding enable States to meet Interstate needs? Are they likely, under the current demands across the systems, to do so?

To get a true picture of the current Federal funds available to address Interstate System needs, one must understand the FAHP structure overall. The Transportation Equity Act for the 21st Century (TEA-21) continued the longstanding trend in authorizing legislation which increased the flexibility afforded the States under the FAHP while providing a substantial increase in funding. First, a key characteristic of the FAHP is that project selection is clearly a State prerogative within the Federal funding categories and subject to the planning processes. Second, national priorities are expressed in the structure of the FAHP, with categories provided for key eligibilities which can be system-based or improvement-based (e.g., Interstate Maintenance, the National Highway System, the Highway Bridge Replacement and Rehabilitation Program). Third, TEA-21 increased the ability of States to transfer among program categories so that there is some flexibility allowed States to move funds from one eligibility category to another, depending upon competing demands on other systems and for other purposes.

Therefore, many categories can be used to fund specific types of improvements to the Interstate System but only the Interstate Maintenance (IM) category must be used for the Interstate alone. For example, improvements from the IM category can only be applied to system preservation or the addition of HOV lanes on the Interstate. Likewise, the only improvements made on the Interstate from the Highway Bridge Replacement and Rehabilitation Program (HBRRP) funds are for the repair or replacement of deficient bridges, including the addition of lanes on those bridges. States can choose to supplement IM with programs which have broad eligibilities, such as the Surface Transportation Program (STP) (essentially a block grant), on their Interstates. National Highway System (NHS) and HBRRP funds are routinely used for improvements off the Interstate System.

FAHP Funds Available for Interstate by Category

For purposes of this analysis, available Federal funds, by category, were projected for the 10-year period assuming that the FY 2003 funding levels in TEA-21 would be continued through 2007.

System Preservation

The IM Program was authorized specifically to fund preservation of highways on the Interstate System. The primary eligibilities are the resurfacing, restoration, rehabilitation, and reconstruction of existing Interstate System facilities. IM Program funding for the 10-year period 1998-2007 is estimated at $47 billion including the Minimum Guarantee funds that are added to the IM Program by law. When matched by State or local governments at a 90 percent Federal share, there would be an estimated $52 billion available for Interstate Maintenance activities for the 10-year period. This would cover the $49.1 billion highway preservation needs under the Cost to Maintain Scenario and fund about 16 percent of the additional highway preservation costs under the Cost to Improve scenario.

Widening

The IM Program funds described above may not be used to add lanes to the Interstate System unless those lanes are for high occupancy vehicles. The prime categories for Interstate widening in the form of single occupant vehicle lanes are the NHS Program and the STP.

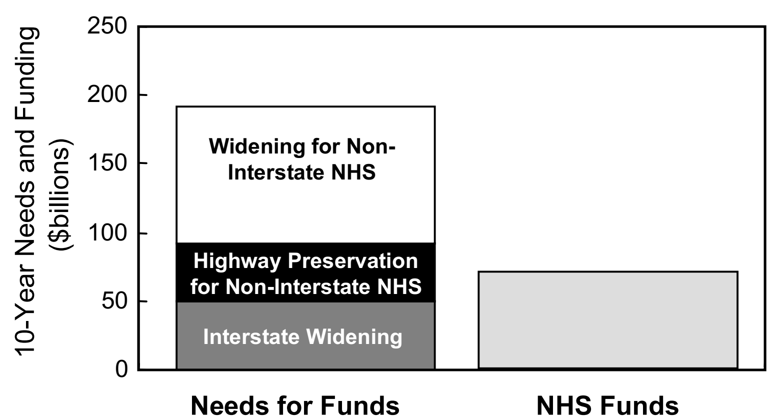
Projected authorizations for the NHS Program for the 1998-2007 are $56 billion, including the Minimum Guarantee funds that are added to the NHS Program by law. When matched by State or local governments at an 80 percent Federal share, there would be an estimated $70 billion available for activities eligible under the NHS Program. If about a quarter of the funds were used to fund widening the Interstate, the widening component of the Cost to Maintain scenario would be fully funded at $16.8 billion. With the Interstate System constituting about 29 percent of NHS mileage and serving over half of NHS vehicle miles of travel, the use of one-fourth of the NHS Program funding for Interstate widening seems reasonable.

Q. **If we use NHS funds for the widening in the Interstate Cost to Maintain scenario, will other NHS needs be met?**

A. Not completely. The remaining $39 billion of NHS funds would not quite cover the $43 billion in highway preservation needs identified in the Cost to Maintain scenario for non-Interstate NHS facilities (based on average annual NHS highway system preservation needs from Exhibit B-10 multiplied by 10 years). If States make system preservation their top priority, none of the system expansion needs in the Cost to Improve scenario could be funded from NHS funds. [See Exhibit A-19].

Exhibit A-19

NHS Funding Shortfall under Interstate Cost to Maintain Scenario



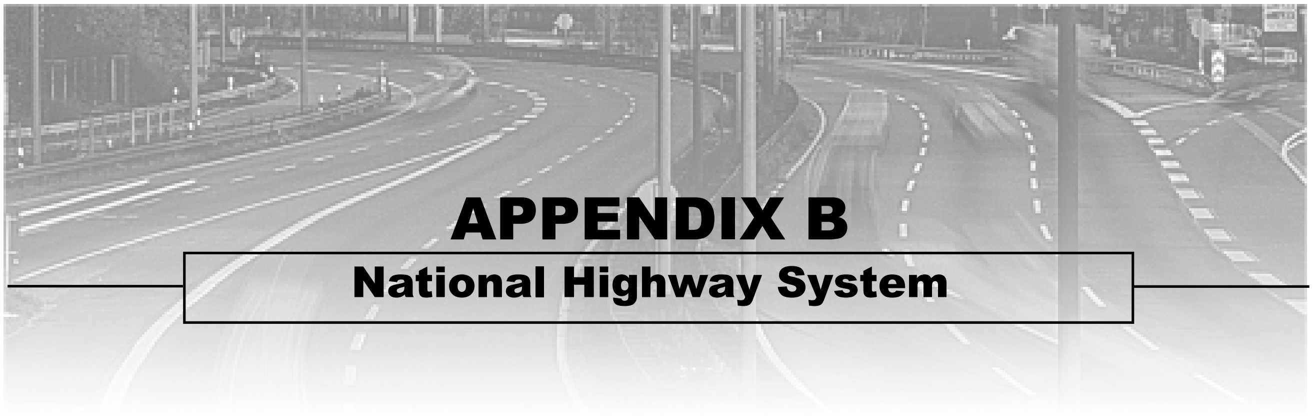
Bridge

The Highway Bridge Replacement and Rehabilitation Program provides funding for the repair or replacement of deficient highway bridges on Federal-aid highways–generally those roads functionally classified as arterials, urban collectors, or rural major collectors. The program may also fund bridge repair or replacement on roads that are generally not eligible for Federal-aid–roads functionally classified as rural minor collectors and local roads. In fact, States are required to spend at least 15 percent of their HBRRP funds (and not more than 35 percent) on such roads. Thus, the HBRRP serves a broader category of highway facilities than most other Federal highway programs.

Projected authorizations for the HBRRP for 1998-2007 are $38 billion, including the Minimum Guarantee funds that are added to the HBRRP by law. When matched by State or local governments at an 80 percent Federal share, there would be an estimated $48 billion available for activities eligible under the HBRRP. The $23.7 billion bridge component of the cost to maintain would require almost half of the available HBRRP funding. As Interstate bridge needs in the Cost to Maintain scenario are about half of total bridge needs (including local roads), States might choose to fully fund the Interstate bridge maintenance needs from HBRRP funds (see Exhibit 7-8).

Summary

The Interstate Needs identified in the Cost to Maintain scenario can be satisfied if 90 percent of IM, one-fourth of NHS, and one-half of HBRRP funds were targeted to this system. If States did so, they would be able to meet the Cost to Maintain scenario on the NHS overall only by supplementing their NHS funds with STP (or non-Federal) funds. Implementation of the Cost to Improve scenario for the Interstate System can be accomplished only at the expense of meeting Cost to Maintain needs on other roads and bridges.



APPENDIX B

National Highway System

Introduction

The National Highway System (NHS) was established by the National Highway System Designation Act of 1995. This system consists of the highways of greatest National interest, including all of the Interstate highways, a large portion of other principal arterial highways, and a small portion of mileage on the other functional systems.

This appendix presents NHS characteristics, conditions, operational performance, finance, and future investment requirement information in a similar format as used to present information on all roads in Chapters 2, 3, 4, 6, 7, 8 and 9. See these chapters for additional background material on the statistics presented in this chapter.

Personal mobility and safety information comparable to that included in Chapters 1 and 5 is not available for the NHS specifically. The type of sensitivity analysis described in Chapter 10 was not performed on the NHS investment requirements separately.

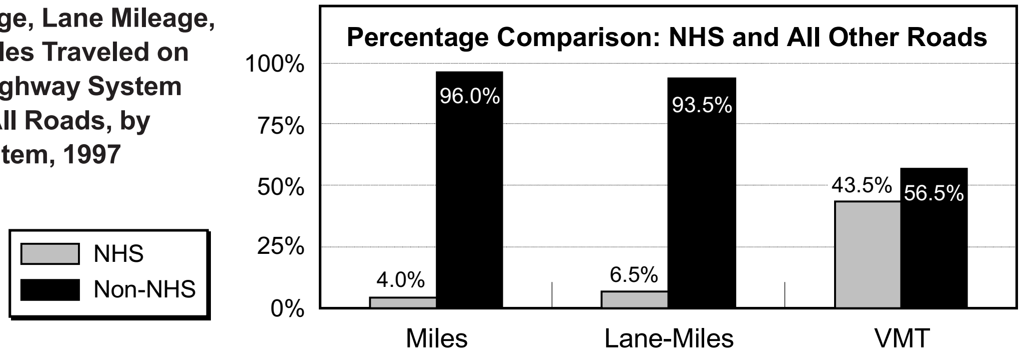
The Federal Highway Administration is currently working on a separate study of the conditions and investment requirements of NHS Freight Connectors. Some preliminary information on the conditions of these vital links is included in Appendix C.

System and Use Characteristics

While only 4.0 percent of total road mileage is on the NHS, these roads carry 43.5 percent of total vehicle miles traveled (VMT). Exhibit B-1 summarizes NHS route miles, lanes miles, and VMT by functional class.

Exhibit B-1

Highway Mileage, Lane Mileage, and Vehicle-Miles Traveled on the National Highway System Compared to All Roads, by Functional System, 1997



	Miles		Lane-Miles		Vehicle-Miles Traveled	
	Total on NHS	Percent of Functional Class	Total on NHS	Percent of Functional Class	Total on NHS (millions)	Percent of Functional Class
Rural NHS						
Interstate	32,919	100.0%	133,573	100.0%	241,451	100.0%
Other Principal Arterial	82,699	84.1%	213,854	85.9%	200,630	87.6%
Minor Arterial	1,703	1.2%	4,084	1.4%	3,494	2.1%
Major Collector	508	0.1%	1,148	0.1%	831	0.4%
Minor Collector	25	0.0%	59	0.0%	26	0.0%
Local	49	0.0%	102	0.0%	46	0.0%
Subtotal Rural NHS	117,903	3.8%	352,820	5.5%	446,478	44.4%
Urban NHS						
Interstate	13,395	100.0%	72,967	100.0%	364,769	100.0%
Other Freeway & Expressway	7,858	86.2%	36,339	87.8%	146,783	91.5%
Other Principal Arterial	18,801	35.2%	68,584	37.2%	152,747	39.4%
Minor Arterial	1,022	1.1%	3,146	1.4%	5,023	1.7%
Collector	243	0.3%	624	0.3%	733	0.6%
Local	119	0.0%	279	0.0%	159	0.1%
Subtotal Urban NHS	41,438	4.9%	181,939	9.6%	670,214	42.9%
Total NHS	159,341	4.0%	534,759	6.5%	1,116,692	43.5%

Source: June 1999 HPMS.

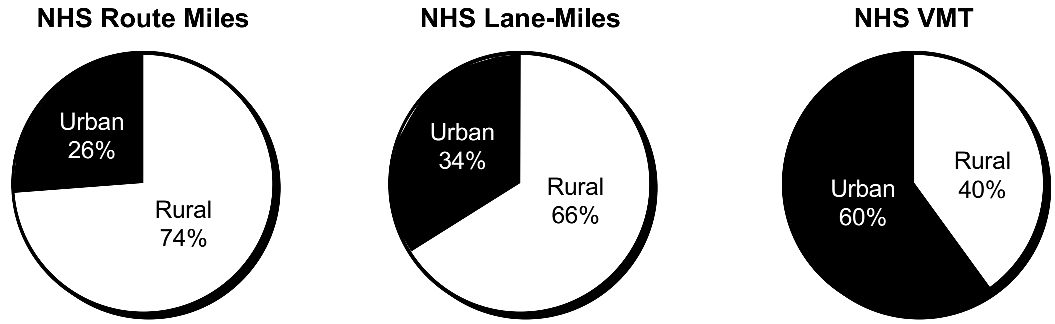
Exhibit B-2 shows how NHS mileage, lane miles, and VMT are split between rural and urban areas. While 74.0 percent of NHS mileage is in rural areas, and 66.0 percent of NHS lane mileage is in rural areas, only 40.0 percent of NHS VMT is in rural areas. Note that all areas over 5,000 in population are considered urban.

System Conditions

The *Federal Highway Administration 1998 National Strategic Plan* introduced a new descriptive term for pavement condition, “acceptable ride quality.” The Strategic Plan stated that by 2008, 93 percent of the NHS mileage should meet pavement standards for “acceptable ride quality.” In order

Exhibit B-2

Rural and Urban NHS Mileage, Lane Miles, and VMT, 1997



to be rated "acceptable" pavement must have an International Roughness Index (IRI) value less than or equal to 170 inches per mile. As shown in Exhibit B-3, the percentage of NHS miles with acceptable ride quality has increased each year from 1993 to 1995, improving from 88.7 percent to 91.7 percent.

Exhibit B-3

Percentage of NHS Miles with Acceptable Ride Quality, 1993-1997

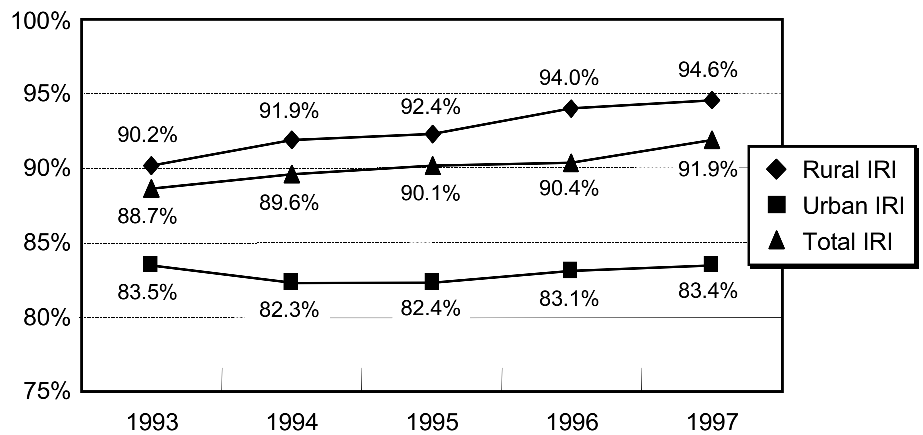


Exhibit B-4 presents information on NHS pavement condition, using the five categories (poor, mediocre, fair, good, very good) discussed in Chapter 3. In that chapter, different standards were applied to Interstate and non-Interstate highways for categorizing pavement, as described in Exhibit 3-3. In Exhibit B-4, the Interstate standards were applied to all NHS sections, regardless of functional class, so that all sections that did not meet the Strategic Plan standard for acceptable ride quality would be classified as "poor." Therefore, some non-Interstate NHS sections that were classified as "fair" in Chapter 3 would be classified as "mediocre" in this Appendix. Also, all non-Interstate NHS sections classified as "mediocre" in Chapter 3 are identified as "poor" in this Appendix.

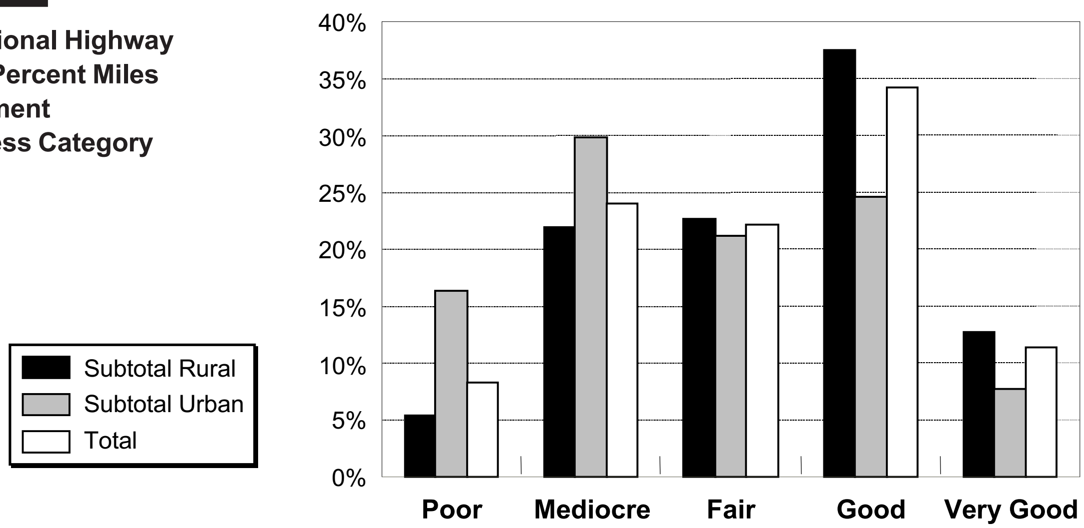
Rural NHS routes tend to have better pavement conditions than urban NHS routes, which is consistent with the results reported for all roads in Chapter 3. The percent of poor pavement for rural NHS routes is 5.3 percent, compared to 16.4 percent in NHS routes in urban areas. The Interstate component of the NHS tends to have better ride quality than the non-Interstate component. Pavement condition on the NHS improved between 1995 and 1997, as described in Exhibit B-5. The percent of pavement in poor, mediocre or fair condition fell from 60.3 percent to 54.4 percent. The percent of pavement in good or very good condition rose from 39.8 percent to 45.7 percent.

Q. **How do NHS pavement conditions compare with pavement conditions on other roads?**

A. The percent of pavement in "good" or "very good" condition in rural areas on the NHS is 50.1 percent, compared to 43.5 percent for all rural arterials and collectors. The percent of pavement in "good" or "very good" condition in urban areas on the NHS is 32.3 percent, compared to 35.4 percent for all urban arterials and collectors. Since the Interstate standards for categorizing pavement were applied to all NHS sections in this appendix, the percentages for "fair," "mediocre" and "poor" pavement aren't directly comparable to those reported in Chapter 3 for all roads.

Exhibit B-4

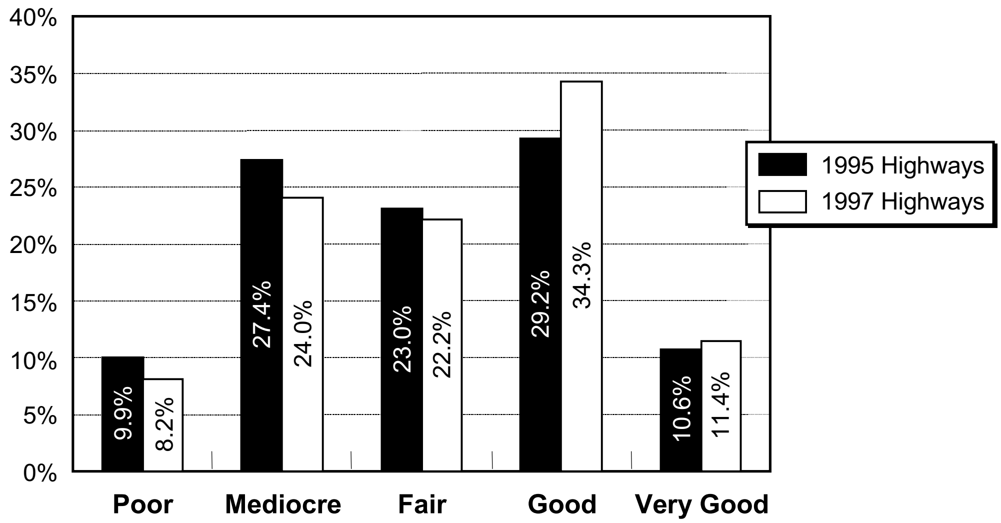
1997 National Highway System Percent Miles by Pavement Roughness Category



	Poor	Mediocre	Fair	Good	Very Good
Rural					
Interstate	3.7%	19.0%	20.2%	40.0%	17.0%
Other Principal Arterials	5.9%	23.0%	23.6%	36.8%	10.7%
Minor Arterials	11.7%	24.7%	15.7%	25.0%	23.0%
Major Collectors	13.2%	23.6%	23.3%	37.9%	2.1%
Minor Collectors	8.3%	50.0%	16.7%	33.3%	0.0%
Local	26.2%	26.2%	19.0%	14.3%	14.3%
Subtotal Rural	**5.3%**	**21.9%**	**22.6%**	**37.5%**	**12.6%**
Urban					
Interstate	9.2%	26.7%	23.6%	31.3%	9.2%
Other Freeways and Expressways	11.3%	34.0%	24.7%	25.6%	4.4%
Other Principal Arterials	23.6%	30.8%	18.1%	19.8%	7.6%
Minor Arterials	22.0%	25.6%	21.5%	18.4%	12.4%
Collectors	29.2%	29.2%	15.5%	14.9%	11.2%
Local	38.7%	14.7%	12.0%	17.3%	0.0%
Subtotal Urban	**16.4%**	**29.9%**	**21.2%**	**24.7%**	**7.6%**
Total	**8.2%**	**24.0%**	**22.2%**	**34.3%**	**11.4%**

Exhibit B-5

Comparison of 1995 and 1997 Pavement Condition on the NHS



Bridge Conditions

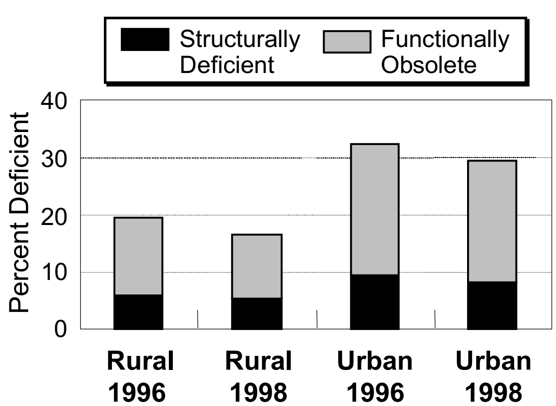
Bridge deficiency data are not yet available for the designated NHS. Exhibit B-6 contains information on bridge deficiencies for the interim NHS (including all Interstate and Other Principal Arterials). From 1996 to 1998 the share of total bridges that were deficient fell from 25.8 percent to 23.1 percent. Structural deficiencies fell from 7.6 percent to 6.9 percent, while functional deficiencies declined from 18.2 percent to 16.2 percent. Deficiencies in both rural and urban areas declined.

Q. **How do bridge conditions on the interim NHS compare with bridge conditions on other roads?**

A. Overall, the percent of deficient bridges is lower on the interim NHS (23.1 percent) than on all bridges in the Nation (29.6 percent). However, the percent of functional deficiencies is higher on the interim NHS (16.2 percent) than on all bridges (13.6 percent). Note that the interim NHS includes all Interstate and Other Principal Arterials.

Exhibit B-6

Interim NHS Bridge Deficiencies



	1996		1998	
	Number	Percent	Number	Percent
Rural Bridges	63,083		62,832	
Deficient Bridges	12,183	19.3%	10,521	16.7%
Structural	3,682	5.8%	3,387	5.4%
Functional	8,501	13.5%	7,134	11.4%
Urban Bridges	64,653		66,164	
Deficient Bridges	20,737	32.1%	19,325	29.2%
Structural	6,008	9.3%	5,509	8.3%
Functional	14,729	22.8%	13,816	20.9%
Total Bridges	127,736		128,996	
Deficient Bridges	32,920	25.8%	29,846	23.1%
Structural	9,690	7.6%	8,896	6.9%
Functional	23,230	18.2%	20,950	16.2%

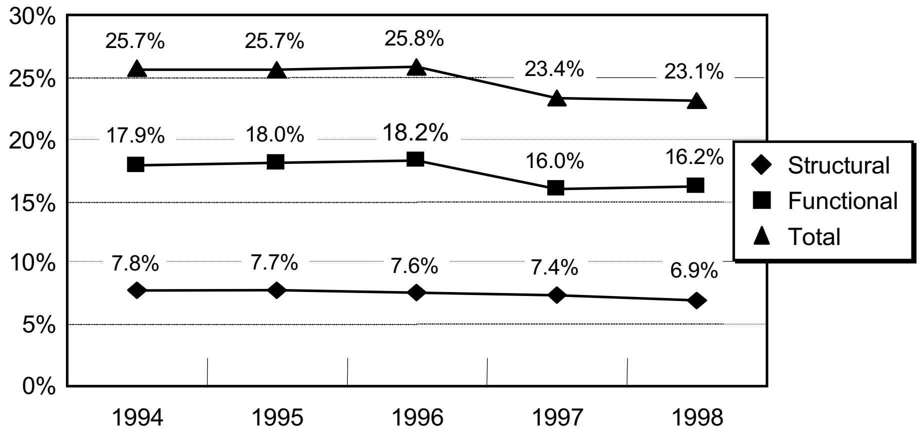
Source: National Bridge Inventory.

The *Federal Highway Administration 1998 National Strategic Plan* established a target to reduce the percentage of NHS bridges that are classified as deficient to 20 percent by 2008. As shown in Exhibit B-7, the percentage of bridge deficiencies on the NHS has declined from 1994 to 1998 from 25.8 percent to 23.1 percent.

Most of the reduction in the percent of bridge deficiencies occurred between 1996 and 1998. While structural deficiencies declined each year from 1994 to 1998, the percent of functionally obsolete bridges rose from 1994 to 1996, before declining in 1997.

Exhibit B-7

NHS Bridges: Percent Deficient, 1994-1998



Operational Performance

Chapter 4 introduced "delay" as a measure of highway operational performance. Delay is a modeled measure calculated as the difference between estimated average travel speed and free flow travel speed. In this report, delay is expressed in terms of vehicle-hours of delay per thousand VMT. Overall delay on the NHS declined from 4.397 to 4.368 hours per thousand VMT between 1995 and 1997.

Q. **How does delay on the NHS compare with delay on all arterials and collectors?**

A. Delay per thousand VMT is lower on the NHS (4.368 hours) than on all arterials and collectors (8.973). Delay is generally lower on the higher-ordered functional systems that make up the bulk on NHS mileage.

Volume/service flow (V/SF) is a measure of the severity of congestion. The V/SF is the ratio between the volume of traffic actually using a highway during the peak hour, and the theoretical capacity of the highway to accommodate traffic. This report has traditionally used a threshold value of 0.80 to describe the onset of congestion. Between 1995 and 1997, the percent of urban peak hour travel on the NHS that occurs in congested conditions rose from 44.9 percent to 45.2 percent.

Q. **How does the percentage of urban peak-hour congestion on the NHS compare to peak-hour congestion on all urban principal arterials?**

A. The percent of peak-hour urban traffic that operates at a V/SF greater than or equal to 0.80 is higher on the NHS (45.2 percent) than on all urban principal arterials combined (40.2 percent). The NHS includes the entire Interstate system, and V/SF ratios on urban Interstates tend to be higher than on other urban principal arterials.

Q. **How do the conditions and performance of NHS routes with heavy truck traffic compare to those with fewer trucks?**

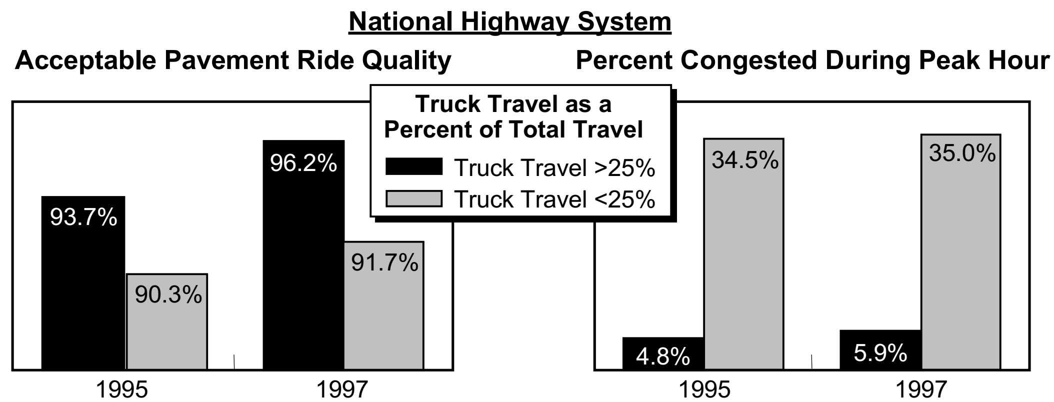
A. Approximately 20 percent of NHS mileage has truck traffic that exceeds 25 percent of total traffic on these routes. Exhibit B-8 compares the percent of pavement with acceptable ride quality and the percent of congested travel for NHS routes with 25 percent or more trucks with those with lighter truck traffic. As indicated earlier, to meet the FHWA Strategic Plan standard for acceptable ride quality, pavement must have an IRI value of 170 or less. In this exhibit, congested travel includes sections with a V/SF ratio of 0.80 or higher.

This exhibit shows that on the NHS pavement is in better condition on routes with high truck travel than on those with fewer trucks, and the portion of miles with smooth pavement increased from 1995 to 1997. While heavier vehicles cause more damage to pavement than lighter vehicles, routes most used by trucks are typically those with pavement with a higher strength than average, and that receive more than average attention from the appropriate jurisdictions for rehabilitation and maintenance.

The exhibit also shows that there is less congestion on routes with a high percentage of truck travel, but that the congestion on those routes is increasing. Truck drivers chose routes with less congestion when feasible.

Exhibit B-8

Conditions and Performance of NHS Routes With Heavy Truck Traffic



Finance

In 1997, all levels of government spent $22.5 billion for capital outlay on the NHS. This represents 46.2 percent of the total capital outlay on all roads. An estimated $9.1 billion of Federal grants to States and local governments was used for capital outlay on the NHS in 1997. This is the equivalent of 40.5 percent of the total capital outlay for the NHS.

Q. **How reliable is this NHS finance data?**

A. The overall NHS expenditure data are derived from annual expenditure reports provided by the States to FHWA. The reported NHS capital outlay figures were reduced for some States because they appeared to be reporting expenditures on the Interim NHS, rather than the smaller officially designated NHS. The $22.5 billion in this report appears consistent with the $20.3 billion shown in the 1997 C&P report.

The 40.5 percent Federal share of NHS funding was derived from an analysis of a new report of Federal obligations on the NHS developed from FHWA's Fiscal Management Information System (FMIS). This value is well below the 61.7 percent Federal share reported in the 1997 C&P report, which was estimated based on functional class data.

The newly developed data suggests that the Federal government is funding a smaller percentage of total capital expenditures on the NHS (40.5 percent) than of capital expenditures off the NHS (41.6 percent). This may be accurate, or there might be problems in the data that are making the Federal share of NHS capital expenditures appear smaller than it really is. If States have been over-reporting total NHS expenditures or if Federal obligations for some projects on the NHS have been coded in FMIS as if they weren't on the NHS, then the Federal share on the NHS identified in this report would be understated.

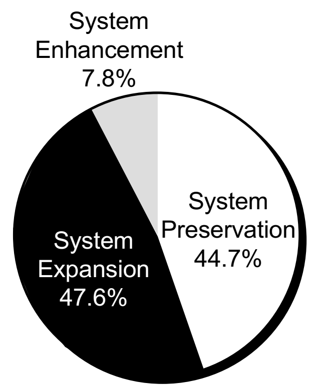
Investment Requirements

Of the $94.0 billion average annual Cost to Improve Highways and Bridges introduced in Chapter 7, $40.9 billion or 43.5 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 B-9 breaks down these totals into its separate system preservation, system expansion, and system enhancement components for rural and urban NHS routes.

Exhibit B-9

NHS Component of Cost to Improve Highways and Bridges (Billions of 1997 Dollars)

	System Preservation			System Expansion	System Enhance-ments	Total
	Highway	Bridge	Total			
Rural	$5.4	$1.5	$6.8	$6.2	$0.9	$13.9
Urban	$6.4	$5.0	$11.4	$13.3	$2.3	$27.0
Total	**$11.8**	**$6.5**	**$18.2**	**$19.5**	**$3.2**	**$40.9**



Distribution by Improvement Type

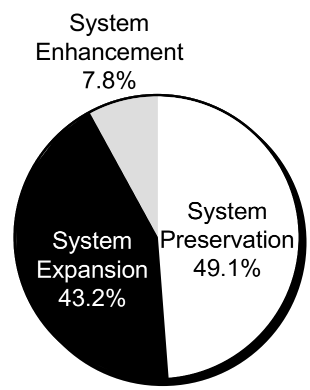
Of the $56.6 billion average annual Cost to Maintain Highways and Bridges discussed in Chapter 7, $26.8 billion or 47.3 percent is for the NHS. At this level of investment, average pavement conditions for highways overall would be maintained at current levels, and the current backlog of deficient bridges would be maintained. The highway and bridge investment scenarios attempt to maintain the overall system rather than individual functional class or the NHS. At the level of investment specified, average IRI on the NHS would improve by 9.8 percent, and average IRI on non-NHS sections would get worse.

Exhibit B-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 B-10

NHS Component of Cost to Maintain Highways and Bridges (Billions of 1997 Dollars)

	System Preservation			System Expansion	System Enhance-ments	Total
	Highway	Bridge	Total			
Rural	$4.2	$0.7	$4.9	$4.1	$0.6	$9.6
Urban	$5.0	$3.3	$8.3	$7.4	$1.5	$17.2
Total	**$9.2**	**$4.0**	**$13.1**	**$11.6**	**$2.1**	**$26.8**



Distribution by Improvement Type

Q. **Is the NHS component of the Cost to Maintain Highways and Bridges different than the results that would be obtained if only NHS sections were analyzed?**

A. Yes. As indicated earlier, investing at the level of the Cost to Maintain Highways and Bridges would maintain IRI for highways overall, but average IRI on the NHS would improve, and average IRI off the NHS would get worse. Using the same analytical approach but considering only NHS sections, the Cost to Maintain NHS Highways and Bridges would be $23.2 billion. This level of investment would be adequate to maintain average IRI on the NHS at current levels, as well as make equally cost-beneficial investments in system expansion and system enhancement.

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.

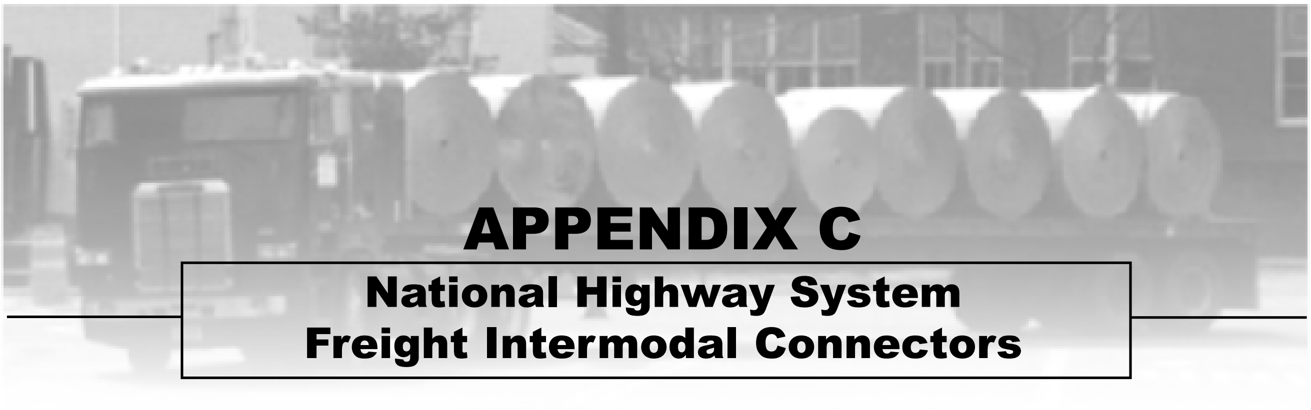
Comparison of Spending and Investment Requirements

Investment by all levels of government on the NHS would need to increase approximately $4.3 billion (19.1 percent) above the 1997 level of $22.5 billion to reach the level of NHS component of the Cost to Maintain Highways and Bridges. NHS investment would need to increase approximately 81.8 percent to reach the Cost to Improve Highways and Bridges. As shown in Exhibit B-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 for the NHS than for other roads. This difference is somewhat deceptive, because as indicated earlier, the recommended investment pattern for the Cost to Maintain would actually improve IRI on the NHS. Average annual investment on the NHS would only need to increase by 3.1 percent to $23.2 billion in order to maintain average IRI on the NHS at current levels.

Exhibit B-11

Average Annual Investment Required to Maintain and Improve Highways and Bridges Versus 1997 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 $1997)	$26.8	$29.8	$56.6	$40.9	$53.1	$94.0
1997 Capital Outlay	$22.5	$26.2	$48.7	$22.5	$26.2	$48.7
Percent Difference	19.1%	13.7%	16.2%	81.8%	102.7%	93.0%



APPENDIX C

National Highway System Freight Intermodal Connectors

Background

Section 1106(d) of TEA-21 enacted June 9, 1998, requires the Secretary to conduct a "review of the condition of and improvements made, since the designation of the National Highway System, to connectors on the National Highway System that serve seaports, airports, and other intermodal freight transportation facilities..." National Highway System (NHS) connections to major passenger and freight intermodal terminals were designated in November 1995 by the Federal Highway Administration in cooperation with the States and approved by Congress in TEA-21. Connections to 1407 major freight and passenger terminals were identified totaling 2032 miles. There were 519 freight terminals (port, rail, and pipeline facilities) approved by TEA-21. In addition, 100 major freight airports were identified in cooperation with FAA. An analysis of the condition of and the investments on the connectors is presented here. Additional analyses on the investment process and impediments to making investments is underway and will be reported to Congress in June 2000.

Data Collection

To obtain the information necessary to meet the requirements of Congress, it was decided that a field inventory of the freight connectors by FHWA Division Offices in each State was necessary. Inventory data was obtained for the following categories: connector condition, investment information, and the investment process. Much of the information was obtained from existing data sources maintained within the State DOTs, MPOs and possibly local jurisdictions when available. However, in most cases, on-site visits were needed to supplement available sources. The field inventory information was designed to be collected on a field visit and relies primarily on the observations and judgement of the field data collector.

Information on investments was critical to the study, however, there were difficulties associated with getting complete data, especially where local and private sector funding is involved. The Transportation Improvement Programs (TIPs) and Statewide Transportation Improvement Programs (STIPs) were the primary source of information. Since not all improvements are listed as separate projects on the TIPs and STIPs, they had to be supplemented with input from local agencies or private sources, or discussions with terminal operators where possible. The inventory also requested information on any perceived impediments to investments on connectors.

Connector Condition

Pavement Condition

This is a key element in the serviceability of a connector which can affect the speed of travel, and in the case of poor pavement condition, can cause damage to the vehicle and its contents. The rating of pavement was broken into five categories, primarily based on the speed that the truck could comfortably travel (See Exhibit C-1).

Exhibit C-1

Pavement Rating Categories

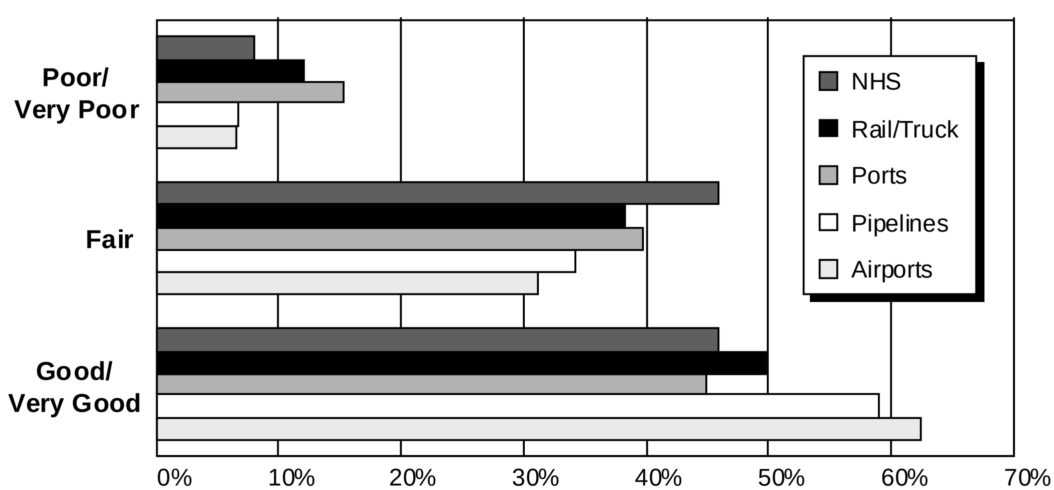
Very good	Newly built or resurfaced and distress free
Good	Smooth surface with little to no cracking or rutting
Fair	Serviceable with shallow rutting and moderate cracks beginning to occur, but does not affect travel speed on the connector
Poor	Same problems as fair but worse, causing some reduction in speed
Very poor	Major problems with potholes etc., causing substantial reductions in speed

For all the connectors inventoried, about half were considered good or very good, 37 percent were rated as fair, and 12 percent were rated as poor or very poor. The average for all of the NHS with poor/very poor rating is 8 percent. Fair pavements would be considered due for resurfacing and poor and very poor are past due for resurfacing and possibly reconstruction. Pavement condition by terminal type was also calculated.

While airports and pipelines were about average with 7 percent in the poor and very poor categories, rail/truck and ports showed 12 percent and 15 percent respectively. The poor and very poor rating are important because they cause reductions in the speed and efficiency of a facility and may also damage the vehicle and its contents (See Exhibit C-2).

Exhibit C-2

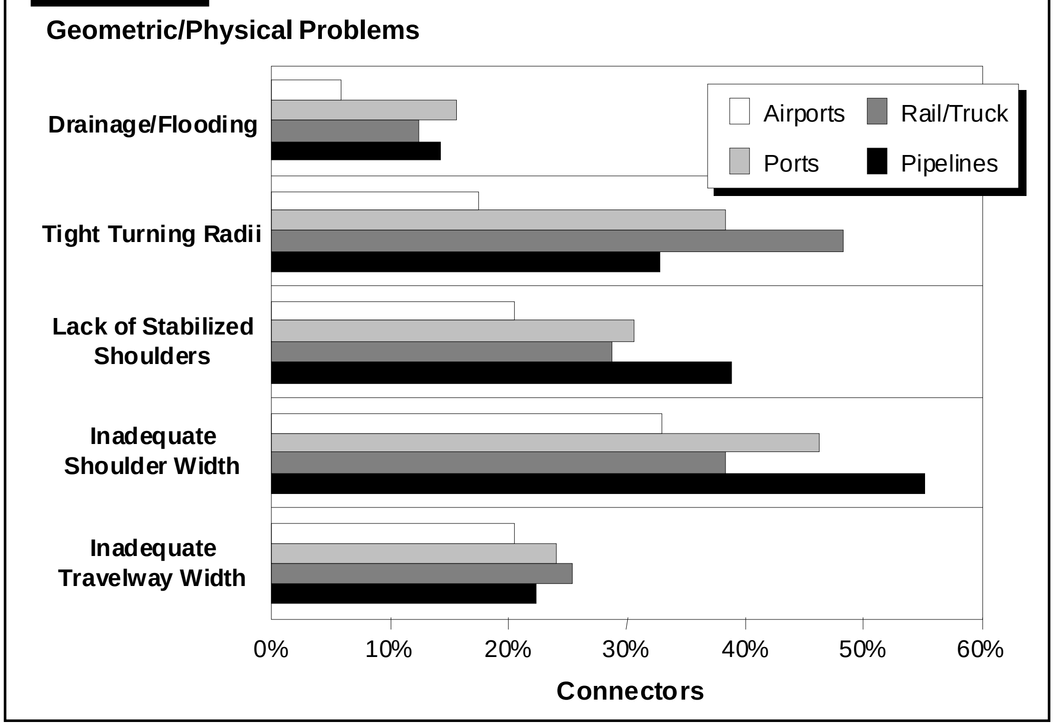
Pavement Conditions



Geometric and Physical

A list of physical features were listed on the inventory form. These items were checked when they were considered deficient. The top 5 problems are shown below.

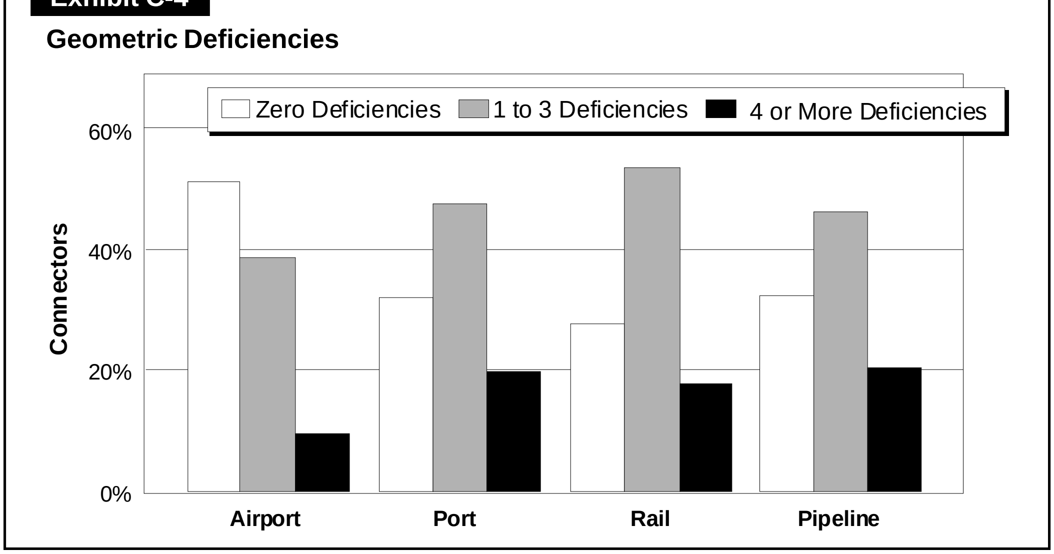
Exhibit C-3



Inadequate shoulder width (insufficient width to accommodate a parked truck without hindering traffic flow), turning radii (right turning trucks are required to make wide turns into adjacent lanes), and lack of stabilized shoulders (shoulder not paved or not able to support heavy trucks) were the most prevalent problems. Inadequate travelway width (roadway width is not adequate for two-way truck traffic) and flooding were also significant problems. Any one of these are a problem where heavy truck traffic is present.

A number of connectors also showed multiple deficiencies. Exhibit C-4 shows that almost half the terminals have at least 2 deficiencies and 10 to 20 percent have 3 or more deficiencies.

Exhibit C-4

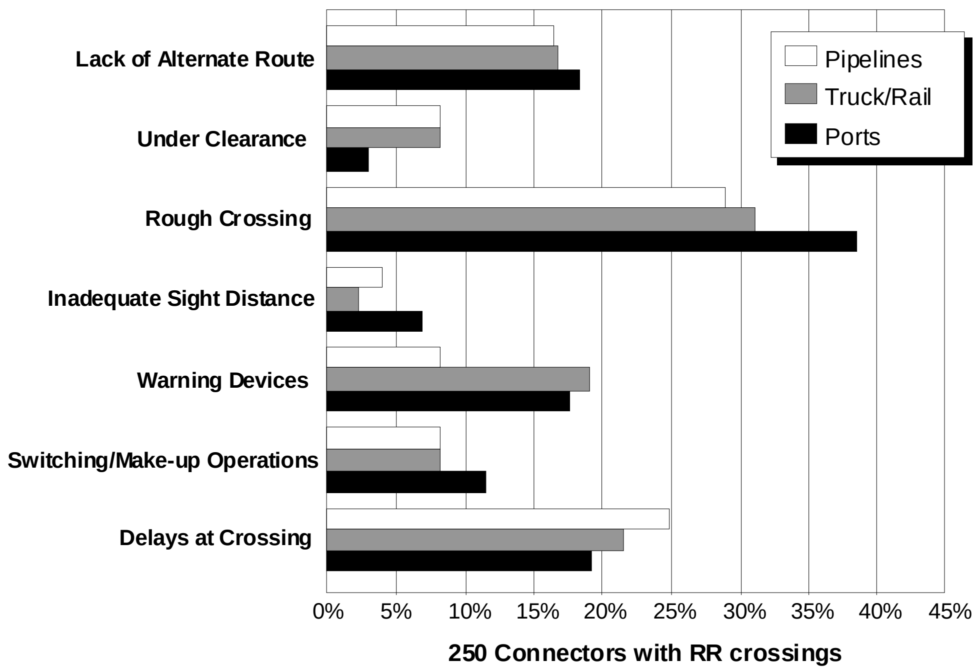


Railroad Crossings

Because of the presence of active railroad crossings near or adjacent to most freight terminals, they were evaluated as a separate category. There were 250 connectors with active crossings and 25 percent of the connectors had railroad crossing inadequacies (See Exhibit C-5).

Exhibit C-5

Railroad Crossing Problems



The most common problems were "rough crossing" (roughness or profile causes a significant reduction in speed to crossing vehicles), delays (delaying traffic for excessive periods), substandard crossing warning devices, and lack of alternative route if blocked by a train (extended delays that essentially block access to the facility). Lack of alternate routes, delays at crossings and switching/ make-up operations could seriously affect the operation of a terminal. The remaining items indicate a significant number of unsafe or substandard crossings.

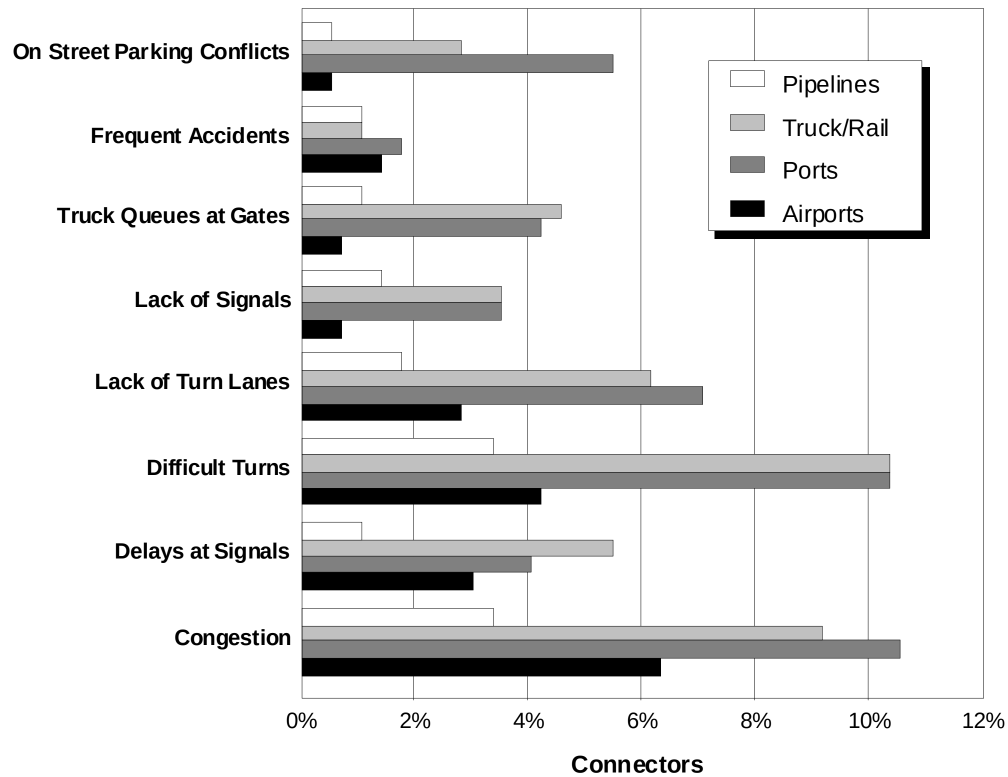
Traffic Operations and Safety

Over half of the freight connectors exhibited safety and/or operational problems. (See Exhibit C-6)

Heavy traffic, difficulty making left and right turns and lack of turning lanes were the most prevalent problems causing congestion on the connectors. Delays at traffic signals, on-street parking conflicts, and truck queues at facility gates are also shown.

Exhibit C-6

Operational Problems



Investment Information

Information on improvements made since the connectors were designated in November 1995 to the present and those programed for the next three years was requested. Investment levels by terminal type and funding source were gathered from State and MPO programing documents and other available sources. Exhibit C-7 shows funding by source.

Exhibit C-8 shows funding by terminal type.

To make a comparison with investment levels on the NHS system, the annual investments were calculated on a per mile basis. Exhibit C-9 shows annual investments per mile by terminal type for three years beginning in 1995.

When looking at average annual investments per mile on the overall NHS System of $141,500, connectors compare favorably. However, this may not represent what is occurring on the vast majority of connectors. To demonstrate this, the annual investment level without the five most costly projects was calculated. For example, these are "mega" projects like the Alameda Corridor and the San Francisco Airport connections that are not representative of investment activity on a typical connector. Airports seem to do the best but this may be due to the associated passenger activity and the importance of air travel to a community. Truck/rail is next best with a significant amount of work associated with modernizing and relocating terminals. The level of investment for ports appears to be very low ($40,628), less than 30 percent of the average for the NHS ($141,500), especially since ports exhibit the most deficiencies overall.

These investment levels on the connectors seem to indicate that there is significant under investment on freight connectors. The exhibit below may give some indication as to why this is occurring.

Exhibit C-7

Funding by Source*

	Past 3 Years	Next 3 Years
Federal	$229,272,642	$441,020,563
State	$81,576,843	$262,572,241
Local	$132,598,043	$177,403,774
Private	$134,810,000	$40,147,000
Total	**$578,257,528**	**$921,143,578**

* The "Past 3 Years" funding represents improvements made between November 1995 and late 1998, when the field inventory of the connectors was collected. For most connectors, funding identified for the "Next 3 Years" represents planned improvements for 1999 through 2001.

Exhibit C-8

Funding by Terminal Type*

	Past 3 Years	Next 3 Years
Airport	$230,229,157	$246,737,459
Pipeline	$19,122,800	$15,009,000
Port	$206,338,572	$391,364,621
Truck/Rail	$122,566,999	$268,032,498
Total	**$578,257,528**	**$921,143,578**

* The "Past 3 Years" funding represents improvements made between November 1995 and late 1998, when the field inventory of the connectors was collected. For most connectors, funding identified for the "Next 3 Years" represents planned improvements for 1999 through 2001.

Exhibit C-9

Annual Investment Levels Per Mile

Terminal Type	3-Year	3-Year w/out Top 5
Airport	$355,291	$80,731
Pipeline	$59,572	$12,483
Port	$136,129	$40,628
Truck/Rail	$119,811	$66,732
All NHS	**$141,500/mile**	

* The "3-Year" funding represents improvements made between November 1995 and late 1998, when the field inventory of the connectors was collected.

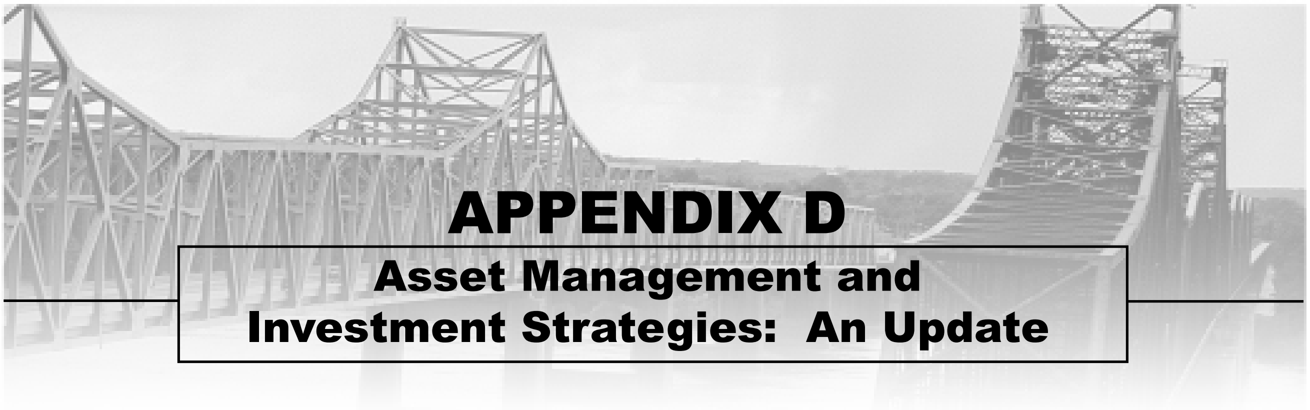
Exhibit C-10 shows that most connectors are owned by local governments, which may account for the low investments levels on freight connectors. Typically, local jurisdictions see freight as a private business activity which benefits the region and Nation as a whole. Since local roads are typically not a responsibility of the States, and in many cases cannot match Federal funding on local roads, they do not see freight connectors as their responsibility. States and MPOs often see freight as a lower priority because of the pressing needs of passenger travel.

Exhibit C-10

Freight Connector Mileage by Jurisdiction

Jurisdiction	Mileage	Percent
State	338	29%
Local	580	49%
State and Local	255	22%
Total	**1173**	**100%**

The inventory form also asked what factors contributed to needed improvements going unprogrammed. Those indicated from the survey form as to why this is occurring (in order of importance) are: 1) Low priority in State/MPO plans; 2) Lack of local match or sponsorship; 3) Lack of private sector participation; 4) Neighborhood-Community opposition; 5) Environmental concerns; and 6) Physical or Other Constraints.



APPENDIX D

Asset Management and Investment Strategies: An Update

Introduction

This document, the ***1999 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance Report (C&P Report) to Congress***, focuses 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 Report’s content does not include an explicit discussion of potential options appropriate for responding to anticipated system conditions and requirements.

This Appendix is the first in a series of updates on initiatives to expand State capabilities to meet highway and bridge user requirements through improved decision-making processes with respect to resource allocation, programming and project selection. Provided in this Appendix is an assessment of current practice: What do we have? How is it working? What do we need? How do we get there? Subsequent editions will report on State progress in specific areas such as implementing Engineering Economic Analysis (EEA) principles and techniques. EEA decision-support tools include life-cycle cost and benefit/cost analysis. In addition, future updates will address the extent to which the decision-making approach is oriented toward multi-modal considerations.

Current Practice
(What Do We Have?)

Much of the current paradigm for State-level transportation decision-making was defined by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 which required each State to develop a Statewide plan. Ideally, this plan presents a fiscally realistic vision, covering 20 years or more, of strategies for addressing a State's mobility and economic requirements. It reflects the full range of modal choices, covering for example highways, rail and transit. The plan also covers the management of existing assets to include maintaining, monitoring, and improving transportation system performance. This requirement for a statewide plan was continued under the Transportation Equity Act for the 21st Century (TEA-21).

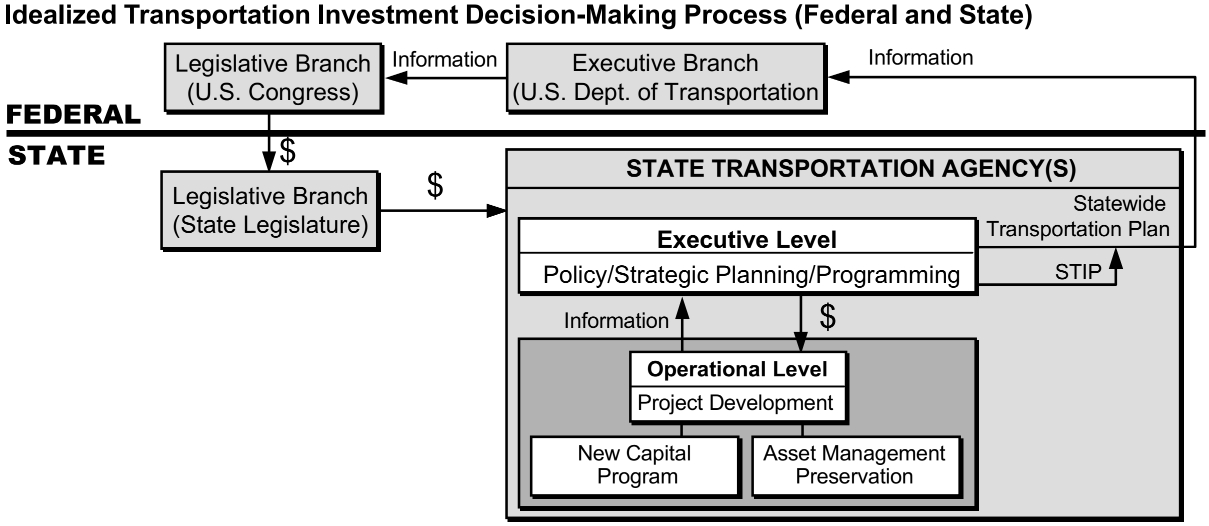
Also required by ISTEA and TEA-21 is a "financially constrained" Statewide Transportation Improvement Plan (STIP). This is a list of projects that a State plans to advance over, at minimum the next 3 years. The STIP must indicate the source of funding for included projects, as well as the financial plans for ensuring the continued operation and maintenance of the existing system. It is intended that the short-term capital investment and operational decisions provided in the STIP will be consistent with the policies and objectives delineated in the Statewide plan.

Most State highway agencies currently have some of the more common elements that provide information into the Asset Management process. The two most common are pavement and bridge management systems. These systems are intended to cyclically monitor the condition, measure the real-life performance, predict future trends, and recommend candidate projects and preservation treatments. In addition, many include analytical tools such as deterioration models and optimization algorithms designed to evaluate the impacts and trade-offs of current and future alternative policies, programs, and projects. All of these features are not, however, necessarily used in every State.

In summary, although each State has a unique approach to making transportation investment decisions, three dimensions are common to all highway agencies. First, each State has a long-term, strategic planning element that is intended to provide guiding policies and objectives. Second, each State has a requirement to produce a short-term program of projects intended for funding. And, finally, each State has mechanisms for evaluating and selecting projects for actual implementation. Underlying this general process are data and analyses as well as policy considerations. (See Exhibit D-1.)

Exhibit D-1

Idealized Transportation Investment Decision-Making Process (Federal and State)



Assessment of Current Practices
(How Is It Working?)

During the decades of the 1960s, 1970s, and even into the 1980s, transportation preservation projects were selected and developed without the benefit of today's vast technology expansion and the information resources made possible by the technical revolution in computers, automated data collection, testing equipment, design procedures, analytical tools, and so forth. Investment decisions were project driven, and asset preservation and upgrading were frequently by-products of facility expansion and new construction. Over the past two decades, progress in the planning and programming arena of system preservation, upgrading, and operation has been considerable, with asset management becoming a more important element in the State's overarching policies and transportation plans.

Today, most State transportation plans include more explicit policies and goals relative to asset management. However, the link between the transportation plan and actual programming and resource allocation decisions may be tenuous if state-of-the-art engineering, economic and business practices are not in place. The policies and objectives regarding Asset Management and investment are intended to guide project selection and development. In the past, transportation investment and maintenance decisions within and among asset classes tended to reflect tradition, intuition, personal experience, resource availability, and political considerations, with systematic application of objective analytical techniques applied to a lesser degree because of lack of availability. Further, success was often measured in terms of controlling backlogs, not in optimizing system performance, maximizing return-on-investment, or minimizing user impacts. Currently more States are developing performance measures and targets to guide the overall decision-making process.

Achieving the situation where programs and projects reflect predetermined goals and policies is difficult for a number of reasons. First, available analytical tools are subject to technical constraints related to data inputs, assumptions and theoretical understanding. Second, practical realities related to institutional considerations, social objectives, and political goals may circumvent the process. And, third the planning, programming, and project development process in many States must deal with antiquated data systems, disparate management systems (such as for pavements and bridges), and limited communication channels, especially along horizontal lines.

Technical Considerations

Although management systems, such as pavement and bridge systems, have been under development for many years and these systems have inherent investment analysis capabilities, few States use economic efficiency criteria to assess the relative merits of overarching alternative investment strategies within all asset classes, e.g., one highway facility versus another based on relative costs and benefits.

Most States limit application of their management systems to monitoring conditions and then plan and program their projects on a "worst first" basis. Existing management systems typically function at the operations level and focus on one particular asset. The current approach to asset management in general and resource allocation and investment analysis, in particular, is tactical rather than strategic.

Another technical issue facing State DOTs is the requirement for appropriately trained analysts with the ability to translate the results of complex analytical processes into relevant conclusions that can be readily understood by the lay person. Furthermore, it is important for the analysts to have a full understanding of the important concepts and techniques. States face some difficulty in finding and retaining staff with these capabilities due to the personnel situation described earlier.

Practical Realities

Beyond the technical hurdles, State practitioners are faced with a host of practical realities that confound objective, analytically based decisions. Institutional considerations, social objectives and political goals have the potential to dominate the resource allocation and project selection process.

Examples of institutional considerations include the legislative earmarking of Federal and State funds. In addition, State budgets generally cover time horizons of 1 to 2 years. Therefore, committing available funds over the long-term is difficult. The short budget cycle, combined with uncertain future funding levels, creates pressure to select the alternative with the lowest initial cost, regardless of total life-cycle cost and return-on-investment. In other words, the cost-effective solution may not be the most politically practical solution.

A further complication arises from the competition between political objectives and the technical decision-making process. For example, elected and appointed officials may find a strictly long-term perspective demanded by the analytical approach to be untenable. In addition, the public often measures the success of such officials by their ability to advance specific projects and services. As such, decisionmakers may prefer a process that will accommodate individual efforts, as opposed to a technical approach that does not specifically reflect such efforts. Long-term cost-effective solutions therefore may not be the most attractive because of competing policy objectives.

Integration

In many of the State DOTs, communication across asset classes (horizontal) and from the day-to-day manager to the highest executive (vertical) has historically been limited. This situation inhibits a systems approach to managing assets. States that have established management systems have done so by focusing on individual asset classes. The result has been so called “stovepipe” operations with limited horizontal coordination. For instance, bridge management systems were developed by bridge engineers and pavement management systems were produced by pavement engineers. Typically, there is little, if any, data exchange between systems. Furthermore, there is little consistency with respect to investment decision procedures. As a result, these systems are not able to evaluate trade-offs between various classes of assets, for example, highways versus bridges.

Complicating coordination across asset classes is the typical State DOT’s organizational structure. Many State DOTs experienced most of their growth and development during the Interstate Highway construction years. As a result, most of these organizations have budgets, staffs, and other internal resources that support the requirements of a highway construction program and are not necessarily geared to highway preservation and modal system efficiencies.

Improving the Process
(What Do We Need?)

"Asset Management" is a still-emerging concept in the highway industry. But at its heart, it provides a solid foundation from which to monitor the transportation system and optimize the preservation, upgrading, and timely replacement of highway assets through cost-effective management.

Although the transportation community continues to refine the definition of Asset Management as it gains more experience with it, the following "working definition" may be offered:

> Asset Management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning. [Source: Asset Management: Advancing the State of the Art into the 21st Century Through Public-Private Dialogue, Federal Highway Administration (FHWA) / American Association of State Highway and Transportation Officials (AASHTO) Sponsored Workshop, September 1996.]

An Asset Management decision-making framework is guided by performance goals, covers an extended time horizon, draws from economics as well as engineering, and considers a broad range of assets that include physical as well as human resources. Asset Management provides for the economic assessment of trade-offs between alternative improvements and investment strategies from the network- or system-level perspective—that is, between modes and/or asset classes within modes. At the same time, it allows for the more complete comparative analysis of options for individual projects.

Asset Management links user expectations for system condition, performance, and availability with system management and investment strategies. An Asset Management system will report on progress made in achieving goals and will also evaluate the process relative to the goals. Furthermore, the impact of alternative management and investment strategies on realizing the expressed goals may be readily determined and communicated.

The focus is on assets (dollars, people and physical resources) and system performance and includes return on investment, maximizing economic efficiency, accountability, opportunity costs and future requirements. This broad approach to resource allocation and programming decisions can provide greater value to the system and overall satisfaction for end-users. Program quality and system performance will improve.

Asset Management not only aides in the decision-making process, but also provides for a fact-based dialogue between system users and other stakeholders, State government officials, and managers concerned with day-to-day operations. This results from relevant, objective and credible information being accessible to all participants in the decision-making process. As such, decisions can be based on detailed input regarding available resources, current system condition and performance, and estimates of future performance. The information underlying Asset Management—sometimes raw data and other times data generated from the analytical process—results in an improved understanding of the economic trade-offs, return on investment and potential value of the end product.

Asset Management provides easy access to quantitative and qualitative data and allows decision-makers to more readily identify and focus on key issues. Further, the ability to weigh and articulate the impact of choosing one alternative over another through "what if" analyses is enhanced. And, importantly, the documentation explaining the selection of a particular strategy is improved. A fact-based, reproducible, systematic approach can enhance the dialogue among decision-making bodies regarding capital investment levels.

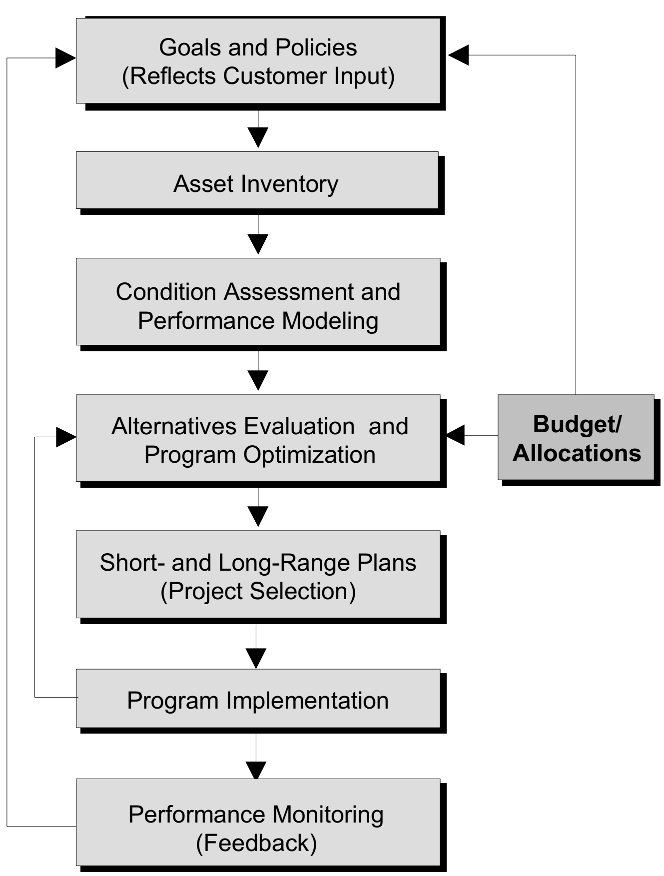
Distilled to its essence, Asset Management is a strategic, as opposed to tactical, approach to managing assets. The process works as follows: First, performance expectations, consistent with goals, available budgets and organizational policies, are established and used to guide the analytical process, as well as the decision-making framework. Second, inventory and performance information is collected and analyzed. This information provides input on future system requirements (also called "needs"). Third, the use of analytical tools and reproducible procedures produces viable cost-effective strategies for allocating budgets to satisfy agency needs and user requirements, using performance expectations as critical inputs. Alternative choices are then evaluated, consistent with long-range plans, policies and goals. The entire process is reevaluated annually through performance monitoring and systematic processes.

Exhibit D-2 illustrates a generic Asset Management system and lists key questions that inform the analytical process. The components are indicated as well as the relationships among them. Various issues, tools and/or activities are associated with each component. For example, "trade-off analysis" would include the application of an array of engineering economic analysis (EEA) tools including benefit/cost analysis, life-cycle cost analysis, and risk analysis.

Exhibit D-2

A Generic Asset Management System

SYSTEM COMPONENTS



KEY QUESTIONS

- What is our mission? What are our goals and policies?
- What is included in our inventory of assets?
- What is the value of our assets? What are their functions? What services do they provide?
- What was the past condition and performance of our assets? What is the current and predicted future condition and performance of our assets?
- How can we preserve, maintain, or improve our assets to ensure the maximum useful life and provide acceptable service to the public?
- What resources are available? What is the budget level? What is the projected level of future funding?
- What investment options may be identified within and among asset component classes? What are their associated costs and benefits?
- Which option, or combination of options, is "optimal?"
- What are the consequences of not maintaining our assets? How can we communicate the impact of the condition and performance of our assets on the system and end user?
- How do we monitor the impact of our decisions? How do we adjust our decision-making framework when indicated?
- How can we best manage our assets in order to least inconvenience the motoring public when we repair or replace these facilities?

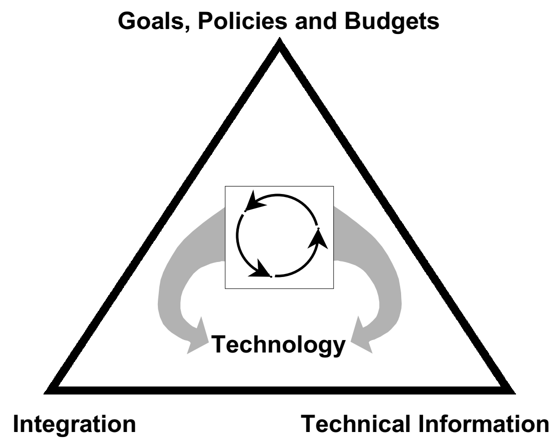
The components indicated would typically be included in any Asset Management approach, although the specifics of any given system would differ to suit a particular highway agency. States will define the parameters of their own systems based on State decision variables, such as policies, goals, asset types and characteristics, budgets and State operating procedures and business practices. Furthermore, any Asset Management system should be flexible enough to respond to changes in any of these variables or factors.

The assets likely to be included in a State's initial Asset Management implementation efforts will depend on the organization's existing capabilities, particularly in the area of technical, financial, and human resources.

What is needed to support the Asset Management approach is a logical sequence of decision steps constituting a decision framework. The framework is supported by (1) information regarding organizational goals, policies, and budgets; (2) horizontal and vertical organizational integration to implement the decision steps in practice; and (3) technical information to support the decision-making process. The critical inputs to the Asset Management decision-making framework are depicted in Exhibit D-3.

Exhibit D-3

Strategic Asset Management Framework Requirements



Technology enables an Asset Management system to function. Asset Management relies on technology in two key areas. First is the collection, storage and analysis of data. Data can be gathered more quickly with higher quality and spacial accuracy than ever before. These data can then be stored, retrieved and analyzed with powerful data servers and software. For example, with the advances in geographic information systems (GIS) and global positioning systems (GPS), the important spatial component of analysis can be more fully explored. With the development of faster and more capable computers, the application of more robust and sophisticated modeling software is possible.

The second important aspect of technology relates to the presentation and communication of the analytical results to decision-makers inside and outside the agency. Most DOTs have their computers on networks which allow for greater levels of communication than ever before. Again, advances in software, including GIS, allow for the presentation of these results graphically. Through advanced multimedia capabilities, today's software can effectively paint a picture of what the analysis predicts, markedly improving the communication of ideas.

The critical inputs to the Asset Management decision-making framework are addressed in the following sections.

Organizational Goals, Policies, and Budgets

Asset Management is a customer-focused, goal-driven management and decision-making process. Organizational goals, policies, and budgets establish a consistent evaluative philosophy. Goals and performance indicators are literally the levers that drive the Asset Management decision framework, establishing investment levels that reflect service levels and resource commitments consistent with the perceived needs of the public. Analysis procedures regarding alternative options are implemented within this framework.

Decisions regarding program investments are optimized according to goals established by elected officials and policy makers. Performance goals provide a way to convey to the public how DOT officials are managing the public's assets. Asset Management provides a logical, fact-based approach to dealing with and explaining the impact of the practical realities discussed earlier.

The success of program strategies and practices is measured by changes in performance and remaining structural life. Performance criteria and measures also help decision-makers identify and target critical system requirements.

Organizational policies may be thought of as a broad overlay to the process. Nonengineering/ noneconomic factors that reflect an agency's values, perceptions and predispositions may modify performance-based decisions. For example, established policies, or "rules of thumb," may direct an agency to select an investment alternative based on historic practice or other reasons. Also, management may assign noneconomic resource constraints to some asset components.

The key to establishing performance goals is determining user priorities, values and standards related to areas such as ride smoothness and overall level of service; travel time; overall system mobility; accessibility to the system; and availability of facilities. Goals may be defined in terms of the percentage of assets that meet agency performance levels, as one example.

Integration

Key to an Asset Management decision-making framework (see the triangle at Exhibit D-3) is organizational integration. The strategic orientation of Asset Management demands a system that (1) includes channels of communication which will transmit the overarching information required by legislators, the public and other stakeholders, agency executives, and front-line practitioners; and (2) will supply information and coordinating mechanisms across functions and asset classes within the organization.

The prevalent "stovepipe" approach to managing assets (discussed earlier), in which decisions are primarily driven by the objectives of individual organizational units, will be coordinated and integrated in an Asset Management approach so that communication occurs horizontally as well as vertically. A comprehensive, fully integrated Asset Management system weaves together information on all asset inventories, condition and performance databases, and alternative investment options.

Vertical communication channels start at the traditional asset management systems and continue to the highest executive-level decisionmakers. Vertical communication is essential to the success of Asset Management in two ways. First, effective communication between the various organizational levels will assist in overcoming implementation challenges by helping senior managers to understand the factors that drive decisions at the operational, or working level. Those workers on the frontline will be supplied the information necessary to appreciate the connection between the agency's strategic goals and tactical decisions resulting in particular actions. In this way, buy-in and support for incorporating Asset Management principles, concepts, and techniques into an agency's organizational culture and decision-making are facilitated.

Second, vertical communication is important in facilitating the flow of information from one level of the organization to another and beyond. Effective information flow within the DOT and from the DOT to the customer—the traveling public—is critical. Performance goals and measures, discussed in the preceding section, facilitate the education and involvement of users and decisionmakers.

Legislators and political appointees need information regarding the importance of long-term time horizons. An example of where this is important is in the need to communicate the merits of system preservation, needed upgrades, and continued operating reliability which customers expect of all the facilities and assets a highway agency manages. The relationship between preservation, upgrading, operation, and return on investment and customer satisfaction must be effectively articulated and clearly demonstrated to decision-makers.

Horizontal communication implies organizational integration and is important to the Asset Management decision-making framework because input from functions ranging from finance to planning to information management to human resources is required. To make Asset Management a viable process, managers in these various disciplines will need to be comfortable with Asset Management analyses and will need to incorporate the findings of an Asset Management process into their work. In addition, horizontal communication between those responsible for the various asset classes is crucial.

There are both opportunities and constraints facing organizations embarking on Asset Management systems. In particular, the component "stovepipe" structure provides a foundation from which to build more sophisticated data collection procedures and advanced analytical approaches. However, the stovepipe structure also fosters a sense of ownership and may discourage communication and cooperation.

State DOTs, however, have already begun to lay the groundwork in varying degrees for new formal or informal organizational structures. Many have recognized the value of communication as essential to a productive work environment and are engaged in reengineering their organizations consistent with these principles.

Technical Information

Since much data is already available, the goal is to take that data and convert it to information. This requires (1) the ability to collect, process and evaluate the data; (2) the analytical tools to evaluate and select the most cost-effective alternative investment strategies, both within and among program areas; and (3) the tools and expertise to effectively communicate this information to other groups who may not be familiar with the programs or situation. As indicated earlier, DOTs will build on current capabilities. Agencies will integrate the new with the old. They will also work to improve current approaches and tools.

Information Management

The technological strides made in information management—gathering, processing, analyzing, storing, retrieving and communicating enormous quantities of data—has made comprehensive Asset Management a feasible goal.

Asset Management is a data-intensive process and information management is at the center. It requires, for example, inventory-based information on all the assets in the portfolio of interest. This includes descriptions, types and numbers, functional responsibilities, and past, current and anticipated future condition and performance.

Many State DOTs have established databases and collection procedures that support existing component asset management systems such as for pavements, bridges and maintenance. States have made significant strides forward in deploying these systems, yet much remains to be done in terms of establishing mechanisms for bringing the data from these disparate systems to a common decision-making platform.

New Asset Management structures will build upon the existing systems and capabilities. The new tools will need to be compatible with the established systems. It is interesting to note that component management systems are not expected to be replaced, as they will continue to be appropriate for consideration of asset-specific issues such as those related to project design.

Asset Management requires much more than co-locating a collection of pavement, bridge and maintenance management capabilities under one umbrella. Improved information systems (including hardware and software), analytical tools, and interfaces between functions and asset classes need to be linked so the required information is communicated to the relevant decision-makers in a universally comprehensible form. This does not necessarily imply a single database; separate databases that include compatible referencing systems for information exchange may be appropriate. In addition to relational databases, key technologies in this area are likely to include GIS and GPS.

Questions about what data to collect, at what frequency, with what level of quality, and at what cost, need to be addressed in the context of what is required for the "bottom line" decisions. Data collection is not an end in itself. As indicated earlier, data collection procedures should be consistent with an agency's goals as expressed in their performance measures.

Analytical Tools

Engineering, economic and behavioral models are an integral part of an Asset Management-based decision-making process. Analytical tools used in the course of Asset Management relate investment to performance of the system. The fundamental objective is to maximize benefits for users while minimizing agency costs. Asset Management recognizes the impact that the condition and performance of the transportation system has on the user as well as the more traditional perspective which focuses on the impact that the user has on the system.

The analytical tools facilitate the discussion underlying the decision-making process by providing the ability to articulate the impact of choosing one alternative over another through engineering and economic-based "what if" analyses. Increasingly sophisticated analytical applications, greater understanding of key relationships and concepts, and improved procedures contribute to the ability to credibly calculate and report the results of alternative investment scenario evaluations. These tools provide a means of quantifying and communicating the importance of transportation investments to the public and decision-makers.

Engineering Economic Analysis (EEA) provides a broad collection of tools which collectively allow competing investment options to be prioritized according to relative economic efficiency levels. These tools include life-cycle cost analysis, benefit/cost analysis, optimization and prioritization, and risk analysis. These analytical procedures consider initial and discounted future agency, user and other costs (such as external costs) over the life of each alternative investment option. They attempt to identify the option that will achieve established performance objectives at the most viable long-term cost, or provide maximum benefit for a given investment/funding level.

EEA can also quantify the risk of not realizing, in practice, the level of benefits and costs predicted by the economic/engineering modes for the strategy implemented. There is inherent uncertainty in many of the assumptions—such as resource availability, costs, weather, and travel demand—that drive the engineering/economic models. The risk is important to decision-makers and should be provided for consideration. Risk analysis models can assist with this.

Forecasting Tools. Forecasting tools are critical to Asset Management, particularly those that relate future investment levels to future condition and performance. These tools help to assess the impact of say, inadequate routine maintenance and deferred capital maintenance. Examples include probabilistic and deterministic performance prediction models and traffic forecasting models.

Group Decision-Making Analytical Methods. As a cautionary note, implementing an integrated systems approach to investment analysis presents the potential of creating adversarial situations as a result of the competition between assets within and among modes or assets. This is most probable in the case of setting performance standards where higher or lower standards imply changes in funding levels. Objective tools are available to assist in conflict resolution by helping the parties to find "win-win" solutions where all participants gain.

It should be noted that while many of the above tools appear promising to Asset Management, some have not been tested in actual practice. Therefore, future research may be called for to ascertain their applicability.

Strategies for Implementation (How Do We Get There?)

Recent Federal and State Initiatives

The American Association of State Highway and Transportation Officials (AASHTO) and FHWA have made Asset Management a national priority. AASHTO is providing national leadership and guidance to States as they work to incorporate Asset Management principles and practices into their business process. The goal is to supply generic Asset Management approaches to organizational integration, performance-measure development, application of analytical tools, and information management. These generic processes and tools may then be directly utilized ("as is") or be applied after in-house and/or customized revisions. The potential advantage of adopting the generic approach is cost effectiveness, as well as the opportunity to share technical expertise and experience with other States.

Although the fundamental tenants of Asset Management will be visible in each State practicing the discipline, the assumptions made, the tools employed, and the information used will vary from State to State. Each State will bring its unique organizational strengths and perspective to the implementation process. In addition, each State's Asset Management system will reflect its unique decision-making process. One size will never "fit all" in State Asset Management.

AASHTO and FHWA jointly sponsored two major executive workshops in 1996 and 1997 to explore and benchmark the application of Asset Management in transportation agencies. These workshops introduced the Asset Management concept and provided information on private-sector activities in this area. The first workshop emphasized the importance of a comprehensive approach to managing the Nation's transportation system. Participants included high-level executives from AASHTO, FHWA and State DOTs and leaders in Asset Management from non-transportation sectors that shared Asset Management-related concerns with the transportation community.

During the second conference, participants were charged with evaluating current Asset Management practices and techniques. As discussed earlier in this Appendix, the current approach to managing assets is component-by-component. Participants also began to explore what an integrated, comprehensive approach to managing assets might mean for their agencies. A major goal of the workshop was to formulate a strategy for advancing Asset Management as a national initiative. AASHTO responded to input from this conference with the establishment of an Asset Management Task Force, development of a Strategic Plan, and sponsorship of an Asset Management Guide for State Transportation Agencies.

The AASHTO, with technical assistance from FHWA, is sponsoring a National Cooperative Highway Research Program (NCHRP) project to develop the Guide [NCHRP Project 20-24(11)]. The objective of this project is to provide:

- A synthesis of current Asset Management practices and available tools;
- A framework for an Asset Management system;
- Recommended research for filling gaps in existing knowledge and developing tools for the next generation of the Guide; and

- A first generation Asset Management Guide for use by AASHTO member agencies which will (1) offer advice on how to effectively apply and/or enhance Asset Management principles to their unique organizations; and (2) highlight case studies of best practices among the States.

This work will lay the foundation for defining initiatives to advance integration efforts within State DOTs. Upon completion of the NCHRP activity in 2001, AASHTO, in consultation with FHWA, will determine the appropriate next steps to continue to assist the States in advancing Asset Management.

The executive workshop series is recognized as a valuable forum for exchanging information and was continued with a peer review seminar in December 1999 that focused on current State capabilities in various aspects of Asset Management to include:

- Moving from a concept to an action plan
- Integrating maintenance management systems
- Integrating management systems
- Integrating data
- Assessing preservation and improvement trade-offs.

Details of State experience in these areas were shared as part of the peer exchange.

American Association of State Highway and Transportation Officials Initiatives

AASHTO has traditionally set standards and provided guides for many different aspects of transportation system design, construction, management and investment. This information provides a point of reference and guidance for AASHTO member agencies as they develop their own approaches; AASHTO standards and guides are intended to suggest and not to mandate.

In this context, AASHTO is assisting States in improving their business practices through the advancement of Asset Management principles and practices. AASHTO has taken the lead in bringing together States and facilitating knowledge sharing and resource pooling to enhance existing tools and procedures and to develop new approaches and tools.

Task Force

On November 16, 1997, AASHTO created an Asset Management Task Force of nine experts drawn from State DOTs. The Task Force's mission is to provide guidance for State Asset Management activities and develop and distribute to member States innovative Asset Management approaches, processes, and tools. Early work has included organizing the executive seminars which were discussed earlier, developing a strategic plan (see below) and sponsoring the NCHRP Guide, also discussed previously.

Strategic Plan

In November 1998, the AASHTO Board of Directors approved an Asset Management Strategic Plan. The plan establishes AASHTO's vision, mission, goals and it recommends actions regarding Asset Management. It also points the way toward work that will fill technological gaps.

The goals specified in the Strategic Plan are to (1) document the state-of-the practice; (2) conduct major seminars and information sharing; (3) develop an Asset Management guide that will document the state-of-the-practice and state-of-the-art and will bridge the gap between the two; and (4) provide needed training.

Federal Highway Administration Initiatives

In conjunction with AASHTO efforts and as part of the Agency's reorganization, the FHWA created an Office of Asset Management in February 1999. The Office affirms the Agency's commitment to partnering with AASHTO to advance Asset Management principles. The Office's primary role is to provide technical assistance by developing tools, techniques, training and consultative services to the States, as they work to adopt a comprehensive, fully integrated Asset Management program.

The Federal government is uniquely suited to provide technical assistance in the area because all 50 States can benefit from a nationally coordinated technical program, rather than 50 disparate efforts. Although the States own and operate the assets targeted by Asset Management, AASHTO has asked FHWA to help with research and development, training and other technical areas because of the expense and requirements for staff expertise associated with these activities.

The Office is composed of a multidisciplinary staff drawn from economics, engineering, policy, planning, and technology assessment areas. Three teams make up the new Office:

- System Management and Monitoring;
- Construction and System Preservation; and
- Evaluation and Economic Investment.

The teams work together on overlapping activities.

The Construction and System Preservation Team is responsible for construction and maintenance, technical support and outreach, quality management, pavement smoothness and system preservation. FHWA has placed a special emphasis on preservation as the Agency's mission has shifted from building the Interstate System to preservation of infrastructure assets. The National Qaulity Initiative (NQI), a partnership effort among AASHTO, FHWA, and related industry associations, is housed within this team. The NQI objective is to focus attention on continuous quality improvements within the highway industry. New team initiatives include the establishment of a joint AASHTO/Industry/ FHWA agreement for optimizing highway performance.

The System Management and Monitoring Team is charged with refining and advancing pavement and bridge management systems and with developing and promoting new systematic approaches for assets where they presently do not exist, such as for tunnels and roadway hardware. The team is partnering with States and FHWA field units to develop a toolbox for implementing the new AASHTO pavement standards for the International Roughness Index, rutting, faulting, and cracking that were issued in the summer of 1999. In a related area, the team initiated a pilot study with selected States and with FHWA's Office of Pavement technology to analyze the real-life performance of Superpave pavements through the use of PMS data as an "engineering analysis tool." This project will also demonstrate how PMS data can be used as input to future pavement designs.

The Evaluation and Economic Investment Team's portfolio includes outreach activities designed to explain and promote Asset Management. It also has the lead in developing, recommending and advancing initiatives to facilitate Asset Management principle-centered strategic investment decisions. Two primary tracks have been identified: (1) identification and development of procedures to facilitate horizontal and vertical integration and (2) development and promotion of an array of procedures for inclusion in an EEA toolbox, such as life-cycle cost analysis and benefit/cost analysis.

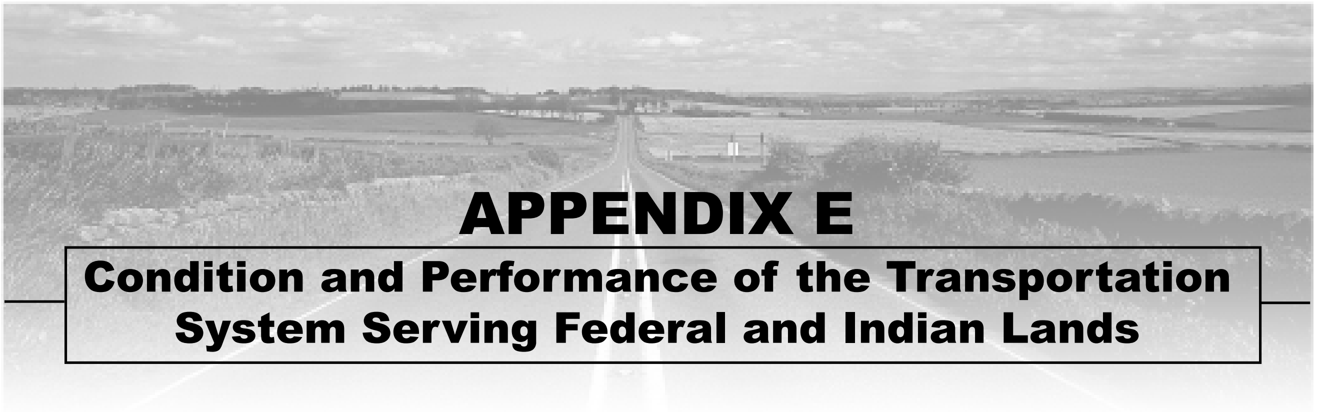
Essential to the FHWA Office of Asset Management are cooperative programs with AASHTO, the Transportation Research Board, industry, and other Federal and State agencies to support and advance Asset Management.

Conclusion

AASHTO and FHWA are convinced that Asset Management is a better way of doing business. An Asset Management philosophy focuses on the benefits of investment as well as its costs, and takes a comprehensive view of the entire portfolio of transportation resources. Objective, fact-based tools and techniques are systematically applied to determine how best to deploy available resources in order to achieve system-wide agency goals. Asset Management is an improved way of doing business that responds to an environment of increasing system demands, aging infrastructure and limited resources.

Asset Management also provides the ability to show how, when and why resources were committed. Transportation officials are being held increasingly more accountable to their customers—the American public. The public demands a high return on the portfolio of transportation assets which, of course, represents a collection of public resources.

Making Asset Management a reality requires new information and analytical tools, new approaches to organizational communication, and new management practices. AASHTO and FHWA are both committed to continuing to work together as partners to identify knowledge gaps, develop and fund a long-term research agenda, and assist the States in implementing new tools, techniques and enhanced management approaches and business practices in Asset Management.



APPENDIX E

Condition and Performance of the Transportation System Serving Federal and Indian Lands

Introduction

This appendix documents the surface transportation system serving Federal and Indian lands. It begins with a discussion of the various types of Federal lands, then addresses the role these areas play in the U.S. economy. It then examines the transportation system on Federal lands, assessing its role, condition, funding sources, construction and maintenance expenditures. The conclusion includes an outlook on the future of the transportation system on Federal and tribal lands. The following acronyms are used in this appendix:

Acronyms

BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
COE	U.S. Army Corps of Engineers
CRR	Corps Recreation Roads (COE Roads)
DOA	Department of Agriculture
DOD	Department of Defense
DOI	Department of the Interior
FDR	Forest Development Roads
FLHP	Federal Lands Highway Program
FH	Forest Highway
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
IRR	Indian Reservation Roads
LMHS	Land Management Highway System
MIR	Military Installation Roads
MTMC	Military Traffic Management Command
NPS	National Park Service
RR	Refuge Roads
PFAR	Public Forest Access Roads
PLDR	Public Lands Development Roads
PLH	Public Lands Highway Program (Discretionary Program)
PRP	Park Roads and Parkways

Q. **Are the pavement conditions percentages presented in this appendix developed using the IRI and PSR standards discussed in Chapter 3?**

A. No. The pavement condition ratings are based on separate analyses performed by each of the Federal Agencies. These may not be fully consistent with those reported by States in the Highway Performance Monitoring System.

Q. **Are the figures cited for "backlog" in this appendix fully consistent with the investment backlog for all highways identified in Chapter 7?**

A. No. The backlog figures are based on separate analyses performed by each of the Federal Agencies. The Highway Economic Requirements System (HERS) model was not used to develop the backlog estimates in this appendix.

Characteristics of Federal Roads and Lands

The total area of the 50 States is 2.3 billion acres, of which the Federal Government has title to about 650 million acres. Federal lands, representing about 29 percent of the country's area, are overwhelmingly located in the Western United States. Indian lands make up about 2 percent of the country's area. Exhibit E-1 summarizes the various Federal and Indian lands. Exhibit E-2 summarizes the types and condition of roads serving these areas.

Exhibit E-1

Types of Lands Managed by Federal Land Management Agencies

Federal Land Agency	Federal Lands Served
Department of Agriculture	
Forest Service (FS)	155 National Forests and 20 National Grasslands
Department of the Interior	
National Park Service (NPS)	378 National Parks and Monuments
Bureau of Indian Affairs (BIA)	560 Federally Recognized Tribes and Indian Villages
Fish and Wildlife Service (FWS)	553 Wildlife Refuges and Wetlands Management Districts, 67 Fish Hatcheries and 43 Administrative Sites
Bureau of Land Management (BLM)	264 million acres of public lands
Bureau of Reclamation (BOR)	348 Dams-reservoirs, 308 recreation sites, and 59 power plants
Department of Defense	
Military Installations	500 Military Installations
US Army Corps of Engineers (COE)	
COE Facilities-Civil Works	463 lakes

Federal lands are managed by various Federal Land Management Agencies (FLMA) within the Departments of the Interior, Agriculture, and Defense. Most Indian lands are held in trust by the Department of the Interior or Native Alaska corporations.

Resources Served Within Federal and Indian Lands

Federal and tribal lands have many uses. These include: recreation, grazing, timber harvesting, mineral extraction, energy production and watershed, fish and wildlife, and wilderness protection. Indian communities, villages, and small towns are located in or surrounded by these lands. These lands are also managed to protect natural, scenic, scientific, and cultural resources. Over the past ten years, resource extraction and timber cutting have been significantly reduced. At the same time, recreation use has significantly increased. Exhibit E-3 summarizes uses for Federal and tribal lands.

Many of these areas have multiple uses, while others have a very limited, specific purpose. Approximately one-half of Federal lands are managed under multiple use and sustained yield policy, which relies on effective transportation. The remainder have protected use management policies, but even so, transportation systems are essential to their resource management, development, recreational use and protection. About 2 million Native Americans and military personnel live on these lands.

Role of Federal Lands in the U.S. Economy

Travel, tourism, and recreation are among the largest industries in the United States. This sector ranks third in retail receipts behind automobile and food sales, generating over $450 billion annually. The travel, tourism, and recreation industries can claim a share of many other industry sectors, including transportation, lodging, communications, power, manufacturing, and construction. Travel and tourism

Exhibit E-2

Summary of Roads Serving Federal and Indian Lands

Federal Land Management Agency		Length	Paved	Condition Paved Roads			Bridges	
Road Category	Owner	Miles	Miles	% Good	% Fair	% Poor	Number	% Defic.
Department of Agriculture								
National Forest								
FH	State/Local	29,200	21,400	20	60	20	4,200	48
PFAR	FS	83,000	8,000	25	50	25	5,100	15
FDR	FS	302,000	20,000	25	50	25	2,600	
Department of the Interior								
National Park Service								
PRP	NPS	8,127	5,139	38	22	40	1,252	35
Bureau of Indian Affairs								
IRR	BIA	23,000	5,500	34	37	29	753	19
IRR	State/Local	25,600	10,150				3,362	27
Fish and Wildlife Service								
Public Roads	FWS	5,900	500	30		70	530	
Administrative Rds	FWS	3,100						
Bureau of Land Management								
PLDR	BLM	83,000	1,700	20	30	50	589	6
LMHS	State/Local	7,200	3,600	29	45	26	100	7
Bureau of Reclamation								
Public Roads	BOR	1,980	1,000	65	25	10	600	10
Administrative Rds	BOR	8,000	800	20	40	40	3,900	
Department of Defense								
Military Installations								
MIR	DOD	23,000	23,000	55	25	20		
US Army Corps of Engineers								
COE Recreation Areas								
CRR	COE	4,800						
Leased Roads	COE	3,600					250	50

is the largest employer in 11 States and is the third largest employer nationwide. Over 6.6 million people are employed with an annual payroll exceeding $120 billion.

Approximately 94 percent of Americans over the age of 16 participate in outdoor recreation. More than 10 percent of all consumer spending is on recreation and entertainment, totaling over $40 billion annually. Recreation is one of the fastest growing sectors of the United States economy, expanding at a rate of 5 percent annually. Travel and tourism is also an integral part of many local economies in communities adjacent to Federal and Indian lands.

Travel, tourism, and recreation are heavily dependent on federally owned lands. For example, Federal lands accommodate over 20 percent of recreation activities in the U.S. This percentage is measured in recreation visitor days (RVD). A RVD is equivalent to a 12-hour visit.

The various FLMAs contribute in different ways to travel and tourism:

- **National Park Service** (NPS) areas receive more than 273 million visitors annually, generating more than $5.5 billion annually to local communities. Recreational use in the national parks is expected to double by 2020. As the larger and more popular parks become more crowded, emphasis may shift to other lesser known national parks, nearby State facilities, gateway communities, and private recreational facilities.

Exhibit E-3

Federal and Indian Land Use

Federal Agency	Recreation	Timber	Minerals & Oil	Grazing & Farming	Water Resource	Wildlife	Energy	National Defense	Housing	Industry
	Other Land Uses									
Department of Agriculture Forest Service	✓	✓	✓	✓	✓	✓	✓		✓	
Department of the Interior National Park Service	✓				✓	✓			✓	
Bureau of Indian Affairs	✓	✓	✓	✓	✓	✓	✓		✓	✓
Fish and Wildlife Service	✓	✓	✓	✓	✓	✓	✓			✓
Bureau of Land Management	✓	✓	✓	✓	✓	✓	✓			✓
Bureau of Reclamation	✓				✓	✓	✓			
Department of Defense Military Installations	✓				✓	✓		✓	✓	
US Army Corps of Engineers COE- Civil Works	✓				✓	✓	✓			

- The **Bureau of Land Management** (BLM) estimates that outfitters and guides provide between $50 and $60 million in public land related revenue to the 11 western States. The combined uses of BLM lands annually generate over $1.3 billion in receipts, of which $740 million is shared with State and county governments. Economic benefits on BLM lands from travel and tourism exceed $3.3 billion.
- The **U.S. Fish and Wildlife Service** estimates that visits to the National Wildlife Refuge System generate over $370 million to the economy.
- Visitors spend over $12 billion during recreation visits to areas near **U.S. Army Corps of Engineers** (COE) facilities.

In addition to the benefits from recreation, travel and tourism, Federal lands provide resources for grazing, timber harvesting, oil extraction, mining, electrical generation, and other related activities. In many instances, a portion of the receipts are returned directly to local governments. Exhibit E-4 summarizes recreation and related economic benefits.

Exhibit E-4

Economic Benefits of Federal and Indian Lands(1)

Federal Agency	Recreation: RVD (Million) 1994	Recreation: Economic Benefits ($ Billion)
Department of Agriculture		
Forest Service	288	45.0
Department of the Interior		
National Park Service	116	5.5
Bureau of Indian Affairs	(2)	
Fish and Wildlife Service	34	0.4
Bureau of Land Management	72	3.3
Bureau of Reclamation	22	6.0
Department of Defense		
Military Installations	53	
US Army Corps of Engineers		
COE - Civil Works	192	12.0

(1) Economic benefits include lodging, food, entertainment, recreation, and incidentals expended during travel.

(2) Travel, tourism, and gaming are emerging areas on American Indian lands. Statistical information is not available.

Role of Transportation in the Use of Federal and Tribal Lands

The recreation, travel and tourism industries depend on a quality transportation infrastructure. Nearly 490,000 miles of Federal roads and over 110,000 miles of State and local access roads provide access to and within these lands. Transportation is also critical to the survival and quality of life of tribal communities and other small towns located within Federal lands. It provides the access between Indian housing and education, emergency centers, and employment.

In the United States, pleasure driving accounts for 30 percent of all vehicle miles traveled. The FLMAs have various roads that promote pleasure driving:

- Many Federal Lands Highway Program (FLHP) roads are **Scenic Byways**, a designation conferred by Federal and State agencies.
- The Forest Service designated 136 **National Forest Scenic Byways** in 35 States. The byways total length is 9,126 miles. 74 percent of these byways are also designated as a State or Federal scenic byway.
- There are also more than 3,000 miles of National Park Service roads that also meet the criteria for Scenic Byways. Nine Federal scenic byways pass through National Park Service lands.
- The Bureau of Indian Affairs has identified 1,000 miles with a potential for an Indian Reservation Road Scenic Byways designation. Several Federal scenic byways are in Indian reservations.
- The Bureau of Land Management designated over 60 byways, totaling 3,100 miles in 11 States as **Back Country Byways**.

The remaining byways are largely public and administrative roads. In many remote areas, motorized and non-motorized trails, waterways, and air transports serve as the primary mode of transportation.

Condition and Performance of Roads by Federal Agency

Federal land management agencies are under heavy pressure to accommodate tourist traffic and resource development. For example, heavy visitation to some National Parks is increasing the demand for new parking and wider roads. The FLMAs can often not "build" their way out of this situation since doing so would undermine the very resources agencies are trying to preserve. For the Federal Government to continue its mission of providing visitor enjoyment and conserving resources, innovative and creative solutions will be required. Possible solutions to these problems are briefly discussed at the end of this chapter. The transportation systems serving various Federal and Indian lands are discussed below.

Forest Service

The Forest Service has jurisdiction over 155 national forests and 20 grasslands in the United States. This includes approximately 191 million acres in 40 States, as well as Puerto Rico and the Virgin Islands. This collectively amounts to about 29 percent of all federally owned land. National Forests are used for recreation, watershed management, grazing, wilderness protection, mining, and energy protection. National Forests are being used for lower-impact activities than during the 1980s. National Forests are home to more than half the Nation's inventory of softwood timber, but harvesting has been reduced by about 80 percent since the 1980s.

National Forests contain a diversity of fish and wildlife habitats. National Forests have 128,000 miles of streams, including 3,338 miles of the Wild and Scenic River System, and 2.2 million acres of lakes and reservoirs. The National Forests contains the headwaters for over 80 percent of the freshwater in the United States, and about half of the Nation's cold water fisheries. They are home to more than 60 percent of all the animal species in the country, including 50 percent of big game animals and 140 threatened or endangered species.

There are over 414,000 miles of roads serving the National Forest system. These are divided among three categories: Forest Highways (FH); Public Forest Access Roads (PFAR), which are higher standard arterials; and Forest Development Roads (FDR), which are non-public administrative roads that provide access for the management and protection of the National Forest system. Exhibit E-5 describes mileage, pavement characteristics, and backlog information for these three road categories.

Exhibit E-5

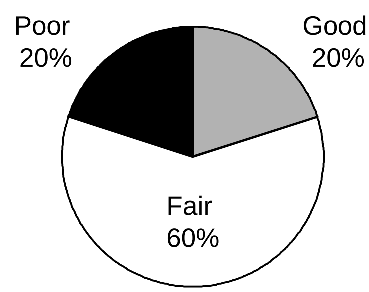
Roads Serving National Forests

	Road Mileage					
Road Type	Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
FH	0	0	7,714	21,500	29,214	4,200
PFAR	0	5,000	70,000	8,000	83,000	5,100
FDR	100,000	82,000	100,000	20,000	302,000	2,600
Total	**100,000**	**87,000**	**177,714**	**49,500**	**414,214**	**11,900**

Exhibit E-6 describes pavement characteristics for Forest Highway Roads. Approximately 60 percent of roads on this system have a "fair" rating.

Exhibit E-6

Forest Highways Pavement Condition (Paved Roads Only)



National Park Service

The National Park Service system includes 378 park units that encompass more than 79 million acres. This extensive network includes national parks, parkways, monuments, historic sites, military parks, battlefields, and recreational areas. Roads are the primary method of transportation within the National Park system, although there are actually about 70 mass transit systems serving these properties. As a result, some of the most popular NPS sites suffer from increasing traffic volume, larger vehicles, and the spiraling demand for visitor parking. More than 3.2 billion vehicle miles are annually traveled within the NPS system, an estimate that increases about three percent each year. In 1994, a report was submitted to Congress on "Alternative Transportation in National Parks," one of the first attempts to address this growing problem of congestion on the NPS system.

There are about 8,127 miles of park roads and parkways (PRP). Exhibit E-7 describes the extent of this system, while Exhibit E-8 identifies pavement condition.

Exhibit E-7

Park Roads and Parkways

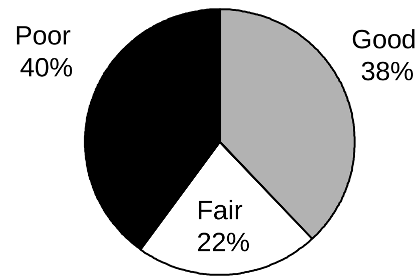
Road Type	Road Mileage: Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges*
Public Roads	---	---	2,988	5,139	8,127	1,252

* In addition to 1,252 bridges, there are 60 tunnels.

Approximately 35 percent of PRP bridges are deficient. The backlog of PRP road, bridge and tunnel improvement needs exceeds $2.2 billion. An additional $350 million would be required to complete all portions of certain park roads that have been partially constructed, such as the Natchez Trace Parkway in Mississippi and the Foothills Parkway in Tennessee. Also, there are national parks where congestion is a major problem and constructing wider or new roads is not an acceptable solution. This increases the need for using alternative modes of transportation.

Exhibit E-8

Park Roads and Parkways Pavement Condition (Paved Roads Only)



Bureau of Indian Affairs

The Bureau of Indian Affairs (BIA) has stewardship over programs that serve Indian tribes and Alaskan native villages. There are more than 560 federally recognized Indian tribes in the United States. Not only do Native Americans have special cultural needs, but many live in isolated locations with little arable land and few known natural resources. Some of the isolation is perpetuated by a lack of transportation facilities. Isolation is also a result of geologic features such as islands, lakes, rivers, and terrain. Except for a few tribes with urban land, oil and mineral resources, or recreational operations, nearly all reservations are among the most economically depressed areas of the country with very high unemployment rates. Some tribal governments have been successful in initiating economic development activities, including small industries and casinos. These require a viable Indian Reservation Roads (IRR) system. In many instances, rural transit is needed to serve Native Americans, particularly the elderly, sick, and those without private vehicles. Some tribes are providing these services on a limited basis.

The IRR system provides access to and within Native American areas. There are two categories of Indian Reservation Roads. BIA system roads include 23,000 miles that are owned and maintained by the BIA and tribal governments. The second category consists of about 25,600 miles of Federal, State, and local public roads that provide access to or within Indian reservations.

Exhibit E-9 describes the extent of the Indian Reservation Roads system. Exhibit E-10 describes pavement condition. Over 2 billion vehicle miles are annually traveled on this system, although it is among the most rudimentary of any transportation network in the United States. Over 66 percent of the IRR system is unimproved, earth and gravel. Some of these roads resemble roads in developing Nations. In some instances, the IRR consist of wheel tracks. In other instances, the road is unimproved earth surface, and many streams are crossed using low water crossings. Approximately 19 percent of the 753 bridges owned by the BIA are deficient.

Exhibit E-9

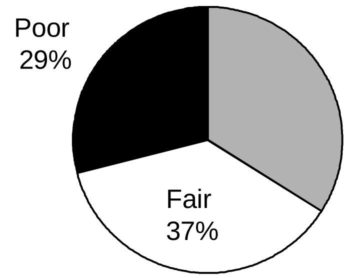
Indian Reservation Roads

Road Type	Road Mileage: Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
BIA & Tribes	6,000	8,500	3,000	5,500	23,000	753
State, Local and Other	2,000	3,850	8,600	10,150	25,600	3,362
Total	**8,000**	**12,350**	**11,600**	**16,650**	**48,600**	**4,115**

These conditions make it difficult for residents of Indian country to travel to hospitals, stores, schools, and employment centers. The poor road quality also impacts safety. The annual fatality rate on Indian Reservation Roads is more than four times the national average. The estimated backlog of improvement needs for BIA and selected State and local IRR roads exceeds $6.8 billion.

Exhibit E-10

Indian Reservation Roads Pavement Condition (Paved Roads only)



Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) manages the National Wildlife Refuge System. This system consists of 553 wildlife refuges and wetland management districts encompassing 93 million acres of land. The FWS properties receive about 34 million visits annually. The FWS also operates 67 National Fish Hatcheries and 43 Administrative Sites which are open to the public for visits and tours. On most FWS roads, traffic volumes are less than 400 vehicles per day, although several refuges have roads with substantial traffic volumes.

The FWS owns approximately 9,000 miles of wildlife refuge roads. Most of these are public roads (also called refuge roads), but there are nearly 3,100 administrative roads within the FWS network. Collectively, these roads have about 271 bridges. Exhibits E-11 and E-12 describe the extent and condition of the FWS system.

Exhibit E-11

Fish and Wildlife Service Roads

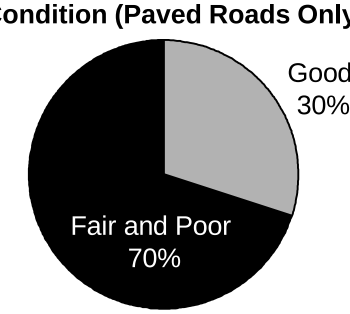
Road Type	Road Mileage: Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
Public Roads		2,800	2,600	500	5,900	271 (1)
Administrative					3,100	
Total (2)		**2,800**	**2,600**	**500**	**9,000**	**271 (1)**

(1) The FWS owns 653 bridges with lengths greater than 10 feet. However, only 271 of these are greater than 20 feet in length.

(2) The FWS also has 100 miles of public hatchery roads and 50 miles of administrative hatchery roads serving fish hatcheries. Also, they have 10 miles of public roads and 2 miles of administrative roads serving administrative sites.

Exhibit E-12

Wildlife Refuge Roads Pavement Condition (Paved Roads Only)



Bureau of Land Management

The Bureau of Land Management (BLM) controls 41 percent of all Federal lands, the largest owner. Its 264 million acres represent nearly 12 percent of the area of the United States. Concentrated largely in the Western U.S. (including Alaska), BLM lands often make up between 20 to 80 percent of each State.

The BLM is responsible for the balanced management of lands and resources. Activities have traditionally included grazing, timber harvesting, mineral and oil extraction, although tourism has increased significantly at BLM sites. Between 1991 and 1997, visitor use at BLM lands jumped by nearly 62 percent. Virtually all visits require the use of an access road.

The BLM lands are served by two categories of roads. Most are Public Lands Development Roads (PLDR) owned by the Bureau of Land Management. These represent the backbone of the BLM system but are not considered public roads. However, there are about 9,000 miles classified as arterials which are considered public roads. Many of them serve public uses and special purposes, such as those that serve recreational development areas. The second category is land management highway system (LMHS) roads. Approximately 7,200 miles of State and local roads are designated as LMHS. Over 70 percent of the LMHS are under county jurisdiction and the remainder under State supervision.

A significant portion of this road system is primitive in nature, but is usually adequate for BLM general management. The BLM has constructed new roads over the last 25 years to meet recreation and other access needs. The condition of paved roads is shown in Exhibits E-13 and E-14.

Exhibit E-13

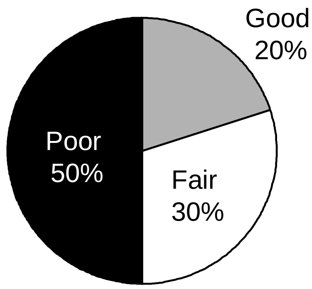
Bureau of Land Management Roads

	Road Mileage					
Road Type	Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
PDLR	29,000	33,200	19,100	1,700	83,000	589
LMHS*	---	---	3,600	3,600	7,200	100
Total	**29,000**	**33,200**	**22,700**	**5,300**	**90,200**	**689**

* This only represents about 50 percent of the anticipated future LMHS to be designated.

Exhibit E-14

Public Lands Development Roads Pavement Condition (Paved Roads Only)



Q. **What are the improvement priorities for the land management highway system?**

A. The top priorities are to 1) correct safety deficiencies, 2) improve the condition of high use roads, and 3) repair or replace deficient bridges.

Bureau of Reclamation

The Bureau of Reclamation (BOR) administers 348 dams and reservoirs in 17 Western States and shares management over 308 recreation sites. Reclamation is the ninth largest electric utility and the second largest producer of hydropower in the United States, with 59 power plants producing nearly 42 billion kilowatt-hours annually. Reclamation is also the Nation's largest wholesale water supplier, delivering 10 trillion gallons of water to more than 31 million people each year. Reclamation projects provide one out of five western farmers with irrigation water.

The Bureau of Reclamation owns approximately 1,980 miles of roads and 600 bridges that are open and intended for use by the general public. These public BOR roads and bridges are eligible for discretionary Public Lands Highway funding under the FLHP. Funding varies since it is a discretionary program. The remainder of the roads and bridges (not intended for use by the general public) are funded through appropriations directly to BOR or by project beneficiaries, and bridges are provided through BOR appropriations. The road system serving BOR lands is summarized in Exhibit E-15.

Exhibit E-15

Bureau of Reclamation Roads

	Road Mileage					
Road Type	Earth	Template	Gravel	Paved	Total	Bridges
Public Roads			980	1,000	1,980	600
Administrative	3,200	3,200	800	800	8,000	3,900
Total	**3,200**	**3,200**	**1,780**	**1,800**	**9,980**	**4,350**

Department of Defense

There are approximately 500 major military reservations in the United States. These encompass about 24 million acres of land. Installation roads are open to use by dependents and public visitors, although some may require a security clearance. Roads on military installations serve housing, offices, commissaries, base exchanges, recreation facilities, unrestricted training facilities, hospitals, and traffic crossing the installation. This road network is similar to the street system in urban areas, and in many cases, military roads are an integral part of a local community. Motorists may not even realize they are on a military street.

Department of Defense (DOD) regulations allow public access to unimproved recreational facilities such as lakes, beaches, and wooded areas for bases within the continental United States. The public may access these areas for fishing, swimming, and hunting except where an overriding military mission specifically requires a suspension of such use. Improved recreational facilities such as baseball, football, and soccer fields, gymnasiums, golf courses, swimming pools, and bowling alleys are also available. Many installations have an annual open house, where the public is invited to tour the installation, attend military demonstrations, and view shows. About one-third of the installations have museums or other cultural attractions, which the public is encouraged to visit. These facilities attract an estimated 15 million visitors annually. Approximately 28 billion vehicle miles are traveled per year on military roads.

About 24,000 miles of paved roads referred to as Military Installation Roads (MIR) are under the jurisdiction of the Department of Defense (DOD). Approximately 2,100 miles (8 percent) are classified as primary and principal arterial roads, about 5,400 miles (21 percent) as collector roads, and about 18,000 miles (71 percent) as local roads. About 24,000 miles are open to public travel, while the remaining roads are located within restricted areas. The extent and condition of DOD roads are described in Exhibits E-16 and E-17.

Exhibit E-16

Roads on Military Installations

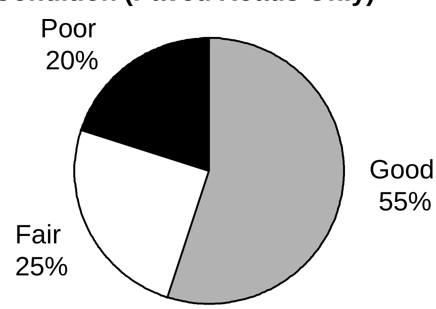
Road Type	Road Mileage: Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
MIR--Public Roads				23,000	23,000	
Administrative				1,200	1,200	
Total				**24,200**	**24,200**	

Deficiencies in military roads generally relate to inadequate traffic capacity, poor geometric features, structurally deficient bridges, and antiquated entrance gates which are below Federal standards.

Additionally, over 1,000 high-accident locations (HALs) have been identified. A HAL is a location with five or more property-damage accidents, three or more injuries, or one or more fatalities. The cost to improve and eliminate deficiencies at these HALs is more than $165 million. Of these sites, there are 175 very high accident locations (VHALs). A VHAL is a location with 10 or more property-damage accidents, 5 or more injuries, or 1 or more fatalities. The annual estimated total accident cost for these VHALs exceeds $150 million, and the total cost to correct safety deficiencies is approximately $30 million.

Exhibit E-17

Military Installation Roads Pavement Condition (Paved Roads Only)



United States Army Corps of Engineers

The United States Corps of Engineers (COE) is the largest provider of water-based recreation. The COE currently administers approximately 11.7 million acres at 463 lakes and waterways. In 1997, there were 4,340 recreation areas, of which 2,500 were managed directly by the COE. These areas are located in 43 States, but the majority of COE resources are east of the Rocky Mountains, where most Americans live. The road system serving COE facilities is summarized in Exhibit E-18.

Exhibit E-18

Roads Serving COE Lakes

Road Type	Road Mileage: Unimproved Earth	Graded Earth Template	Gravel	Paved	Total	Number of Bridges
Public Roads					4,800	250
Lease Roads					3,600	
Total					**8,400**	250

Funding of Roads Serving Federal and Indian Lands

The Federal Government is responsible for providing access within Federal and Indian lands. Before the 1980s, all road improvements were dependent upon the unpredictability of various annual Federal agency appropriations and had to compete with non-transportation needs. This caused many road systems on Federal lands to fall into a state of dilapidation. The 1982 Surface Transportation Assistance Act (STAA) established the Federal Lands Highway Program (FLHP). This consolidated long-range transportation program is financed through the Highway Trust Fund.

Funding and annual authorizations are shown for Fiscal Years 1983 through 2003 in Exhibit E-19. Between FY 1983 and FY 1997, the FLHP received 100 percent obligation limitation each year. Starting in FY 1998, the FLHP received about only 88 percent obligation limitation. The remaining 12 percent of these funds were returned to the States in accordance with TEA-21 provisions.

Exhibit E-19

FLHP Annual Authorization ($ Millions)

	STAA		STURRA		ISTEA		TEA-21	
Category	FY 83	FY 84 - 86	FY 87- 91	FY92	FY93 - 95	FY 96 - 97	FY 98	FY99 -03
PLH-FH	50	50	55	94	113	114	129	162
PLH-D	50	50	40	48	58	58	67	84
IRR	75	100	80	159	191	191	225	225
PRP	75	100	60	69	83	84	115	165
RR	0	0	0	0	0	0	0	20
Total	**250**	**300**	**235**	**370**	**445**	**447**	**536**	**706**

The FLHP funds may be used for transportation planning, research engineering, and construction. Funds may also be used to support transit facilities which provide access to or within Federal or Indian lands. Also, maintenance, rehabilitation and reconstruction of transportation facilities also receive additional funding through other Departmental appropriations.

In recent years, several initiatives were developed to improve transportation on Federal lands. For example, the ISTEA initiated transportation planning and pavement, bridge and safety management systems for the FLHP. The ISTEA provided for a study on alternative transportation in park lands. This study was prepared and submitted to Congress in 1994. The Departments of Transportation and the Interior subsequently signed a memorandum of understanding (MOU) in November of 1997 that lays the groundwork for the NPS and the DOT to develop more efficient transportation systems to serve the national parks. Several MOU initiatives are underway, including the development of a rural Intelligent Transportation System operational test in a national park and a planning guidebook for the NPS.

Some classes of Federal roads are funded though means other than the FLHP. For example, the Forest Service has jurisdiction over non-public Forest Development Roads (FDR). The Bureau of Land Management has worked with States to develop its Land Management Highway System (LMHS) road network. These are State and local public roads that are generally supported by State and local government funds. Additionally, the Department of Defense has jurisdiction over Military Installation Roads (MIR), and these are funded by DOD appropriations. The Army COE has jurisdiction over public roads providing access to lakes managed by them. Exhibit E-20 summarizes these roads.

Exhibit E-20

Federal Roads Not Funded Under the Federal Lands Highway Program

Type	Jurisdiction	Lands Served	Length Miles
Department of Agriculture			
Public Forest Access Roads	Forest Service	National Forest System	83,000
Forest Development Roads	Forest Service	National Forest System	302,000
Department of the Interior			
Fish Hatchery Roads	Fish and Wildlife Service	National Fish Hatcheries	150
Administrative Roads	Fish and Wildlife Service	Refuges, Hatcheries, and administrative areas	3,100
Land Management Highways	State/Local Agencies	Public Lands	7,200
Public Lands Development Roads	Bureau of Land Management	Public Lands	83,000
Reclamation Public Roads	Bureau of Reclamation	Federal Dams, Reservoirs	1,980
Administrative Roads	Bureau of Reclamation	Federal Dams, Reservoirs	8,000
Department of Defense			
Military Installation Roads	Defense Department	Military Installations	24,000
US Army Corps of Engineers			
Corps of Engineers Roads	Corps of Engineers (COE)	COE Recreation	4,900

Funding of road construction and maintenance is shown in Exhibit E-21. Construction includes repair, rehabilitation, reconstruction, replacement or new construction. Maintenance includes routine activities like minor regraveling, surface patching, and cyclic motor grading. Where a Federal agency is shown, the source of funds would generally be through annual appropriations to the agency having jurisdiction of the particular class of road. Where a State is shown, it implies that funds are provided by either the State or local government depending on jurisdiction and practices in individual States.

Future Challenges

Millions of tourists visit Federal lands. High visitation levels, in both large and small areas, are causing problems due to the growing volume of traffic and demands for visitor parking. The FLMAs cannot simply “build” their way out of this situation since this would undermine the very resources the agencies are trying to preserve. Innovative and creative solutions will be required. In addressing these challenges, FLMAs will need to involve all Federal, tribal, State and local stakeholders and understand the complex relationship among each.

Exhibit E-21

Construction and Maintenance Funds - Roads Serving Federal Lands ($ Millions)

Federal Lands Served/ Road Category	Owner	Road and Bridge Construction Funding: Road	Bridge	Source	Maintenance Funding: Amount	Source
Department of Agriculture						
National Forest						
FH	State/Local	115	26	FH	Unknown	State/Local
PFAR	FS	40	10	FS	44	FS
FDR	FS	42	4	FS	55	FS
Department of the Interior						
National Parks						
PRP	NPS	119	25	PRP	37.2	NPS
Indian Lands						
IRR	BIA	226	13	IRR	25.6	BIA
IRR	State/Local			IRR & State		State
Wildlife Refuges & National Fish Hatcheries						
RR	FWS	16	1	RR		FWS & RR
Non Public Roads	FWS			FWS		FWS
Non Public Roads	FWS		~	FWS		FWS
Public Lands						
LMHS	State/Local	Unknown	Unknown	State/Local	Unknown	State/Local
PLDR	BLM	13.8	*	BLM	11.6	BLM
Reclamation Projects						
Reclamation Roads	BOR			BOR		BOR
Administrative Rds	BOR			BOR		BOR
Department of Defense						
Defense Installations					216.5	
MIR	DOD	4.0**	**	DOD	(estimated)	DOD
US Army Corps of Engineers						
COE Recreation Areas						
CRR	COE			COE		COE
Leased Roads	COE			COE & State		COE & State

* Bridge funding part of the $13.8 million funding for construction.
** $4M is the 3-year average. Bridge costs are part of the roadway cost.

- As population increases, the demand for access to Federal lands will continue to grow. This will require a full consideration of alternative transportation systems, including efficient intermodal transfers. Intelligent Transportation Systems will play a more important role in reducing congestion and moving traffic.
- Urban growth is expanding closer and closer to Federal lands and Indian lands. As Federal and Indian lands become part of urban areas, FLMAs will be challenged with all the issues affecting urban transportation officials. The FLMAs will need to undertake and implement effective urban transportation planning in close cooperation with metropolitan local and various other transportation officials.
- Officials will need to look at seamless transportation. This involves two areas. One is how to ensure continuity for drivers as they travel from one FLMA road system to another. The other issue involves providing efficient transfer between various modes (highway, rail, transit, air, and water transportation). The seamless system goal will be to enhance the quality of visitor's experience consistent with environment and resource management plans.
- Environmental and resource concerns will continue to be a major concern in accommodating increase visitors. Developing and implementing transportation systems must be compatible with values of Federal and Indian land.
- The average age of drivers visiting Federal and Indian lands will continue to increase. This will require continued improvements in signs, information systems and accommodation for visitors with disabilities. This will be especially important in urban areas where the need for effective destination guidance is a challenge to implement.
- Effective coordination between Federal agencies, tribal governments, and State and local transportation agencies will remain important.

APPENDIX F

Federal Highway Safety Planning and Improvement Programs

The safety goal of the Department of Transportation is to promote public health and safety by working towards the elimination of transportation-related deaths, injuries, and property damage. The Federal Highway Administration's strategic safety objective is **to reduce by 20 percent the number of highway-related fatalities and injuries in 10 years (by 2008)**. In addition to the agency's safety goal, Secretary Slater has established a specific objective to improve large truck safety. This targets a reduction in the number of truck-involved fatalities by 50 percent over 10 years.*

The FHWA's key highway safety strategies include the following:

- **Promoting safety management processes:** Safety management processes will bring together, in a coordinated approach, the stakeholders that affect highway safety. This includes highway design, operation, and enforcement agencies; the motor carrier industry; and safety advocacy groups. FHWA will work with its partners and stakeholders to develop information and analysis systems to better identify the causes of crashes and develop crash avoidance programs to reduce or eliminate crashes.
- **Deploying lifesaving technologies on the highways:** FHWA will identify and promote the deployment of safety technology with particular emphasis on technologies that address high priority areas, including run-off-road, pedestrian and speed-related crashes. The long-term safety strategy is a technology-based systematic approach to enhance the safety of the roadway, vehicles, and users.
- **Focusing on commercial vehicle and driver safety*:** FHWA will focus on safety programs that identify and implement innovative and performance-based programs. The agency will promote safe driving practices in the vicinity of large trucks; build partnerships to improve motor carrier safety and performance of commercial motor vehicles and drivers; target enforcement on the highest-risk motor carriers; and identify new technologies to enhance the safety performance and productivity of the motor carrier industry.
- **Focusing on human behavior:** FHWA will use its resources to work on educational, outreach and enforcement activities designed to change human behavior while using the roadway environment.

*As of January 1, 2000 the responsibilities for large truck safety were transferred to the new Federal Motor Carrier Safety Administration (FMCSA).

*Motor Carrier and Highway Safety Action Plan**

In early 1999, the Office of Motor Carrier and Highway Safety developed an action plan for the next three years. The plan contains over 65 actions that are designed to focus the agency's resources and capabilities into areas of opportunity that have a high safety payoff.

The action plan directs attention to those areas of greatest concern—poor drivers, unsafe carriers, substandard vehicles, and highway hazards. The plan does not identify all planned actions—only those deemed important to reducing crashes, injuries, and fatalities.

The action plan is organized in five broad chapters:

- **Motor Carriers:** The plan describes actions and technologies that will increase targeted enforcement of high-risk carriers with the objective of bringing them into compliance or putting them out of business. It also identifies how to use penalties more effectively to sustain compliance; how to issue more efficient and understandable regulations; and methods for reaching out to industry to improve voluntary compliance.
- **Drivers and other Highway Users:** The plan describes programs, technologies and research that will reduce pedestrian involvement and vehicular crashes, injuries, and fatalities linked to driver fatigue and behavior.
- **Vehicles and Cargo:** The plan describes actions and technologies that will improve the general safety-worthiness of vehicles through streamlined, targeted, roadside inspections and new regulations.
- **Highway Construction:** The plan describes actions and technologies to identify and reduce run-off-the-road crashes; reduce speed-related crashes; improve work zones; and promote better safety management.
- **Border Crossings:** The plan describes actions that will improve motor carrier safety related to border crossings.

Highway safety investment and oversight are a shared responsibility. Renewed attention has been focused on the need for better enforcement practices, regulations, and procedures; more effective application of new technologies; better data; innovative research; and stronger outreach techniques.

The action plan serves as a turning point for the Department to review what's being done; reprioritize and change how it's being done; identify new technologies; increase the agency's knowledge of safety; and change the organizational structure to take advantage of safety opportunities. The action plan is also a commitment to working with Congress, state officials, the motor carrier industry, other safety agencies, motor vehicle manufacturers, and the public to reduce injuries and fatalities.

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*As of January 1, 2000 the responsibilities for large truck safety were transferred to the new FMCSA. The new Safety Core Business Unit in FHWA will be responsible for the remaining action items pertaining to highway safety.

Rail-Highway Crossings Program and Hazard Elimination Program

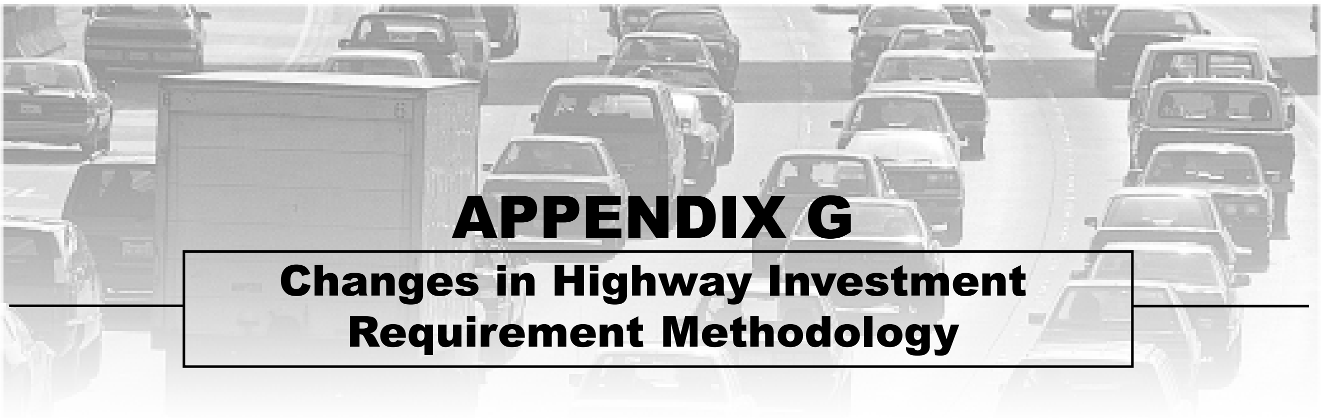
There are also specific safety improvement efforts legislated under 23 U.S.C. Section 130 (Rail-Highway Crossings Program) and 23 U.S.C. Section 152 (Hazard Elimination Program). Since the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Rail-Highway Crossings and Hazard Elimination Programs are no longer separately funded. The ISTEA set aside 10 percent of the funds apportioned for the Surface Transportation Program for the States to carry out Sections 130 and 152.

Since the Rail-Highway Crossings Program began in FY 1974, over $3.47 billion has been obligated by the States. States have implemented more than 32,000 projects, primarily for the installation of signs and markings, flashing light signals, automatic gates, and crossing surface improvements.

Since the Hazard Elimination Program began in FY 1974, over $4.81 billion has been obligated. More than 35,000 projects have been implemented under this program. These projects consist primarily of improving traffic channelization; installing and upgrading traffic signals; installing guardrail and median barriers; widening the traveled-way and/or shoulders; improving pavement skid resistance; installing impact attenuators; and placing or upgrading pavement markings.

State and Community Highway Safety Grants

The 402 program began in 1966 and is the joint responsibility of FHWA and NHTSA. (See 23 U.S.C. 402). State and Community Highway Safety grants are apportioned to the States to pay for the non-construction costs of highway safety programs aimed at the reduction of injuries, deaths, and property damage from motor vehicle accidents. These projects generally consist of developing or upgrading traffic record systems; collecting and analyzing data; conducting traffic engineering studies and analyses; developing technical guides and materials for States and local highway agencies; developing work zone safety programs; encouraging the use of safety belts and child safety seats; developing roadway safety public outreach campaigns; reducing impaired drivers; developing programs to combat drivers who speed or drive impaired; and developing programs to reduce aggressive driving.



APPENDIX G

Changes in Highway Investment Requirement Methodology

Introduction

The projected average annual highway investment requirements for 1998-2017 shown in this report are not directly comparable to those shown for 1996-2015 in the 1997 C&P report. Since the release of the "1997 Status of the Nation's Surface Transportation System—Condition and Performance" (C&P Report), the FHWA has conducted a series of outreach meetings with members of the academic community, congressional staff and other transportation professionals on the report and the HERS model. As a result of this process, the FHWA has reevaluated several of the procedures used in the development of previous reports.

As discussed in the introduction to Chapter 7, in previous C&P reports, separate external adjustments were made to account for some types of capital improvements, but other improvement types were omitted completely. Based on recommendations received during the C&P report outreach process, in this report, the scope of the investment requirements has been streamlined, and expanded to cover all types of highway capital outlay.

During the preparation of the last report, the State travel forecasts for some highway sections were manually reduced to match MPO forecasts. During this process, some errors were inadvertently introduced into the highway database that had an effect on the results, primarily for the Maximum Economic Investment scenario. The Maintain User Costs scenario results were also affected, but to a lesser degree. When these data issues were resolved, it became apparent that they had been masking some undesirable interactions between the new travel demand elasticity features in HERS, and some HERS settings and external adjustment procedures that had previously been in place. To address these problems, a number of changes have been made to the analytical procedures used to develop the investment requirements in this report. The "high cost lane" feature in HERS, that allowed the model to consider adding lanes in locations where it normally would not be feasible has been turned off. Some external model adjustments that formerly offset some of the high cost lanes have been eliminated, or folded into the streamlined adjustment process mentioned above.

Based on the recommendation of an expert panel that reviewed the HERS model, the emissions cost module in HERS has been utilized in this report, so the benefit cost analysis now considers this factor. The travel demand elasticity values used have also been increased. This change suppresses some travel demand in congested urbanized areas, which offsets an increase in the base VMT forecasts used in this report.

Some other modifications have been made to the HERS model that also have an impact on the results, most notably the development of new safety analysis procedures. The new procedures make increased use of specific highway characteristics affecting safety, and better reflect the effects of highway improvements on safety.

Summary

Exhibit G-1 compares the original investment requirements reported in the 1997 C&P report with the values obtained by analyzing the same data with the current analytical procedures. The effects of inflation, expanding the scope of the investment requirements, and revisions to the data and model are shown separately.

Exhibit G-1

Impact of Analytical Changes on Amounts Reported in the 1997 C&P Report (Billions of Dollars)

	Maintain User Costs	Maximum Economic Investment
Amounts reported in 1997 C&P report based on 1995 data ($1995)	**40.5**	**70.2**
Convert to 1997 Dollars	3.0	5.2
Expand scope to include all improvements ($1997)	5.3	9.2
Data Corrections and Model Changes ($1997)	-0.7	-2.0
Revised estimates based on 1995 data ($1997)	**48.2**	**82.6**

Based on 1995 HPMS data, the 1997 C&P report projected average annual highway investment requirements for 1996-2015 would be $40.5 billion in 1995 dollars under the Maintain User Costs scenario (excluding bridges) and $70.2 billion in 1995 dollars under the Maximum Economic Investment scenario (excluding bridge). Revised projections based on 1995 HPMS data using the analytical procedures developed for this report show an increase of 19 percent to $48.2 billion in 1997 dollars for the Maintain User Costs benchmark, and an increase of 18 percent to $82.6 billion in 1997 dollars for the Maximum Economic Investment scenario.

The increase in investment requirements is primarily due to inflation, and an expansion in the types of capital improvements included. The remainder is caused by data corrections, analytical changes and model enhancements, which largely offset each other.

Effect of Inflation

The bid price index, which is used to calculate the costs of highway improvements, rose between 1995 and 1997. The rural index increased by 9.0 percent and the urban index rose by 6.8 percent. Converting the investment requirements from 1995 dollars to 1997 dollars causes them to increase by approximately 7.5 percent for both the Maximum Economic Investment scenario, and the Maintain User Costs benchmark.

Expanding the Scope of the Investment Requirements

In previous reports, separate external adjustments were made to account for some types of capital improvements not captured in the modeling process, but other improvement types were omitted completely. To allow for comparisons between investment requirements and current capital spending, a “C&P-related capital outlay” figure was used that excluded current spending on items not included in the investment requirements. A significant problem with this approach is that it makes it difficult to relate the investment requirements to other commonly available figures for current and future spending (i.e. the increase in funding under TEA-21 compared to ISTEA). To make this comparison accurately, it would be necessary to deduct all amounts estimated to be used for safety, traffic operations, environmental enhancements, or for new construction related to economic development. Unfortunately, the raw data required to make this type of adjustment is not commonly accessible, which has led to erroneous use of the C&P report investment requirements. This problem was noted by some participants at the C&P report outreach sessions.

Another concern expressed at the outreach meetings was that excluding safety, traffic operations facilities, and environmental enhancements from the analysis implies that this type of spending is not considered to be important by the agency. On the contrary, this type of investment is critical to allow FHWA to achieve its strategic goals.

Based on these comments, the "report-related capital outlay" concept has been dropped from this report, and the investment requirements in this report have been expanded to include all types of highway capital outlay. To accomplish this, the external adjustment process has been streamlined, and is now based on an underlying assumption that the overall percentage of capital investment that is used for types of capital improvements that are not modeled are likely to remain roughly the same in the future. Expanding the scope of the investment requirements to include all types of capital outlay increases both the Maximum Economic Investment scenario, and the Maintain User Costs benchmark by approximately 13.1 percent.

This modification does not increase or reduce the gap between current spending and investment requirements, since investment requirements and the spending figures they are compared to both have been increased by the same percentage. The relationship between current spending and investment requirements is discussed more fully in Chapter 8.

Data Corrections, Changes in Analytical Procedures and Model Enhancements

During the preparation of the 1997 C&P report, VMT growth rates for all highway sections in urbanized areas over one million in population were factored downward from the values reported in HPMS, to be consistent with an aggregate growth rate compiled from rates developed by the MPOs. In the process of making this adjustment, some errors were introduced into the data. A number of stop signs, intersections and traffic signals that had originally been coded were inadvertently eliminated. As a result, when HERS processed this data, it overestimated the capacity and travel speed on a number of sections, reducing the potential benefits of adding lanes. If this problem had not occurred, the investment requirements under the Maximum Economic Investment scenario would have been higher, as HERS would have found more potential projects to be economically justified. The investment requirements under the Maintain User Costs scenario would have been reduced somewhat, as HERS would have had a broader range of possible improvements to choose from, when selecting the best mix of projects to maintain user costs at baseline levels.

When these data issues were resolved, it became apparent that the new travel demand elasticity features were interacting with some other HERS settings and external adjustment procedures in ways that had not been fully anticipated. To address this problem, the FHWA expanded the scope of its previously scheduled review and outreach efforts to consider more aspects of the C&P report and HERS. This effort has led to the revision of the methodology used to develop the investment requirements.

As shown in Exhibit G-1, the combined effect of the data corrections, analytical changes and model enhancements was to reduce the Maintain User Cost scenario by $0.7 billion (1.7 percent) and to reduce the Maximum Economic Investment scenario by $2.0 billion (2.9 percent).

High Cost Lanes

For each highway section in HPMS, States code a Widening Feasibility rating. The investment requirements analysis in previous versions of the C&P 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, build a parallel route, or acquire expensive right-of-way. For highway investment requirement scenarios developed using the HPMS Analytical Process model, the widening costs projected by the model were increased externally to account for high cost lanes. When HERS was developed, the high cost lane procedure was built into the model as an optional setting. In this report, it has been assumed that highway sections can not be widened beyond the width specified as feasible by the States, and the high-cost lane feature in HERS has been turned off. This change was made for two reasons, one related to the underlying HPMS data, and one related to the operation of the HERS model.

The number of HPMS sections coded by States as infeasible to widen has declined over time. While States once appeared to be taking a narrow view of feasibility, limiting the number of sections where widening was coded as feasible, they now appear to be taking a more expansive view, and only rating widening as infeasible if it would be close to impossible to accomplish. Based on this, it is more appropriate to treat these sections as being impossible to widen, rather than simply very expensive to widen.

Another factor in the decision to change this procedure was that the new travel demand elasticity features in HERS appeared to be combining with the high-cost lane feature to add an excessive number of lanes in urbanized areas. As currently implemented, HERS considers an all-or-nothing approach to widening; the model calculates the number of lanes required to fully accommodate projected future traffic, and then chooses between adding all of them, or adding no new lanes. Since travel demand elasticity causes future travel to increase in some scenarios, this makes HERS more likely to add additional high cost lanes, rather than simply not widening at all. Procedures are now being developed to allow HERS to consider adding variable numbers of lanes, so the model will not be faced with an all-or-nothing choice and can evaluate the optimal number of lanes (if any) to add to any given section. It is likely that this modification will reduce the number of high cost lanes that HERS would add, which might allow the high cost lanes feature to be turned back on in the future, without risk of distorting the data.

External Adjustment Procedure Changes

The HERS results are supplemented by external adjustments to account for functional classes and types of capital investment that are not currently modeled. Rural minor collectors and rural and urban local roads are not represented in the HPMS sample database, so HERS cannot estimate investment requirements for these systems. The 28 improvement options that HERS considers primarily address pavement and capacity deficiencies on existing highway sections. Currently, HERS does not directly consider new roads and bridges, or system enhancements (improvements primarily related only to safety, traffic operations, or environmental enhancements).

As indicated earlier, the external adjustment process in this report has been changed. A number of external adjustments made to the HERS results in recent reports have been discontinued. Most of these are now captured in the streamlined external adjustment procedure, which assumes that types of improvements that are not currently modeled will need to continue to be funded in the future, and will consume the same overall percentage of highway capital investment. Separate adjustments for TSM/ITS, metropolitan expansion, local roads, and rural minor collectors are no longer included. The new external adjustment process also captures some of the investment requirements for new roads that were formerly modeled as part of the high-cost lane feature in HERS.

Metropolitan Expansion Adjustment

In the 1997 C&P Report, the Metropolitan expansion adjustment added about $10 billion to both scenarios. The logic behind this adjustment was that as the population of the Nation increases, additional facilitates are required to accommodate the growth, especially in expanding urban areas. The costs of these additional facilities were therefore factored into the total improvement costs. This adjustment received some criticism following the last report, since it was viewed as not wholly consistent with the relatively low 20-year travel growth projections used in the report. As new construction is factored into the streamlined adjustment process, this separate adjustment is no longer required.

TSM/ITS Adjustment

During the development of the highway investment requirements for the 1997 C&P report, a number of the high-cost lanes added by HERS were offset by more efficient use of existing lanes, via investments in such things as freeway surveillance and control, high occupancy lanes, ramp metering, incident management, and signalization improvements. Since the high-cost lane feature in HERS has been turned off in this report, this special adjustment is no longer required. The TSM/ITS investment requirements are now factored in the streamlined external adjustment procedure. The benefits of ITS are most apparent in changes in system reliability. At the moment, HERS does not measure the benefits of reliability, so the model could not easily incorporate ITS options. Future plans for HERS include the development of new ways to incorporate system reliability into the analytical framework of the model, and allow ITS improvements to be considered and evaluated directly.

Local Roads and Rural Minor Collectors Adjustments

In the 1997 report, investment requirements for local roads were based on an old Department of Agriculture study, that has not been updated. Investment requirements for rural minor collectors were estimated based on 1993 data, the last time HPMS sample section data was collected for this functional class. Continuing to rely on these old data does little to add to the quality of these estimates so these separate adjustments have been replaced with the streamlined external adjustment procedure.

Emissions Costs Module

An emissions cost module has been added to HERS as a first step in addressing the societal costs of highway improvements. This module was not utilized in the preparation of the 1997 C&P report, since there is a great deal of uncertainty about the proper values to assign to the societal costs of different pollutants, and about the best method to apply them in a section-by-section analysis.

In June 1999, an independent panel of experts reviewed the new travel demand elasticity and emissions costs procedures in HERS. The panel concluded that the simplifications HERS uses to allow section-by-section analysis of social costs as a result of pollutant emissions probably overstate the negative impacts of emissions overall, particularly in rural areas. However, they indicated that the HERS procedures would tend to underestimate social costs in some non-attainment areas. The panel recommended a number of enhancements that should be made to the HERS emissions module to refine its analysis. The emissions costs figures are derived in part from the Environmental Protection Agency's MOBILE5a and PART5 models, which are scheduled to be supplanted shortly by updated versions.

Posed with the question as to whether it would be better to start utilizing the existing emissions module in the C&P report, or wait until a next-generation module can be developed, the expert panel suggested that it would be better to include the emissions costs analysis in the C&P report, with caveats about the appropriateness of the data and the underlying air quality models, rather than to simply continue to exclude emissions costs from the HERS benefit cost analysis.

The emissions costs used in HERS for this report appear to be in the same order of magnitude, but generally higher than those used in the March *1999 Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*. Due to the differences between the scope of the two reports, the Cost Allocation Study approach is not directly transferable to the HERS model. The HERS emissions module was developed before the release of EPA's *The Benefits and Costs of the Clean Air Act, 1970-1990* report, so this report does not reflect any of that report's findings. The Department of Transportation plans to work with the EPA to develop a better approach for reflecting emissions costs in the HERS analysis for use in future C&P reports.

Travel Demand Elasticity

The travel demand elasticity features in HERS recognize that as a highway becomes more congested, travel volume on the facility is constrained, and that when lanes are added to a facility, the volume of travel may increase. Travel demand elasticity is introduced in Chapter 7. Some implications of this model feature are discussed in Chapters 7, 9, and 10.

For the 1997 C&P report, short term elasticity was set at -0.8, with an additional -0.2 (total, -1.0) used for long term elasticity. In June 1999, an independent panel of experts reviewed the new travel demand elasticity and emissions costs procedures in HERS. One of their recommendations was that these values be increased.

Since HERS is a segment-level analytical tool, its elasticity values need to take into account the diversion of traffic to and from other road segments, rather than simply considering new/suppressed trips, or shifts to and from other modes of transportation. When a highway segment is widened, it may attract a significant amount of traffic from parallel routes, in addition to causing some shift from transit, and some new trips that would not have otherwise occurred. If a highway segment becomes severely congested, but is not widened, some trips will be suppressed entirely, some people will shift to transit, and others will shift to parallel highway routes if they are available, and less congested. The panelists indicated the values used in HERS were too low, since they were supposed to reflect route diversion. **For network-level analytical tools, it would be more appropriate to use lower elasticity values than HERS, since these network-level analyses should be able to handle route diversion directly.**

For this report, short term elasticity was set at -1.0, with an additional -0.6 (total, -1.6) used for long term elasticity. Increasing the elasticity values has the effect of suppressing travel on congested routes, and inducing additional travel on non-congested routes.

Travel Growth in Large Urbanized Areas

In the 1995 C&P report, and earlier editions, the highway investment requirements were developed based on static VMT growth projections. The models available at that time did not have the capability of projecting the effects that changes in the condition or future performance of a highway section could have on future travel growth. This made it critically important that the VMT projections fed into the models accurately predicted the most likely level of future travel growth. Although the concepts of demand and system management were introduced in the 1991 and 1993 C&P reports, the basic State-supplied travel demand forecasts in HPMS were accepted as given.

During the preparation of the 1995 C&P report, it was judged that individual HPMS sample section travel growth projections provided by the States were not adequately incorporating the effects that aggressive Transportation System Management (TSM) and Transportation Demand Management (TDM) strategies would have on reducing future travel demand. Regional traffic growth forecasts developed by Metropolitan Planning Organizations projected an aggregate average annual growth rate of 1.5 percent over 20 years. To be consistent with these forecasts, the travel growth rates for all highway sections over one million in population were factored downward, to force their average growth rate for the 1994-2013 period to be 1.5 percent, rather than the 2.23 percent projected for these sections in HPMS.

The addition of travel demand elasticity features to the HERS model makes the VMT growth projections dynamic. HERS recognizes that changes in the costs of using a highway facility will affect future travel growth on that facility. As discussed in Chapter 9, one implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. As indicated in Chapter 10, the accuracy of the highway investment requirements projected by HERS is no longer fully dependent on the accuracy of the travel demand forecasts fed into the model. Instead, the accuracy of the investment requirements depends on the accuracy of the input forecast, as modified by the travel demand elasticity features in HERS. The introduction of travel demand elasticity into HERS changes the factors that should be considered in determining what baseline forecast should be entered into the model. It is no longer critical to determine which forecast is more likely to be “right”. Instead, the baseline forecast needs to be compatible with the travel demand elasticity features in HERS, to allow the model to accurately produce a spread of travel growth projections for different possible levels of investment.

As discussed in Chapter 7, the HERS model assumes that the VMT growth projections entered for each sample section represent the travel that will occur if the pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway-user costs at current levels. While this assumption may not be valid for all State-supplied HPMS sample forecasts, the State-supplied values appear to meet this assumption better than the MPO regional forecasts. The MPO forecasts already build in the effects of TDM programs, which the HERS travel demand elasticity features are designed to mimic. Therefore, using the MPO forecasts raises the risk of double counting the same effects.

Because the State-supplied travel forecasts are more consistent with the assumption HERS makes about the baseline forecasts, they were utilized for all HPMS sample sections in this report. The weighted average growth rate for all sections in urbanized areas over 1 million in population for 1998-2017 was 1.86 percent. As pointed out in Chapter 9, at current funding levels, HERS modifies this projection down to 1.66 to 1.70 percent. This is consistent with the most recent survey of MPO's, which indicates their 20-year regional forecasts currently project a growth rate of 1.68 percent, up from 1.5 percent four years ago. The MPO's are more likely to consider funding constraints in developing their regional travel growth projections than the States are in developing their projections for HPMS.

In the 1997 report, the State-supplied travel growth rates for sections in urbanized areas were factored down manually and elasticity was applied. The baseline average annual travel growth rates for 1996-2015 were factored down from the 1.88 percent projected by the States to 1.5 percent. For the Highway Maintain User Costs scenario in the 1997 report, the effective travel growth rate remained approximately 1.5 percent, after elasticity was applied. For the Maximum Economic Investment scenario the travel demand elasticity features in HERS increased the effective travel growth rate above this level. Subsequent analysis of the travel demand elasticity procedures in HERS, and comments from the independent panel that review the model suggest that the approach used in the development of the 1997 report may have double-counted the impacts of some MPO policies to control travel growth. However, since the expert panel also concluded that the elasticity values used in the 1997 report were too low, any potential double-counting may have been offset.

Chapter 10 explores the effects of reducing the State-supplied growth projections for highway sections in large urbanized areas. Exhibit 10-1 shows that reducing the baseline growth projection down to the level of the latest MPO forecasts would only reduce investment requirements by 1 to 2 percent.

Q. **Since State-supplied growth forecasts are utilized for large urbanized areas in this report, does this imply that the State forecasts are more accurate than the MPO regional forecasts?**

A. No. As a point estimate of future travel growth, the MPO regional forecasts may well be more accurate. The MPO forecasts tend to consider more factors than the State-supplied forecasts, which improves their reliability. However, the MPO forecasts tend to have built-in adjustments for factors that the travel demand elasticity features in HERS also account for.

The State-supplied HPMS forecasts are utilized in this report because they are more compatible with the HERS travel demand elasticity procedures. This does not imply they are more accurate than the MPO forecasts. At current funding levels, the travel demand elasticity features in HERS reduce the baseline HPMS travel growth projections down to a level that is consistent with the latest survey of MPO's. This would indicate that the travel demand elasticity features in HERS compensate for the differences in the underlying assumptions between the MPO forecasts and the State-supplied forecasts.

Q. **Could the travel demand elasticity features in HERS be modified to be more compatible with the MPO growth forecasts?**

A. Yes. In the long term, the model could be modified to assume the baseline forecasts fed into it already take into account TDM effects. A short term solution would be to lower the elasticity values, which would reduce the risk of double-counting TDM effects.

However, using the original values coded on the HPMS segments is a better approach from a technical perspective. The MPO travel growth rates are not section-specific, and an arbitrary external adjustment must be made to the HPMS segment data in order to make it line up. This approach reduces the accuracy of the individual highway segment analyses, and creates the potential for introducing errors into the data.

Deficiency Levels

As described in Chapter 7, HERS identifies potential improvements by forecasting future conditions and performance, and identifying deficiencies in eight highway section characteristics: pavement condition, surface type, volume/capacity (V/C) ratio, lane width, right shoulder width, shoulder type, horizontal alignment (curves) and vertical alignment (grades). When 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. Based on a benefit/cost analysis, HERS may either implement one of the improvements identified, or leave the section unchanged.

Different "Deficiency Levels" can be set in HERS to regulate when the model will identify a section as deficient, and which types of improvements the model will consider to address the deficiencies. HERS has 28 distinct types of improvements to choose from, but for an individual section the model only evaluates the potential improvements it deems to be most appropriate. For this version of the report, the deficiency levels in HERS have been modified to allow the model to consider up to six alternative improvements for each section 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. In previous C&P reports, the model only actively considered one or two alternatives at a time. The result of this change is that HERS now implements lower-cost less aggressive improvements on some highway sections, in lieu of the higher-cost improvements it may have otherwise implemented.

Revised Safety Module

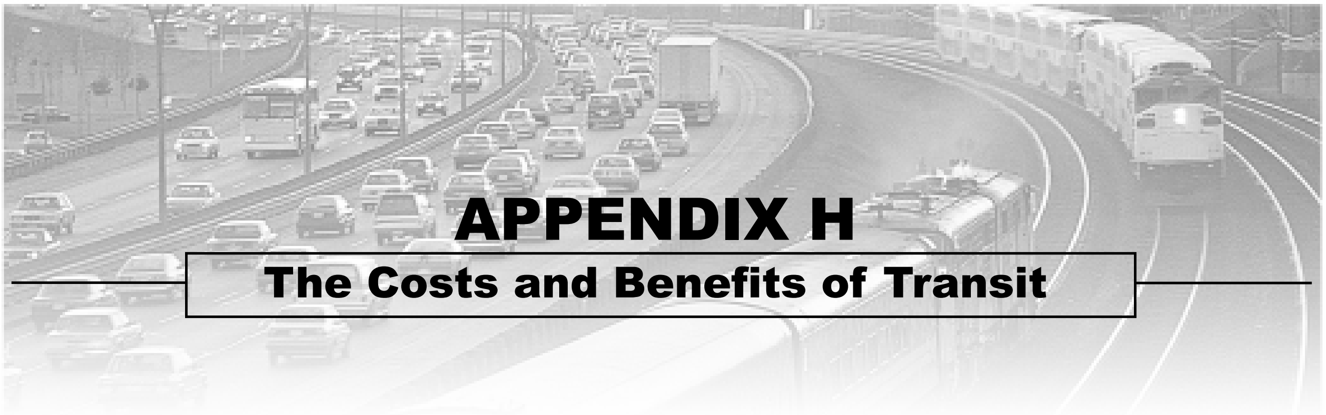
The most significant enhancement to HERS since the release of the 1997 C&P report has been the development of new safety analysis procedures. The new procedures make increased use of specific highway characteristics affecting safety, and better reflect the effects of highway improvements on safety. The new relationships between highway characteristics and crash rates in the HERS safety procedures cause the safety effects of potential highway improvements play a more noticeable role in the evaluation of improvements. By increasing the safety benefits of widening lanes, improving alignments, and/or widening shoulders, the new procedures make it more likely that HERS will implement these types of improvements. The new equations also project that the safety benefits of reducing congestion will be higher than the levels previously predicted by HERS.

The new HERS safety module allows the user to input forecast reductions in future injury and fatality rates due to factors not directly considered in the HERS analysis, such as changes in vehicle designs, emergency care, and driver behavior. This adjustment is made to avoid having HERS claim full credit for injury and fatality reductions in its benefit cost analysis of potential projects, when some of these reductions will probably be driven by factors exogenous to the HERS model. However, this feature was not used for the main scenarios in this report, pending further research on the appropriate values for these reductions. The impact of including some preliminary values in the analysis is explored in the sensitivity analysis in Chapter 10.

Other HERS Enhancements

The capacity calculations in HERS have been updated to conform to the 1997 revisions to the Highway Capacity Manual. The effect of these changes is to increase the estimated capacity of some highway sections, which tends to delay or eliminate the implementation of widening improvements. While these changes are not as significant as the adjustments made previously to conform to the 1994 Highway Capacity Manual discussed in previous C&P reports, they do tend to reduce improvement costs.

The value of time procedures have been revised to make them more consistent with the Department of Transportation standard. A number of other parameters have also been modified to incorporate newly available data. Several other minor upgrades have been made to the model, but do not significantly affect the overall investment requirement projections.



APPENDIX H

The Costs and Benefits of Transit

The three public policy functions served by mass transit in the United States are described in Chapter 2. These functions are: *basic mobility*, providing mobility services to the poor and elderly; *congestion relief*, helping to alleviate automobile congestion on crowded urban expressways and arterials; and *location efficiency*, enabling urban residents to live in high density, mixed use developments without dependency upon auto transportation.

Operating Costs by Policy Function

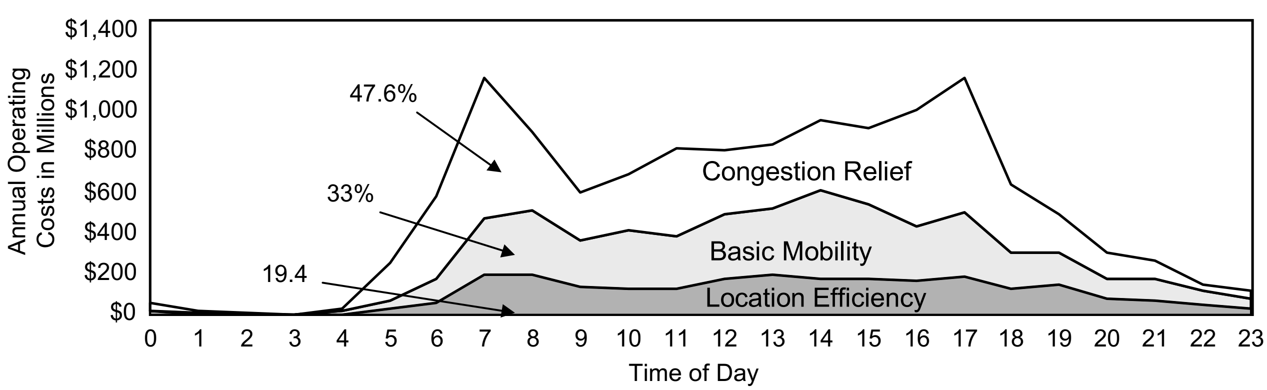
The cost of a particular transit trip depends on a number of variables. The most important factors include:

1) Time of day (peak or off-peak)
2) Vehicle type (bus or rail)
3) Trip distance.

Exhibits 2-16 and 2-17 show how the trips under each of the three policy functions vary across each of these factors. This variation can be combined with estimates of the contribution of each of the three cost factors to allocate transit operating costs by policy function. Exhibit H-1 illustrates the relative contribution of each of the three market niches to transit costs by time of day in 1995. Transit services for the 34.7 percent of trips filling congestion relief roles (those made by above-poverty households with cars) account for 47.6 percent of costs. The basic mobility trips (40.1 percent) incur 33.0 percent of operating costs, while the like figure for the 25.3 percent of trips made for location efficiency is 19.4 percent. This cost pattern reflects the emphasis that most transit systems place on providing a means for commuters to circumvent congested highways.

Exhibit H-1

Transit Function Costs by Time of Day, 1995*

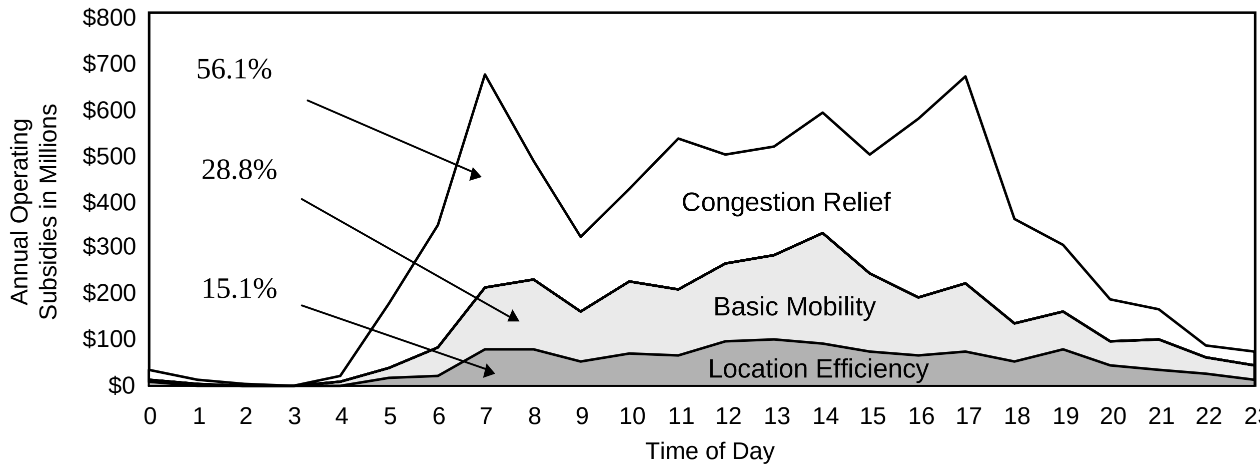


*Approximately 21 percent of costs are not classified in this chart.

Exhibit H-2 shows the costs by transit policy function remaining after the subtraction of fare revenues. This procedure provides an estimate of the subsidies that local, State, and Federal taxpayers provided to local transit operations in 1995. The greatest subsidies are incurred for congestion relief, where 56.1 percent of public subsidies were incurred in 1995. The 40.1 percent of basic mobility trips accounted for only 28.8 percent of public subsidies. Similarly, 25.3 percent of location efficiency trips incurred 15.1 percent of public subsidies.

Exhibit H-2

Transit Subsidies by Function and Time of Day, 1995*



*Approximately 21 percent of costs are not classified in this chart.

Benefits by Policy Function

The benefits of transit can also be classified by policy function. Exhibit H-3 arrays transit's benefits across the three market niches. These benefits and the methodology used to derive them can be summarized as follows:

- The benefits of basic mobility are estimated at $23 billion in 1995. These benefits are calculated using econometric consumer surplus analysis, and represent the difference between transit riders' willingness to pay for trips and the amount they actually do pay. This amount is unlikely to change significantly from year to year.
- Location efficiency was estimated to be worth $20 billion in 1995. This calculation is based on hedonic measurements of property values relative to proximity to transit services, presumed to reflect inter alia auto ownership cost savings.
- The benefits of congestion relief provided by transit are estimated at $15 billion in 1995. This estimate is based on the travel time savings from using transit and the cross price elasticities between auto travel on congested freeways and nearby rapid transit lines.

Exhibit H-3

Transit's Estimated Benefits by Market Niche, 1995

	Aggregate Benefits	Measurement Used*
Basic Mobility	$23 billion	Consumer Surplus
Location Efficiency	$20 billion	Property Values
Congestion Relief	$15 billion	Travel Time

* 1993 Estimates *(FTA 1996 Report: An Update)*
Source: FTA analysis of 1995 NPTS Database.

These measurements are imprecise, representing an aggregation of benefits across a variety of circumstances. However, the scale and relative benefit amounts among transit's market niches are consistent with economic theory and with the willingness of local taxpayers to persistently support transit in serving these niches as worthwhile public policy functions.

Exhibit H-4 summarizes the per-trip costs, subsidies, and benefits of transit, according to the public policy functions described earlier. With a per-trip benefit of $11.66, location efficiency transit services appear to generate the greatest return for the lowest subsidy ($0.85). The total net benefit of location efficiency in 1995 was $9.82 per passenger. Congestion relief generated the least net benefit, $3.07. Basic mobility produced a per-trip benefit in the intermediate range of $6.44.

Exhibit H-4

Per-Trip Summary of Transit's Economic Performance, 1995

	Cost	Subsidy	Benefit	Net Benefit
Basic Mobility	$ 1.96	$ 1.01	$ 8.40	$ 6.44
Location Efficiency	$ 1.85	$ 0.85	$11.66	$ 9.82
Congestion Relief	$ 3.29	$ 2.29	$ 6.37	$ 3.07

Source: FTA analysis of 1995 NPTS Database.

APPENDIX I

Transit Investment Condition and Investment Requirements Methodology

This appendix contains a technical description of the methods used to determine transit asset conditions and future investment requirements. It is primarily a description of the Transit Economic Requirements Model (TERM) and one of the key improvements made to the model for this reporting cycle, stemming from the 1999 National Bus Condition Assessment.

Transit Economic Requirements Model

The Transit Economic Requirements Model (TERM) provides estimates of the total annual capital expenditures required to maintain or improve the physical condition of transit systems and the level of service they provide. The estimate represents the total urbanized area transit investment required by all levels of government. The model also generates estimates of current transit conditions and performance evaluates the impact of varying levels and types of investment on future conditions and performance.

TERM's Structure

TERM forecasts investment needs via four distinct modules:

- Asset Rehabilitation and Replacement
  - Reinvestment in existing assets to maintain and improve the assets' physical condition
- Asset Expansion
  - Investments in new assets such as vehicles and facilities to maintain operating performance to meet forecasts of travel demand
- Performance Enhancement
  - Investments in additional transit capacity to improve operating performance
- Benefit-Cost Tests
  - All investments identified are analyzed on a benefit-costs basis, and only those with a benefit-cost ratio greater than 1 are included in the national investments estimate. This roughly corresponds to the "Maximum Economic Investment" concept in HERS.

The TERM modules are further subdivided by mode, asset type, and urban area characteristics. In addition to investment estimates, TERM generates estimates of the physical condition of the Nation's transit assets, as described in Chapter 3.

Asset Rehabilitation and Replacement Module

The Asset Rehabilitation and Replacement Module identifies investment to maintain and improve the physical condition of the existing transit asset base. The module simulates the deterioration of the asset base over time, requiring investments in rehabilitation and replacement of transit assets in order to maintain or improve overall condition levels. The module uses two key inputs:

- National Transit Asset Inventory
- Statistically determined models of how asset condition decreases over time.

National Transit Asset Inventory

The National Transit Asset Inventory is a comprehensive list of transit assets owned and operated in the United States. It includes records from FTA's National Transit Database (NTD) vehicle inventory, the Rail Modernization Study, and an expanded and more thorough database of additional transit assets developed specifically for us in TERM. The specialized TERM database includes over 22,000 records, detailed by five major asset types:

- Guideway Elements
- Facilities
- Systems
- Stations
- Vehicles.

This extensive database allows the synthesis of assets where agency-reported data are missing or incompatible with the other known agency assets. Values used in the model's input parameter determine the specific threshold in the deterioration process at which assets are rehabilitated and replaced.

Modeling Transit Asset Conditions

The Asset Rehabilitation and Replacement module uses statistically determined functions to simulate the deterioration of transit vehicles and facilities. These asset decay curves predict asset condition as a function of asset type, age, usage rate, and maintenance history. For example, straight and curved track sections are deteriorated using different decay curves because these assets deteriorate at different rates. Assets that have greater use and/or lower maintenance typically have more rapid physical deterioration rates and a lower overall condition. TERM rehabilitates and replaces assets using thresholds that are independently established for each asset category.

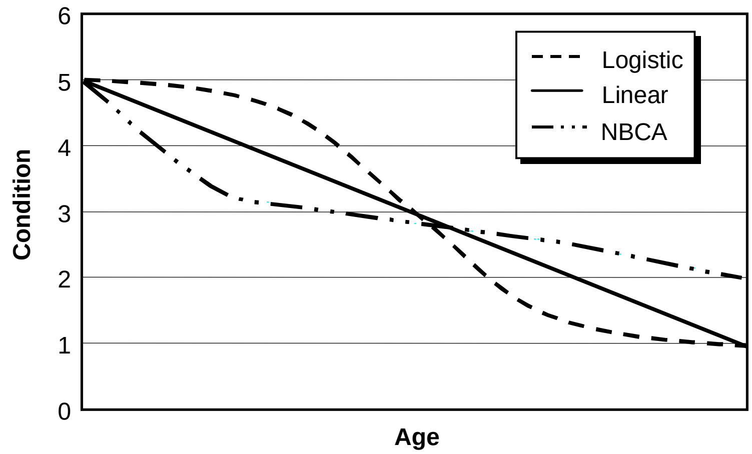
Prior to the 1997 report, average asset age was used as the measure of vehicle condition. While this may be a useful, intuitive proxy for condition, this measure incorporates the implicit assumption that assets deteriorate in a linear fashion over time.

In order to improve on this simple methodology, the 1997 Report calculated asset conditions using a non-linear, logistic decay function (Exhibit I-1). This functional form was derived from earlier studies of asset conditions, based primarily on the rail assets of the Chicago Transit Authority. When decay curves of this form are used, most assets will be at either a relatively high or relatively low condition level, with relatively few in the middle range. These decay curves are then applied within the Transit Economic Requirements Model (TERM) to data on assets from the National Transit Database, thereby generating an average condition level for each asset type.

This report uses a significant improvement in the modeling of asset decay for two asset types: urban buses and urban bus maintenance facilities. This improvement comes via the 1999 National Bus Condition Assessment (NBCA), in which the condition of a stratified national random sample of buses and maintenance facilities was evaluated by direct inspections. Data from this sample were used to derive new decay curves for these two assets, which are incorporated into TERM. As such, the new data play an important role both in determining current asset conditions and in estimating future investment requirements. An example of the form of the estimated decay curve for bus vehicles is shown in Exhibit I-1. Note that the estimated decay curves for bus vehicles are substantially different from the logistic form noted above (and which continues to be used for other asset types). In this form, decay is relatively rapid in the early years, followed by slower decay for an extended period, and ending with a sharp decline in asset condition. Improvements planned for the next report include a similar assessment of rail vehicle conditions.

Exhibit I-1

Asset Decay Curves



The Cost to Maintain Conditions and Cost to Improve Conditions scenarios are calculated by the Rehabilitation and Replacement Module. The key choice parameter for these scenarios is the replacement policy, which is specified as the condition level (on the 1 to 5 scale noted above) at which an asset is replaced. TERM allows a different replacement policy for each of the five major asset categories, and this feature was utilized for this report (in model runs for the 1997 report, the replacement policy was set identically for each asset type). Multiple iterations of the model are then run until the “target” condition for each asset type at the end of the 20-year investment horizon is achieved. For the Maintain Conditions scenario, the targets are the initial average condition levels for each of the five asset types. For the Improve Conditions scenario, the target is a “good” (condition rating 4.0) level for each asset type. Each model run requires approximately 3½ hours on a 456 mhz, 128 mb PC, and each scenario required 7-10 iterations to reach the targets.

The Rehabilitation and Replacement Module estimates only investments required to maintain the base year fleet; it does not account for expansion assets purchased during the 20-year model run. This function is performed by the Asset Expansion Module.

Asset Expansion Module

The Asset Expansion Module identifies investments required to maintain current operating performance. The module does this by accommodating growth in transit use at the base year level of performance. Using growth in transit passenger miles traveled (PMT) from MPO forecasts, the module programs the purchase of transit vehicle and other assets required to maintain the base year level of performance (based on vehicle utilization rates). The model screens investments to ensure that passenger miles per peak vehicle at least reach a national threshold. Investments are foregone in cases where utilization fails to achieve the threshold. Investments estimated by the Asset Expansion Module during the first part of the 20-year forecast period are the subject to the Asset Rehabilitation and Replacement Module later in the analysis period.

Metropolitan Planning Organization (MPO) Forecasts

Metropolitan planning organizations in most large urbanized areas make long-range forecasts of transit passenger growth and vehicle travel growth as part of the transportation planning process. These are the most comprehensive forecasts of transit travel growth available. In order to obtain these forecasts, MPOs in 32 of the largest urbanized areas were surveyed for their forecasts. In several cases, only transit passenger trips (rather than passenger miles) were forecast; in these cases, the trip growth figure was used. One notable omission from the survey is the New York Metropolitan Transportation Council, which does not forecast transit travel growth. Instead, the forecast from the New Jersey Transportation Planning Authority (which covers part of the New York City urbanized area) was used. Transit travel growth for the 370 urbanized areas not in the sample was estimated using the average regional (North, South, Midwest, West) growth rate. The weighted-average transit PMT growth rate calculated from the MPO forecasts and used in TERM was 1.90%, though the rates for individual urbanized areas range from 7.7% (Los Angeles) to –0.6% (Cincinnati). See Chapter 10 for a sensitivity analysis of the effect that different growth rates have on investment requirements.

Performance Enhancement Module

The Performance Enhancement Module identifies transit capacity investment to improve operating performance beyond the asset expansion module. The module identifies investments based on the national average vehicle operating speed. In the NTD, average rail operating speed exceeds the average bus operating speed, and this principle is employed along with the MPO forecasts to identify rail investments required to increase system speed and reduce vehicle utilization. The module makes investments required to improve transit operating speed in urban areas with the lowest speeds and to reduce vehicle utilization rates for the most crowded transit operators. The module estimates the investment levels required to allow systems falling below the minimum operating speed threshold or above the maximum vehicle utilization threshold to add new transit capacity until these threshold values are attained.

Earlier versions of TERM also contained a New Starts Pipeline submodule within the Performance Enhancements module. However, this feature is no longer utilized.

Benefit-Cost Tests

All investments identified in TERM are subject to a benefit-cost test. To analyze the output of the investment modules, TERM utilizes two separate benefit-cost filters. The first is used to analyze investment proposed by the Rehabilitation and Replacement and Asset Expansion modules, and the second filter is used for investment proposed by the Performance Enhancement module.

Benefits and costs in the Rehabilitation and Replacement and Asset Expansion modules are modeled at the transit agency level and on a mode-by-mode basis. For each agency and mode in the TERM database, the model first estimates the mode's discounted stream of capital investment and operating and maintenance expenditures over the 20 years of the model run (including Asset Expansion Module-generated investments). This stream is then compared to the discounted stream of benefits anticipated from continued operation of that agency/mode. If the level of projected benefits is in excess of the estimated capital and operating and maintenance expenditures (i.e., if the benefit-cost ratio is greater than 1), the model's estimate of agency and mode capital investment needs is included in the overall national investment needs estimate. If the benefit-cost ratio is less than 1, the agency and mode are not considered to be cost effective and are discontinued. The benefits accounted for in the model are discussed below.

For Performance Enhancement projects, investments are evaluated on an urbanized area basis. Each investment in a new start project is analyzed based on the known characteristics of the urbanized area the investment is expected to serve, the expected total cost and time period for project development, expected operating and maintenance costs, and the level and type of benefits associated with a typical new start investment of the proposed type (on a per-mile basis). These benefits and costs are compared using a discounted net present value analysis. Projects with a BC ratio greater than 1 are included in TERM's national summary of Performance Enhancement investments, while those failing the test are omitted.

The Benefit-Cost modules screen for benefits from three categories:

- Transportation System User Benefits
  - Travel time savings, reduced highway congestion and delay, reduced auto costs, and improved mobility
- Transit Agency Benefits
  - Fare revenue increases and reductions in operating and maintenance costs
- Social Benefits
  - Reductions in air and noise emissions, reduced roadway wear, and transportation system administration.

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 reinvestment in current transit assets and new transit investments identified by TERM accrue to new and existing users of the transit system and are captured in the class of transportation system user benefits. Some of the benefits are used to evaluate Rehabilitation and Replacement and Asset Expansion investments (e.g., operating and maintenance costs), while others are used to evaluate Performance Enhancement investments (e.g., reduced new rider costs and reduced emissions).

The most important omission from TERM is its absence of supply or demand elasticities. On the demand side, while transit service improvements might be expected to induce more transit ridership in and of themselves, TERM does not take account of this. There is also no linkage between TERM and HERS, and thus no cross-elasticity of demand, meaning that TERM does not take into account the effect that investments leading to a decrease in the cost of substitute form of travel (i.e., highways) have on the demand for transit. Instead, transit PMT growth is taken as an exogenous input from the MPO forecasts. These forecasts themselves do take some of these demand elasticities into account, however, given their role in environmental and fiscal planning for metropolitan transportation. The forecasts also take into account desired and planned transit investments (or the lack thereof) in estimating future transit travel growth. On the supply elasticity side, TERM does not take account of the potential impact that large-scale investments could have on the cost of building new transit infrastructure. For example, expansions of existing rail systems may occur in areas that are more expensive to build in (indeed, this may be the very reason that rail investments did not occur *first* in these areas).

Rural and Specialized Transit Service Investments

Rural and specialized transit service providers are not required to report to the NTD. As a result, agency asset and service level details are not available, and these operators are not included as part of the TERM analysis. Instead, investment requirements for these operators are made using older, rule-of-thumb methods.

Data on rural vehicles and fleet age, as reported in Chapter 3, is available from the Community Transportation Association of America. The cost to maintain conditions for rural and specialized transit vehicles is calculated by determining the number of vehicles that must be replaced annually to maintain the current average fleet age and multiplying this number by the average cost per replacement vehicle. The vehicle replacement ages are set using FTA's minimum useful life guidelines. The resulting investment requirement estimates are then added to the TERM results.

While data are available on the inventory and condition of maintenance facilities for rural and specialized transit operators, no information is available on required capitalization costs. FTA grants for all urban facilities have about equaled the grants for vehicles over the last several years. Rural area facility needs are likely to be proportionately less than urban needs, since, because of the nature of rural service, there is less need for ancillary facilities such as terminals, stations, and park-and-ride lots. Similar considerations apply to specialized transit facilities. Accordingly, for purposes of analysis, rural and specialized facility needs are calculated at one-half of rural vehicle needs. This is based on the past relationship between transit bus and bus facility expenditures. The resulting requirements are then added to the TERM results.