CHAPTER 7

Capital Investment Requirements

Summary

Exhibit 7-1 compares the 20-year average annual investment requirements in this report with those presented in the 2002 C&P report. The first column shows the projection for 2001 to 2020 based on 2000 data shown in the 2002 C&P report, stated in 2000 dollars. The second column restates these highway and transit values in 2002 dollars, to offset the effect of inflation. The third column shows new average annual investment requirement projections for 2003 to 2022 based on 2002 data.

Results for highways, bridges, and transit are presented for two key scenarios, one in which the status of the current system is maintained, and one in which it is improved. However, the exact specifications of the scenarios differ for each mode. Investment requirements for highways and bridges are drawn from the Highway Economic Requirements System (HERS), which estimates highway preservation and highway and bridge capacity expansion investment; the National Bridge Investment Analysis System (NBIAS), which estimates future bridge preservation requirements; and external adjustments to reflect functional classes and improvement types not directly modeled. Transit investment requirements for urbanized area operators that report to the National Transit Database (NTD) are estimated from the Transit Economic Requirements Model (TERM). Requirements for rural and special services are estimated separately based on the number of vehicles, the percentage of overage vehicles, vehicle replacement costs, and actual and industry-recommended replacement ages.

Exhibit 7-1 *Highway, Bridge, and Transit Investment Requirement Projections Compared with Data from the 2002 C&P Report*

Statistic	2001–2020 Projection (Based on 2000 Data) 2002 Report	2001–2020 Projection (Based on 2000 Data) Adjusted for Inflation	2002–2022 Projection (Based on 2002 Data)
Average Annual Investment Requirements	**2000 $**	**2002 $**	**2002 $**
Cost to Maintain			
Highways and Bridges	$75.9 bil	$77.1 bil	$73.8 bil
Transit	$14.8 bil	$15.4 bil	$15.6 bil
Cost to Improve			
Highways and Bridges (Maximum Economic Investment Level)	$106.9 bil	$108.5 bil	$118.9 bil
Transit	$20.6 bil	$21.4 bil	$24.0 bil

This chapter focuses on the estimated investment requirements for the “Improve” and “Maintain” scenarios noted in Exhibit 7-1. Chapter 9 includes an analysis of the projected impacts of these and other future investment levels on conditions and performance. Chapter 10 includes a sensitivity analysis, showing how the estimated investment requirements would change under different assumptions about the values of key model parameters.

Background information on the development of the future investment requirements estimates, and the motivation for using economic analysis as the basis for the estimates, is presented in the introduction to Part II. That section also discusses uncertainty in the investment requirement modeling process and the relationship between pricing and investment requirements. As noted there, increased adoption of congestion pricing (which is not accounted for in the investment estimates presented in this chapter) would be expected to lead to more efficient operation of the highway network, lower levels of congestion, and some delay or reduction in future capital investment requirements. More information on the methodology used to develop the investment projections, including recent changes to the methodology, is contained in Appendices A, B, and C. Part V of this report examines some fundamental data and analytical issues relating to the types of investment/performance analysis reflected in this chapter.

Both the highway and transit analyses depend heavily on forecasts of future demand. Chapter 10 explores the effects that varying assumptions about future travel demand and some of the other key parameters in the highway and transit investment requirement analytical processes would have on the projections identified in Exhibit 7-1. Highway travel growth forecasts are also discussed in Chapter 9.

Highways and Bridges

The average annual **Maximum Economic Investment** for ("Cost to Improve") highways and bridges is projected to be $118.9 billion for 2003 to 2022. This figure represents an "investment ceiling" above which it would not be cost beneficial to invest. Accounting for inflation (using FHWA's Construction Bid Price Index), this estimate is 9.5 percent greater than the "Cost to Improve" for 2001 to 2020 reported in the 2002 C&P report. The average annual **"Cost to Maintain"** highways and bridges is projected to be $73.8 billion for 2003 to 2022, which is 4.3 percent lower than the estimate in the 2002 C&P report for 2001 to 2020, again accounting for inflation. At this level of investment, future conditions and performance of the Nation's highway system would be maintained at a level sufficient to keep average highway user costs from rising above their 2002 levels.

Q. What is the Federal share of the highway and transit investment requirements identified in this report?

A. The investment requirements identified in this report represent the projected levels of total capital investment that would be necessary to obtain certain outcomes. The question of what portion should be funded by the Federal government, State governments, local governments, or the private sector is outside the scope of this report.

Chapter 6 includes information on historic trends in public funding for highways and transit by different levels of government.

The changes in projected investment requirements from the 2002 report are attributable both to changes in the underlying characteristics, conditions, and performance of the highway system as reported in the available data sources, and to changes in the methodology and models used to generate the estimates. Notable HERS methodological changes include the addition of new procedures designed to reflect the impact that certain types of operational strategies and Intelligent Transportation Systems (ITS) deployments may have on system performance, revised pavement deterioration models and updated improvement cost estimates, and the consideration of work zone delay in the benefit calculations.

Considering operations strategies and investments, which are considerably less costly in terms of initial outlays than conventional capacity investments, results in a lower estimate of the amount of investment necessary to achieve a given level of performance. Updated, increased assumptions about the unit costs of capacity investments tend to make such improvements relatively less attractive at lower funding levels, but still cost beneficial overall, resulting in an increased cost of implementing all such investments. Including work zone delay in the calculations furthers this trend by making major projects with lengthy construction times relatively less attractive as well in benefit-cost terms, especially for scenarios based on relatively lower overall levels of investment. Further information on these methodological changes is found later in this chapter, as well as in Appendix A.

Q. A figure of $375 billion in needed 6-year Federal highway and transit spending has been widely cited as coming from the 2002 C&P report? What is the comparable number from this report?

A. Though widely cited as coming directly from the 2002 C&P report, **the $375 billion figure did not appear anywhere within the report itself.** The investment requirement scenarios presented in the C&P report are long-term, 20-year estimates shown in constant base-year dollars. These scenarios are intended to be illustrative of how alternative investment levels might impact the future conditions and performance of the transportation system, and the report does not endorse any particular level of investment. The estimates are not intended to correspond to any specific legislative period or cycle, and no assumptions are made about what level the Federal share of capital investment under any particular scenario would or should be. Outside analysts can and do make use of the statistics presented in the C&P report to draw their own conclusions about these types of issues, but any such analysis would require a series of additional assumptions that are not reflected in this document.

The NBIAS model was first used for estimating future investment requirements for bridge preservation in the 2002 C&P report. Since that time, the model has been significantly enhanced. The most notable change was the extension of all aspects of the analysis to the individual bridge level; previously, the model had evaluated bridge replacements on a case-by-case basis, but had assessed routine repair and rehabilitation actions on a more aggregated basis. The new approach, coupled with revised estimates of bridge engineering and construction costs, has revealed additional opportunities for cost-beneficial bridge preservation investment. Further information on NBIAS is presented later in this chapter, as well as in Appendix B.

The increase in the Maximum Economic Investment for highways and bridges relative to the last report is also related to the fact that capital investment by all levels of government between 2000 and 2002 remained below the "Cost to Maintain" level. Consequently, the overall performance of the system declined, which increased the number of potentially cost-beneficial highway and bridge investments that would address these performance problems. Improvements in the methodology used to model highway investment, allowing for more flexibility in choosing expansion options, also resulted in more cost-beneficial projects being found by the models, and in higher estimated costs for some of these projects on heavily congested roads in major urban areas.

Transit

The estimated average annual **"Cost to Maintain"** transit asset conditions and operating performance is estimated to be $15.6 billion, compared with $14.8 billion in 2000 dollars presented in the last report. Eighty-seven percent of transit investment requirements will be in urban areas with populations of over 1 million, reflecting the fact that 91 percent of the Nation's passenger miles are currently in these areas. The average annual **"Cost to Improve"** both the physical condition of transit assets and transit operational performance to targeted levels by 2022 is estimated to be $24.0 billion, compared with $20.6 billion in 2000 dollars for the 2000 to 2020 period presented in the last report.

Fifty-eight percent of the total amount needed to maintain conditions and performance, or $9.0 billion dollars annually, and 62 percent of the total amount needed to improve conditions and performance, or $14.9 billion annually, are estimated to be for rail infrastructure. Vehicles and guideway elements are estimated to require the largest amount of the total capital investment of all rail assets between 2003 and 2022, followed in descending order of investment requirements by stations, power systems, and facilities.

Forty-two percent of the total amount needed to maintain conditions and performance, or $6.5 billion dollars annually, and 39 percent of the total amount needed to improve conditions and performance, or $9.1 billion annually, are estimated to be for nonrail infrastructure. Vehicles are estimated to require the largest amount of the total capital investment in nonrail assets between 2003 and 2022, followed in descending order of investment requirements by facilities, guideway elements (dedicated lanes for buses), power systems, and stations.

Since the 2002 report, the asset inventory and asset deterioration information in TERM has been improved through special data collection efforts and engineering surveys. Ridership forecasts have been revised downward very slightly from 1.6 percent to 1.5 percent per year based on updated information collected from an expanded list of metropolitan planning organizations (MPOs). Changes in investment requirements reflect real changes in projected ridership, transit infrastructure size, and transit asset replacement costs. They also reflect improvements in the Federal Transit Administration's (FTA's) knowledge about the magnitude, deterioration, conditions, and replacement costs of these assets.

Highway and Bridge Investment Requirements

This section presents the projected investment requirements for highways and bridges for two primary performance targets. The "Maximum Economic Investment" scenario (Cost to Improve Highways and Bridges) identifies the level of investment that would be required to significantly improve system performance in an economically justifiable manner. The "Cost to Maintain Highways and Bridges" represents the annual investment necessary to maintain the current level of highway system performance. The impacts of a wider range of alternative investment levels on various measures of system performance are shown in Chapter 9. Chapter 9 also explores recent trends in highway expenditures compared with recent changes in system performance.

The combined highway and bridge investment requirements are drawn from the separately estimated scenarios for highways and for bridges, and from external adjustments to the two models. These scenarios are defined differently, owing to the different natures of the models used to develop them. However, it is useful to combine them. This aggregation is particularly helpful when trying to compare these scenarios to current or projected investment levels, since amounts commonly referred to as "total highway spending" or "total highway capital outlay" include expenditures for both highways and bridges. Chapter 8 compares current highway and bridge spending with the investment requirements outlined in this section.

The average annual **"Maximum Economic Investment for Highways and Bridges"** over the 20-year period 2003 to 2022 is projected to be **$118.9 billion** in 2002 dollars. The average annual **"Cost to Maintain Highways and Bridges"** is projected to be **$73.8 billion** (also in 2002 dollars).

Note that these projections implicitly assume the continuation of current tax and fee structures. As pointed out in the "Congestion Pricing and Investment Requirements" section in the Introduction to Part II of this report, any shifts in financing mechanisms that significantly alter the costs incurred by individual users would have an effect on these results. The 2006 edition of the C&P report will begin to address this phenomena in a more quantitative manner. Note also that the accuracy of these projections depends on the validity of the technical assumptions underlying the analysis; Chapter 10 explores the impacts of altering some of these assumptions.

Maximum Economic Investment for Highways and Bridges

The average annual "Maximum Economic Investment for Highways and Bridges" is broken down by functional class and type of improvement in *Exhibit 7-2*. The estimated investment requirements for urban arterials and collectors total $69.2 billion, or 58.2 percent of the total average annual "Maximum Economic Investment for Highways and Bridges." Investment requirements on rural arterials and collectors are $32.4 billion (or 27.3 percent of the total), while the investment requirements for rural and urban local roads and streets total $17.2 billion (14.5 percent).

Exhibit 7-2 *Average Annual Maximum Economic Investment for Highways and Bridges (Billions of 2002 Dollars)*

Functional Class	System Preservation Highway	System Preservation Bridge	System Preservation Total	System Expansion	System Enhancements	Total
Rural Arterials & Collectors						
Interstate	$2.6	$0.7	$3.3	$2.5	$0.7	$6.4
Other Principal Arterial	$4.3	$1.0	$5.3	$1.7	$1.1	$8.1
Minor Arterial	$4.2	$1.0	$5.2	$1.0	$0.6	$6.8
Major Collector	$6.1	$1.5	$7.6	$0.6	$0.5	$8.7
Minor Collector	$1.2	$0.6	$1.8	$0.4	$0.2	$2.4
Subtotal	**$18.4**	**$4.8**	**$23.2**	**$6.1**	**$3.1**	**$32.4**
Urban Arterials & Collectors						
Interstate	$4.9	$2.1	$7.0	$15.9	$1.9	$24.9
Other Freeway & Expressway	$2.1	$0.7	$2.8	$8.3	$0.7	$11.8
Other Principal Arterial	$5.6	$1.3	$6.8	$7.7	$1.6	$16.2
Minor Arterial	$3.8	$0.9	$4.6	$5.4	$0.7	$10.7
Collector	$2.1	$0.4	$2.5	$2.5	$0.6	$5.7
Subtotal	**$18.4**	**$5.3**	**$23.7**	**$39.8**	**$5.6**	**$69.2**
Rural & Urban Local	$6.4	$2.3	$8.8	$6.9	$1.5	$17.2
Total	**$43.2**	**$12.5**	**$55.7**	**$52.9**	**$10.2**	**$118.9**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System

This scenario combines the "Maximum Economic Investment" scenarios from the Highway Economic Requirements System (HERS) and the National Bridge Investment Analysis System (NBIAS) with external adjustments to the two models.

Cost to Maintain Highways and Bridges

Exhibit 7-3 shows the average annual "Cost to Maintain Highways and Bridges" by type of improvement and functional class. The estimated investment requirements for urban arterials and collectors under this scenario total $41.4 billion, or 56.1 percent of the average annual "Cost to Maintain Highways and Bridges." Investment requirements for rural arterials and collectors total $21.6 billion (29.3 percent), while the investment requirements for rural and urban local roads and streets total $10.8 billion (14.5 percent).

The "Cost to Maintain Highways and Bridges" scenario combines the "Maintain User Costs" scenario from HERS and the "Maintain Economic Backlog" scenario from NBIAS with external adjustments to the two models.

Investment Requirements by Improvement Type

Exhibits 7-2 and 7-3 also show investment requirements by type of improvement. The investment requirements are classified into three categories (defined in Chapter 6): system preservation, system expansion, and system enhancement. System preservation, as defined in this report, consists of the *capital* investment required to preserve the condition of the pavement and bridge infrastructure. This includes the costs of resurfacing, rehabilitation, and reconstruction, but does not include routine maintenance costs. System expansion includes the costs related to increasing system capacity by widening existing facilities or

Exhibit 7-3 *Average Annual Investment Required to Maintain Highways and Bridges (Billions of 2002 Dollars)*

	System Preservation			System	System	
Functional Class	**Highway**	**Bridge**	**Total**	**Expansion**	**Enhancements**	**Total**
Rural Arterials & Collectors						
Interstate	$2.2	$0.5	$2.7	$1.8	$0.4	$5.0
Other Principal Arterial	$3.2	$0.7	$3.9	$1.2	$0.7	$5.8
Minor Arterial	$2.7	$0.7	$3.4	$0.6	$0.4	$4.3
Major Collector	$3.3	$1.0	$4.4	$0.3	$0.3	$5.0
Minor Collector	$0.7	$0.4	$1.2	$0.2	$0.1	$1.5
Subtotal	**$12.2**	**$3.4**	**$15.5**	**$4.2**	**$1.9**	**$21.6**
Urban Arterials & Collectors						
Interstate	$3.8	$1.6	$5.5	$7.1	$1.2	$13.8
Other Freeway & Expressway	$1.9	$0.6	$2.4	$3.6	$0.4	$6.5
Other Principal Arterial	$4.7	$0.9	$5.6	$4.1	$1.0	$10.7
Minor Arterial	$3.0	$0.6	$3.7	$3.0	$0.5	$7.1
Collector	$1.4	$0.2	$1.7	$1.3	$0.4	$3.3
Subtotal	**$14.9**	**$4.0**	**$18.9**	**$19.0**	**$3.5**	**$41.4**
Rural & Urban Local	$4.0	$1.5	$5.5	$4.3	$1.0	$10.8
Total	**$31.1**	**$8.9**	**$40.0**	**$27.5**	**$6.4**	**$73.8**

Source: Highway Economic Requirements System and National Bridge Investment Analysis System

adding new roads and bridges. System enhancements include targeted safety enhancements, traffic control improvements, and environmental improvements. Appendix A describes how the investment requirements modeled by HERS and NBIAS were allocated among the three types of improvements.

Exhibit 7-4 displays investment requirements by improvement type for rural and urban areas, for each scenario.

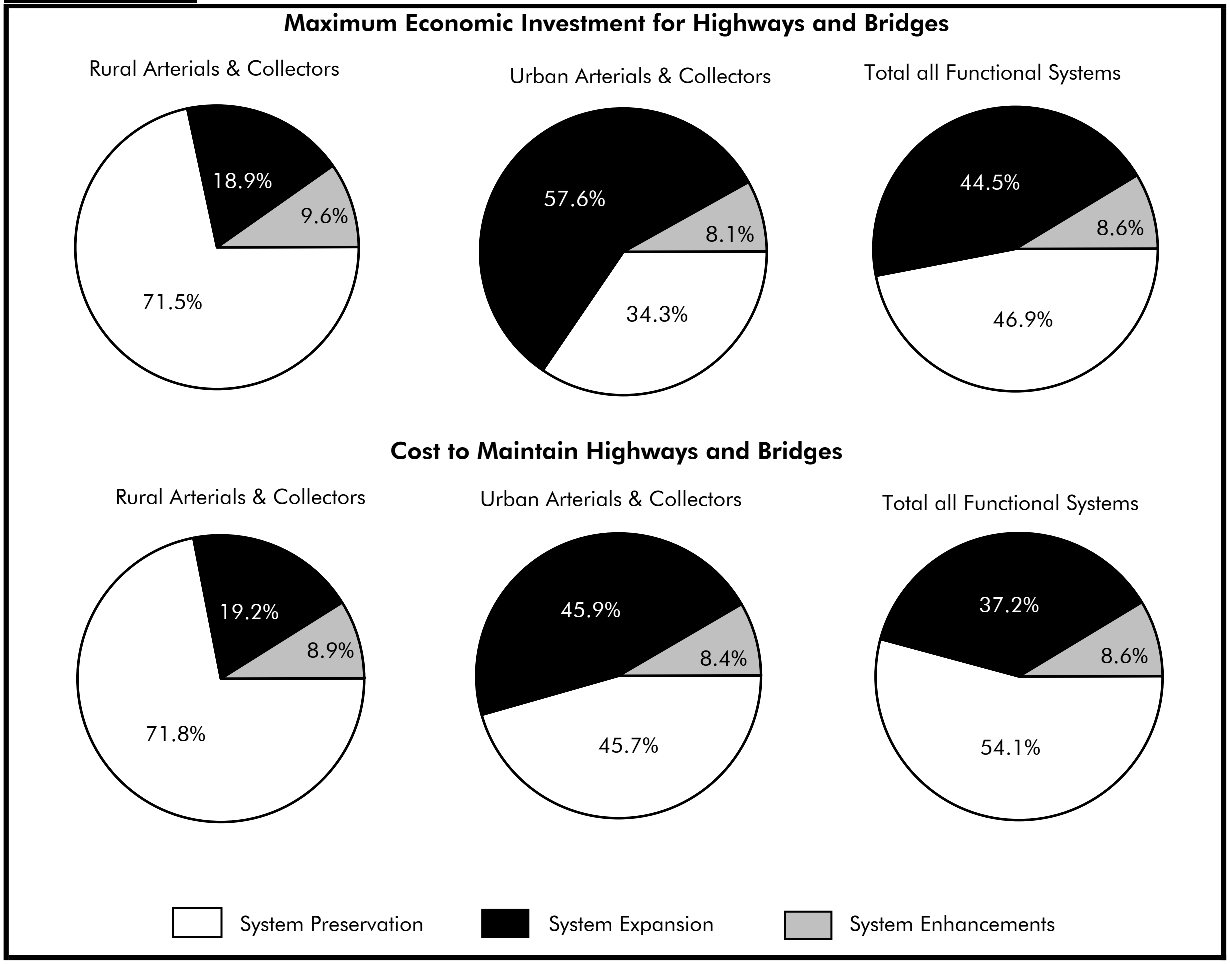
System Preservation

Average annual system preservation investment requirements are estimated to be $55.7 billion under the "Maximum Economic Investment" scenario and $40.0 billion under the "Cost to Maintain" scenario. These totals constitute 46.9 and 54.1 percent, respectively, of the totals for the two scenarios. Exhibits 7-2 and 7-3 also indicate that bridge preservation investments represent about 22 percent of total preservation investment requirements under each scenario. As shown in Exhibit 7-4, system preservation makes up a much larger share of total investment requirements in rural areas than in urban areas.

System Expansion

The $52.9 billion in average annual investment requirements for system expansion represent 44.5 percent of the total "Maximum Economic Investment for Highways and Bridges." Comparable figures for the "Cost to Maintain" scenario are $27.5 billion and 37.2 percent. Exhibits 7-2 through 7-4 indicate that system expansion requirements are much larger in urban areas than in rural areas, both in the total amount and as a share of overall investment requirements, under both investment scenarios.

Exhibit 7-4 *Highway and Bridge Investment Requirements: Distribution by Improvement Type*



Source: Highway Economic Requirements System and National Bridge Investment Analysis System.

Q. Can highway capacity be expanded without adding new lanes or new roads and bridges?

A. Yes. In some cases, effective highway capacity can be increased by improving the utilization of the existing infrastructure. The investment requirements estimates presented in this edition of the report now consider the impact of some of the most significant such operations strategies and deployments on highway system performance. The capital investment costs associated with these strategies are included in the estimates of highway capacity investment presented in this chapter. Operations strategies are further discussed in Chapter 12.

The methodology used to estimate system expansion requirements also allows high-cost capacity improvements to be considered as an option for segments with high volumes of projected future travel, but have been coded by States as infeasible for conventional widening. Conceptually, such improvements might consist of new highways or bridges in the same corridor (or tunneling or double-decking on an existing alignment), but the capacity upgrades could also come through other transportation improvements, such as a parallel fixed guideway transit line or mixed-use high occupancy vehicle/bus lanes.

System Enhancements

Investment requirements for system enhancements represent 8.6 percent of both the "Maximum Economic Investment for Highways and Bridges" ($10.2 billion) and the "Cost to Maintain Highways and Bridges" ($6.4 billion). Investment requirements for safety enhancements, traffic control facilities, and environmental enhancements are not directly modeled, so this amount was derived solely from the external adjustment procedures described below.

Sources of the Highway and Bridge Investment Requirements Estimates

The estimates of investment requirements for highways and bridges under the "Improve" and "Maintain" scenarios were derived from three sources:

- Highway and bridge capacity expansion and highway preservation investments were modeled using HERS.
- Bridge preservation investments were modeled using NBIAS.
- The HERS and NBIAS results were supplemented by external adjustments made to account for functional classes not included in the data sources used by the models and types of capital investment that are not currently modeled.

The model scenarios used in HERS and NBIAS to construct the "Improve" and "Maintain" scenarios are discussed in greater detail below. *Exhibit 7-5* shows the sources of the highway and bridge investment requirements estimates.

External Adjustments

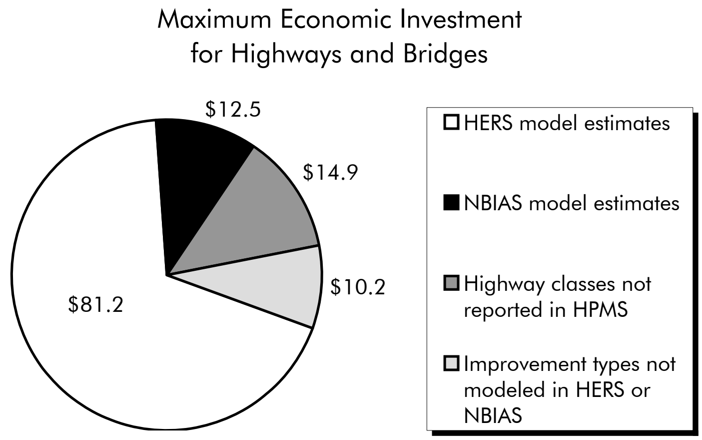
External adjustments were made to the directly modeled improvements generated by HERS and NBIAS in two areas:

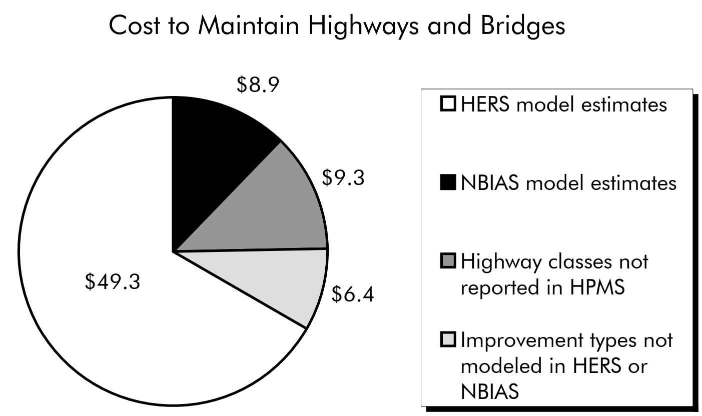
- **Highway functional classes.** Bridges on all functional classes are represented in the National Bridge Inventory (NBI) database used by NBIAS, so all of the investment requirements for bridge preservation shown in this report are derived directly from NBIAS. However, the Highway Performance Monitoring System (HPMS) sample segment database used by HERS does not include rural minor collectors, rural local roads, or urban local roads. Consequently, HERS does not provide estimates for these systems, and separate estimates for highway preservation and system expansion were applied.

Q. Why does the analysis assume that the share of future highway investments for non-modeled items would remain the same?

A. No data are currently available that would justify an assumption that this percentage would change. If this percentage of highway capital expenditures used for rural minor collectors, rural and urban local roads, and/or system enhancements were to rise in the future, then the investment requirements presented in this chapter would be understated. If this percentage falls over time, then the investment requirements shown would be overstated.

Exhibit 7-5 *Sources of the Highway and Bridge Investment Requirements Estimates (Billions of 2002 Dollars)*





- **Improvement types.** The improvement options that HERS and NBIAS consider primarily address pavement and capacity deficiencies on existing highway and bridge sections. Currently, HERS and NBIAS do not directly consider system enhancements. Estimates for this improvement type were applied across all functional classes.

The adjustment procedures assume that the share of total highway investment requirements represented by these functional classes and improvement types would be equivalent to their share of current highway capital spending. The amounts derived from these external adjustments are identified separately in this report because they would be expected to be less reliable than those derived from HERS and NBIAS.

The percentage of total investment requirements that are modeled in HERS and NBIAS is slightly higher than was the case in the 2002 C&P report. This is largely attributable to the fact that the share of combined highway capital expenditures by State and local governments estimated to have been devoted to local roads and rural minor collectors decreased between 2000 and 2002.

Highway Economic Requirements System

The investment requirements shown in this report for highway preservation and highway and bridge capacity expansion are developed primarily from HERS, a simulation model that employs incremental benefit cost analysis to evaluate highway improvements. The HERS analysis is based on data from the HPMS, which provides information on current roadway characteristics, conditions, and performance and anticipated future travel growth for a nationwide sample of more than 111,000 highway sections. While HERS analyzes these sample sections individually, the model is designed to provide results valid at the national level, and does not provide definitive improvement recommendations for individual highway segments.

Q. Does HERS identify a single "correct" level of highway investment?

A. No. The HERS model is a tool for estimating what the consequences may be of various levels of spending on highway conditions and performance. If funding were unlimited, it might make sense to implement all projects identified by HERS as cost beneficial. In reality, however, funding is constrained, and highways must compete for funding with other economic priorities. The investment requirements scenarios in this chapter estimate the resources that would be required to attain certain levels of performance, but are not intended to endorse any specific level of funding as "correct" or "optimal."

Q. How closely does the HERS model simulate the actual project selection processes of State and local highway agencies?

A. The HERS model is intended to approximate, rather than replicate, the decision processes used by State and local governments. HERS does not have access to the full array of information that local governments would use in making investment decisions. This means that the model results may include some highway and bridge improvements that simply are not practical because of factors the model doesn't consider. Excluding such projects would result in reducing the "true" level of investment that is economically justifiable. Conversely, the highway model assumes that State and local project selection will be economically optimal and doesn't consider external factors such as whether this will result in an equitable distribution of projects among the States or within each State. In actual practice, there are other important factors included in the project selection process aside from economic considerations; thus, the "true" level of investment that would achieve the outcome desired under the scenarios could be higher than that shown in this report.

The HERS model initiates the investment requirements analysis by evaluating the current state of the highway system using information on pavements, geometry, traffic volumes, vehicle mix, and other characteristics from the HPMS sample dataset. It then considers potential improvements on sections with one or more deficiencies, including resurfacing, reconstruction, alignment improvements, and widening or adding travel lanes. The HERS model then selects the improvement with the greatest net benefits, where benefits are defined as reductions in direct highway user costs, agency costs, and societal costs. In cases where none of the potential improvements produces benefits exceeding construction costs, the segment is not improved. Appendix A contains a fuller description of the project selection and implementation process used by HERS.

One of the key features of HERS as an economics-based model involves its treatment of travel demand. Recognizing that drivers will respond to changes in the relative price of driving and adjust their behavior accordingly, HERS explicitly models the relationship between the amount of highway travel and the price of that travel. This concept, sometimes referred to as travel demand elasticity, is applied to the forecasts of future travel found in the HPMS sample data. The HERS model assumes that the forecasts for each sample highway segment represent a future in which average conditions and performance are maintained, thus holding highway user costs at current levels. Any change in user costs relative to the initial conditions calculated by HERS will thus have the effect of either inducing or suppressing future travel growth on each segment. Consequently, for any highway investment requirement scenario that results in a decline in average user costs, the effective vehicle miles traveled (VMT) growth rate for the overall system will tend to be higher than the baseline rate derived from HPMS. For scenarios in which highway user costs increase, the effective VMT growth rate will tend to be lower than the baseline rate. A discussion of the impact that future investment levels could be expected to have on future travel growth is included in Chapter 9. Appendix A includes a further discussion of how travel demand elasticity is implemented in HERS.

While HERS was primarily designed to analyze highway segments, and the HERS outputs are described as "highway" investment requirements in this report, the model also factors in the costs of expanding bridges and other structures when deciding whether to add lanes to a highway segment. All highway and bridge investment requirements related to capacity are modeled in HERS; the NBIAS model considers only investment requirements related to bridge preservation.

Operations Investments

For this report, the HERS model has been adapted to take into account the impact that new investments in certain types of intelligent transportation systems (ITS) and the continued deployment of various operations strategies can have on highway system performance, and the amount of capital investment required to reach given performance benchmarks. The types of operations investments and strategies include those targeted at:

- Freeway management (ramp metering, electronic monitoring, variable message signs, and traffic management centers);
- Incident management (incident detection, verification, and response); and
- Arterial management (upgraded signal control, electronic monitoring, variable message signs, and emergency vehicle signal preemption).

Q. What are the costs associated with the operations strategies and investments included in the HERS investment analyses?

A. The costs of the new or increased operations deployments include both the capital costs of the equipment and infrastructure and the ongoing costs of operating and maintaining that infrastructure. The costs include those for both the basic infrastructure needed to support a given strategy (such as a traffic operations management center) and the incremental costs of increasing the coverage of that structure (such as additional ramp meters).

The estimated capital cost of new deployments under the existing trends scenario used for these analyses is $1.5 billion over 20 years (in 2002 dollars). These costs are included in the investment requirements estimates included in this report.

Estimated operating and maintenance costs for the operations strategies over the same 2003 to 2022 time period are $10.9 billion, including $2.9 billion for new deployments and $8.0 billion for the existing infrastructure. These costs are **not** included in the "Cost to Maintain" or "Maximum Economic Investment" figures presented in this chapter, which are limited to capital investment requirements.

Note that the costs shown above only reflect the particular types of improvements currently modeled in HERS, and thus represent a subset of total operations deployments that are expected to occur. This analysis attempts to capture other capital costs relating to operations control facilities via the external adjustment procedure for nonmodeled improvement types discussed above.

Future operations investments are implemented in HERS through an assumed, exogenously specified scenario; they are not included directly in the benefit-cost calculations made within the model, and HERS does not directly consider any tradeoffs or complementarities between ITS and other types of highway improvements. The baseline scenario used for this report assumes the continuation of existing deployment trends. This baseline scenario was used for all of the HERS-based analyses presented in Chapters 7, 8, and 9. Chapter 10 includes a sensitivity analysis considering the potential impact of a more aggressive deployment scenario, as well as one showing the impact of ignoring operations entirely in the analysis.

Appendix A includes a more complete description of the operations strategies, their impacts on performance, and the implementation within HERS.

HERS Investment Scenarios

Two HERS investment scenarios were developed in order to generate the HERS-modeled portion of the two highway and bridge investment requirements scenarios. The HERS portion of the "Cost to Improve Highways and Bridges" was drawn from the HERS "Maximum Economic Investment" scenario, and the HERS "Maintain User Costs" scenario fed into the "Cost to Maintain Highways and Bridges." *Exhibit 7-6* shows the estimated investment requirements under the two HERS scenarios. The impact of the various levels of investment on user costs and other indicators of highway condition and performance is presented in Chapter 9.

The "Maximum Economic Investment" scenario is of interest mainly because it defines the upper limit of highway investment that could be economically justified. It was used to generate the highway preservation and system capacity expansion components of the "Maximum Economic Investment for (Cost to Improve) Highways and Bridges." In this scenario, all improvements with a benefit-cost ratio greater than or equal to 1.0 are implemented in HERS. While this scenario does not target any particular level of desired system performance, it would eliminate the existing highway investment backlog and address other deficiencies that will develop over the next 20 years because of pavement deterioration and travel growth. As shown in Exhibit 7-6, the average annual investment modeled by the HERS "Maximum Economic Investment" scenario is $81.2 billion.

The second major highway investment requirement scenario in this report is the "Maintain User Costs" scenario. It was used to generate the highway preservation and system capacity expansion components of the "Cost to Maintain Highways and Bridges." This scenario gives the level of investment sufficient to allow total highway user costs per VMT at the end of the 20-year analysis period to match the base year levels. Highway user costs include travel time costs, vehicle operating costs, and crash costs. The average annual investment modeled by HERS under this scenario is estimated to be $49.3 billion.

Exhibit 7-6 *HERS Investment Requirement Scenarios, 2003–2022 (Billions of 2002 Dollars)*

Combined Highway/Bridge Scenario	Average Annual Investment	HERS Scenario	HERS-Derived Component [1]
Maximum Economic Investment for Highways and Bridges	$118.9	Maximum Economic Investment	$81.2
Cost to Maintain Highways and Bridges	$73.8	Maintain User Costs	$49.3

[1] The portion of the total investment for each scenario that would be used for types of capital improvements and types of roads that are modeled in HERS.

Q. How is the HERS model used to produce investment requirements estimates for the various funding scenarios?

A. The HERS model selects projects on the basis of their benefits and costs as calculated within the model. The HERS model can thus assign a benefit-cost ratio (BCR) to each selected improvement. The total investment over the 20-year forecast horizon is then estimated by establishing a list of cost-beneficial projects. For the "Maximum Economic Investment" scenario, all projects on the list are implemented. For other scenarios, projects are implemented in order of ranked BCR until a funding constraint is reached. By varying the funding constraint in different HERS runs and examining the output for different indicators, the user can then determine the level of investment that will achieve certain levels of condition and performance. It is important to note that these estimates represent the economically efficient levels of investment that would meet the targets, rather than the minimum amount of investment necessary to meet the same criteria.

The "Maintain User Costs" concept was originally introduced in the 1997 C&P report to provide a new highway system performance benchmark based on economic criteria. It focuses on highway users, rather than the traditional engineering-based criteria, which are oriented more toward highway agencies. This scenario is also an important technical point in the operation of HERS, since the VMT growth rates in the model are partly dependent on changes in user costs, owing to the operation of the travel demand elasticity feature.

The impact of this and other levels of investment on individual highway user cost components (as well as other measures of conditions and performance) are discussed in Chapter 9.

Highway Investment Backlog

The highway investment backlog represents all highway improvements that could be economically justified for immediate implementation, based on the current conditions and operational performance of the highway system. The HERS model estimates that a total of $398 billion of investment could be justified based solely on the current conditions and operational performance of the highway system. Approximately 80 percent of the backlog is in urban areas, with the remainder in rural areas. About 60 percent of the backlog relates to capacity deficiencies on existing highways; the remainder results from pavement deficiencies.

This $398 billion backlog represents a subset of the "Maximum Economic Investment" scenario described above. Based on the average annual

Q. How does the HERS backlog estimate compare with what was reported in the 2002 C&P report?

A. The estimated backlog is significantly higher than the $271.7 billion shown in the 2002 C&P report. This is due to several factors. First, as noted above, highway capital expenditures have been below the Cost to Maintain in recent years. Consequently, the overall performance of the system declined, which increased the number of potentially cost-beneficial highway and bridge investments that would address these performance problems. Second, as discussed in Appendix A, the HERS model has recently been modified to consider a broader range of alternative widening options, while the costs per lane mile of various highway improvements have been revised upward. While the higher costs would cause certain potential improvements to fall below the 1.0 BCR threshold, this is more than offset by the increased costs of other improvements whose BCR would remain above this level, and the broader range of potential improvements that the model can now evaluate.

The overall "Cost to Improve Highways and Bridges," of which the backlog is a subset, is also higher than that estimated in the 2002 C&P report for similar reasons.

investment requirements identified in Exhibit 7-6, the total 20-year investment requirements under this scenario for capital improvements modeled by HERS would be approximately $1.6 trillion. This indicates that approximately 25 percent of the potential cost-beneficial improvements projected over the 20-year period could be implemented immediately if sufficient funding were available, while the remaining 75 percent would address deficiencies that are expected to develop between now and 2022.

Note that this figure does not include rural minor collectors or rural and urban local roads and streets because HPMS does not contain sample section data for these functional systems. The backlog figure also does not contain any estimate for system enhancements.

National Bridge Investment Analysis System

The estimates of future capital investment requirements relating to bridge preservation shown in this report are derived primarily from NBIAS, the successor to the Bridge Needs and Investment Process Model (BNIP) last used in the 1999 C&P report. The NBIAS incorporates analytical methods from the Pontis Bridge Management System. Pontis, first developed by FHWA in 1989, is now owned by the American Association of State Highway and Transportation Officials, which licenses the system to over 45 State transportation departments and other agencies.

While Pontis relies on detailed structural element-level data on bridges, NBIAS adds a capability to synthesize such data from general bridge condition ratings reported for all bridges in the NBI. While the analysis in this report is derived solely from NBI data, the current version of NBIAS is capable of processing element-level data directly. The NBIAS also builds certain economic criteria into its analytical procedures that are not currently included in Pontis. The NBIAS is discussed in more detail in Appendix B.

To estimate functional improvement needs, NBIAS applies a set of improvement standards and costs to each bridge in the NBI. The model then identifies potential improvements, such as widening existing bridge lanes, raising bridges to increase vertical clearances, and strengthening bridges to increase load-carrying capacity, and evaluates their potential benefits and costs.

The model uses a probabilistic approach to modeling bridge deterioration for each synthesized bridge element, relying on a set of transition probabilities that project the likelihood that an element will deteriorate from one condition state to another over a given period of time. The model then applies the Markov modeling approach from Pontis to determine an optimal set of preservation actions to take for each bridge element based on the condition of the element. As described in Appendix B, NBIAS has recently been modified to apply preservation policies at the individual bridge level and can now directly analyze costs and benefits of performing preservation work with the cost of completely replacing the bridge.

Bridge Investment Backlog

As defined in this report, the bridge investment backlog represents the cost of improving all existing bridge deficiencies if the benefits of doing so exceed the costs. The NBIAS defines deficiencies broadly and covers more than the structurally deficient and functionally obsolete categories defined in Chapter 3. The NBIAS estimates that $62.6 billion could be invested immediately in a cost-beneficial fashion to replace or otherwise address currently existing bridge deficiencies.

Q. How does the NBIAS backlog estimate compare with what was reported in previous editions of the C&P report?

A. The estimated backlog is higher than the $54.7 billion shown in the 2002 C&P report, but lower than the $87.3 billion shown in the 1999 C&P report computed using BNIP. The recent modifications to NBIAS to allow maintenance, repair, and replacement needs on an individual bridge level have allowed it to identify a broader range of potentially cost-beneficial improvements. The current estimate remains lower than what was projected by BNIP, as the reported backlog does not reflect potential improvements unless they pass a benefit-cost test.

Q. How does the NBIAS definition of the bridge deficiencies compare with the information on structurally deficient bridges reported in Chapter 3?

A. NBIAS considers bridge deficiencies and corrective improvements at the level of individual bridge elements. The economic backlog of bridge deficiencies estimated by NBIAS thus consists of the cost of all improvements to bridge elements that would be justified on both engineering and economic grounds. It includes many improvements on bridges with certain components that may warrant repair, rehabilitation, or replacement, but whose overall condition is not sufficiently deteriorated for them to be classified as structurally deficient.

Bridge Investment Requirements Scenarios

The investment requirement scenarios for bridges have been renamed in this report to more accurately describe the manner in which they were computed in NBIAS, as the old names were more consistent with the BNIP engineering-based approach.

The "Maximum Economic Investment" scenario is the bridge preservation component of the "Cost to Improve Highways and Bridges" described earlier in this chapter. Where it is cost beneficial to do so, this scenario would eliminate the existing bridge investment backlog and correct other deficiencies that are expected to develop over the next 20 years. As shown in *Exhibit 7-7,* **the average annual investment required under this scenario is estimated to be $12.5 billion**, which is 10.5 percent of the $118.9 billion average annual investment required to improve highways and bridges over a 20-year period.

The "Maintain Economic Backlog" scenario is the bridge component of the "Cost to Maintain Highways and Bridges." This scenario identifies the level of annual investment that would be required so that the cost of addressing all bridge deficiencies in 2022 would remain the same as in 2002. Under this scenario, existing deficiencies and newly accruing deficiencies would be selectively corrected, but the overall level of deficiencies measured in dollar terms would be maintained. **The average annual investment required under this scenario is estimated at $8.9 billion**, or 12.1 percent of the $73.8 billion average annual investment required to maintain highways and bridges over a 20-year period.

Exhibit 7-7 *NBIAS Investment Requirement Scenarios, 2003–2022 (Billions of 2002 Dollars)*

Combined Highway/Bridge Scenario	Average Annual Investment	NBIAS Scenario	NBIAS-Derived Component [1]
Maximum Economic Investment for Highways and Bridges	$118.9	Maximum Economic Investment	$12.5
Cost to Maintain Highways and Bridges	$73.8	Maintain Economic Backlog	$8.9

[1] The portion of the total investment for each scenario that would be used for types of capital improvements and types of roads that are modeled in NBIAS.

Transit Investment Requirements

The FTA uses the Transit Economic Requirements Model (TERM), a model based on engineering and economic concepts, to estimate total capital investment needs for the US transit industry. TERM was developed to improve the quality of these FTA estimates. The 1997 C&P report was the first edition of the report providing investment requirements based on TERM.

This edition of the C&P report uses TERM to project the dollar amount of capital investment that will be required by the transit sector to meet various asset condition and operational performance goals by 2022. These capital investment requirement estimates are based on the asset condition estimation process and results provided in Chapter 3, ridership growth projections, and data from the National Transit Database (NTD) on the existing transit asset base (e.g., number of vehicles and stations) and operating statistics (e.g. operating speed). Since the last edition of the report, the accuracy of the asset inventory and asset deterioration in TERM has been improved through special data collection efforts and engineering surveys also discussed in Chapter 3. Ridership forecasts have been revised downward very slightly since the last report, by 0.1 percent per year, based on updated information collected from an expanded list of MPOs. All investments identified by TERM are subject to a benefit-cost test, which requires that all investments incorporated in the model have a benefit-cost ratio that is greater than 1. The benefit-cost component of TERM has been updated and refined since the 2002 report to be much more responsive to changes in infrastructure costs. The investment requirement estimates presented here have, therefore, been subjected to a much more rigorous benefit-cost test than projected investment requirements based on TERM provided in earlier editions of this report. (A technical description of TERM, including an explanation of changes made to the benefit-cost component of TERM since the last edition of this report, is provided in Appendix C.)

TERM projects capital investment requirements for transit for four combinations of the following investment scenarios:

- **Maintain Asset Conditions**

  Transit assets are replaced and rehabilitated over the 20-year period such that the average condition of the assets existing at the beginning of the period remains the same at the end of the period.

- **Maintain Performance**

  New transit vehicles and infrastructure investments are undertaken to accommodate increases in transit ridership so that the vehicle utilization rate existing at the beginning of the period remains the same at the end of the period. Ridership growth estimates are obtained from MPOs.

- **Improve Conditions**

  Transit asset rehabilitation and replacement is accelerated to improve the average condition of each asset type to at least a "good" level at the end of the 20-year period (2022).

- **Improve Performance**

  The performance of the Nation's transit system is improved as additional investments are undertaken in urbanized areas with the most crowded vehicles and the systems with the slowest speeds to reduce vehicle utilization rates (and crowding) and increase average transit operating speeds. *Earlier versions of TERM assumed that all additional investment undertaken to increase speed would be in light rail services. For this report, TERM has assumed that investment to increase speed in urbanized areas with populations under 1 million is made in BRT.*

Note that the improve conditions and performance scenario is an ideal target and defines an upper limit above which additional investment in transit is unlikely to be economically justifiable.

Exhibit 7-8 provides estimates of the total annual capital investment that will be necessary to meet the four investment scenarios. These estimates combine those calculated by TERM with FTA staff estimates of rural and special service investment requirements. Annual investment requirements for transit are estimated to be $15.6 billion to maintain the conditions and performance of the Nation's transit system at its 2002 level (compared with $14.8 billion in 2000 dollars and $15.4 billion in 2002 dollars in the last report). To improve the average condition level of transit assets to "good" by 2022, as well as to improve performance by increasing vehicle speeds as experienced by passengers and reducing occupancy rates to threshold levels, would require an additional $8.4 billion per year for a total average annual capital investment of $24.0 billion (compared with $20.6 billion in 2000 dollars and $21.4 billion in 2002 dollars in the last report). *These investment requirements assume a 1.5 percent average annual increase in ridership over the 20-year projection period compared with the 1.6 percent average annual increase in ridership assumed in the 2002 edition of this report.* Investment requirements have increased principally as a result of upward revisions, on average, for rail capital costs. The impact of this cost increase has been most noticeable for the improve scenario, which shifts capital investment from bus to light rail. Since the last report, FTA has undertaken two major studies updating light and heavy rail capital cost information.

Exhibit 7-8 ***Summary of Average Annual Transit Investment Requirements, 2003–2022 (Billions of 2002 Dollars)***

Conditions	Performance	Average Annual Cost
Maintain	Maintain	$15.6
Improve	Maintain	$17.1
Maintain	Improve	$22.5
Improve	Improve	$24.0

Source: Transit Economic Requirements Model and FTA staff estimates.

As shown in *Exhibit 7-9,* replacement and rehabilitation costs are estimated to be $10.3 billion annually to maintain conditions and performance, and $11.7 billion annually to improve conditions and performance. The incremental $1.4 billion needed for asset rehabilitation and replacement under the "Improve Conditions" scenarios results from the extra investment required to rehabilitate and replace additional assets to attain an overall physical condition of "good". Asset expansion costs needed to meet the projected 1.5 percent average annual increase in ridership growth are estimated to range between $5.3 billion under the "Maintain Conditions and Performance" scenario to $5.7 under the "Improve Conditions and Performance" scenario. The amount needed to improve performance (by increasing passenger speeds and reducing crowding in systems not operating at "good" performance threshold levels) is estimated to be $6.6 billion annually.

Exhibit 7-9 *Annual Transit Investment Requirements by Type of Improvement (Billions of 2002 Dollars)*

Type of Improvement	Maintain Conditions & Performance	Improve Conditions & Maintain Performance	Maintain Conditions & Improve Performance	Improve Conditions & Performance
Replacement and Rehabilitation	$10.3	$11.7	$10.3	$11.7
Asset Expansion	$5.3	$5.4	$5.5	$5.7
Performance Improvements			$6.6	$6.6
Total	**$15.6**	**$17.1**	**$22.5**	**$24.0**

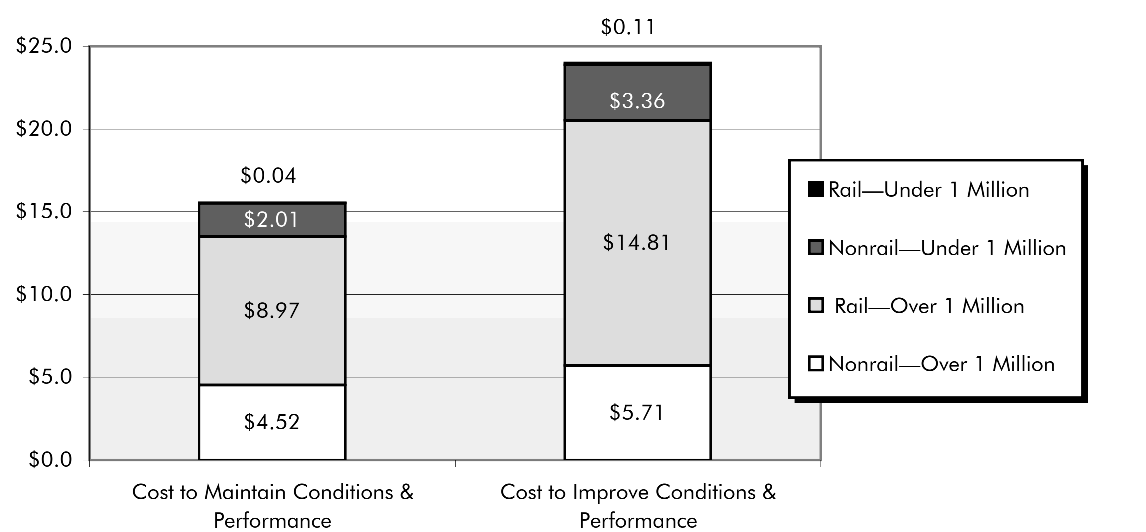
Source: Transit Economic Requirements Model and FTA staff estimates.

Average Annual Costs to Maintain and Improve Conditions and Performance

Requirements by Population Area Size

Exhibit 7-10 provides a summary of transit investment requirements by TERM scenario, area population size, and broad asset type (rail or nonrail). This information is provided in more detail in *Exhibit 7-11*. Eighty-seven percent of investment in transit will be required in urban areas with populations of over 1 million, reflecting the fact that, in 2002, 91.6 percent of the Nation's passenger miles were in these areas.

Exhibit 7-10 *Transit Average Annual Investment Requirements by Area Population Size and Mode, 2003–2022 (Billions of 2002 Dollars)*



Source: Transit Economic Requirements Model and FTA staff estimates.

It is estimated that an average of $13.5 billion annually would be needed to maintain conditions and performance of the transit assets in these large urban areas, and $20.5 billion annually would be needed to improve the conditions and performance of the assets in these areas. The needs of less-populated areas (i.e., those with populations under 1 million) are estimated to be considerably lower than those of more populous areas because they have fewer transit assets. It is estimated that an average of $2.1 billion annually would be needed to maintain the conditions and performance of the transit infrastructure in these less-populated areas, and $3.5 billion would be needed annually to improve them.

Exhibit 7-11 *Annual Average Cost to Maintain and Improve Transit Conditions and Performance, 2003–2022*

Mode, Purpose & Asset Type (Millions of 2002 Dollars)		Cost to Maintain Conditions & Performance	Incremental Cost to Improve Conditions	Incremental Cost to Improve Performance	Cost to Improve Conditions & Performance
Areas Over 1 Million in Population					
Nonrail (*)					
Replacement & Rehabilitation	(Vehicles)	$2,275	$434		$2,709
	(Nonvehicles) (**)	1,049	12		1,061
Asset Expansion	(Vehicles)	639	14		653
	(Nonvehicles)	525	0		525
Improve Performance	(Vehicles)			331	331
	(Nonvehicles) (**)			373	373
Special Service(***)	(Vehicles)	38	21		59
Subtotal Nonrail		**4,526**	**481**	**705**	**5,711**
Rail					
Replacement & Rehabilitation	(Vehicles)	1,468	253		1,721
	(Nonvehicles) (**)	3,787	358		4,145
Asset Expansion	(Vehicles)	914	0		914
	(Nonvehicles) (**)	2,803	99		2,901
Improve Performance	(Vehicles)			652	652
	(Nonvehicles) (**)			4,480	4,480
Subtotal Rail		**8,972**	**710**	**5,131**	**14,813**
Total Areas Over 1 Million		**13,498**	**1,191**	**5,836**	**20,524**
Areas Under 1 Million in Population					
Nonrail (*)					
Replacement & Rehabilitation	(Vehicles)	748	94		842
	(Nonvehicles) (**)	409	0		409
Fleet Expansion	(Vehicles)	238	5		243
	(Nonvehicles) (**)	123	0		122
Improve Performance	(Vehicles)			178	178
	(Nonvehicles) (**)			538	538
Special Service (***)	(Vehicles)	215	116		331
Rural	(Vehicles)	277	121	283	681
	(Nonvehicles) (**)	5	10		15
Subtotal Nonrail		**2,014**	**346**	**1,000**	**3,360**
Rail					
Replacement & Rehabilitation	(Vehicles)	1	0		1
	(Nonvehicles) (**)	14	0		14
Fleet Expansion	(Vehicles)	6	0		6
	(Nonvehicles) (**)	19	1		20
Improve Performance	(Vehicles)			10	10
	(Nonvehicles) (**)			57	57
Subtotal Rail		**40**	**1**	**67**	**108**
Total Areas Under 1 Million		**2,054**	**347**	**1,067**	**3,467**
Total		**15,552**	**1,537**	**6,903**	**23,992**

(*) Buses, vans and other (including ferryboats.)

(**) Nonvehicles comprise guideway elements, facilities, systems, and stations.

(***) Vehicles to serve the elderly and disabled.

Source: Transit Economic Requirements Model and FTA staff estimates.

Q. Why has the amount required to rehabilitate and replace the nonrail infrastructure in both densely and less densely populated urbanized areas increased by more than 35 percent since the 2002 edition of this report?

A. Estimated capital investment requirements for nonrail vehicles in these areas increased due to upward revisions in estimated replacement costs of these vehicles as reported to FTA. Estimated nonrail vehicle rehabilitation and replacement costs are on average 30 percent higher than they were in 2000 as presented in the 2002 report. The amount needed to rehabilitate and replace nonrail, nonvehicle assets also increased because data collected by the Asset Conditions Reporting Module (ACM) and from the New York Metropolitan Transportation Authority (MTA) revealed that the size as indicated by the value of this infrastructure, principally facilities, was considerably larger than previously estimated and, although in very marginally better condition, would require higher rehabilitation and replacement expenditures to support a more extensive infrastructure. Enhancements to the benefit-cost module and lower projected growth in passenger travel on transit exerted downward pressure on projected nonrail needs; however, these impacts were outweighed by the revisions to costs and the increase in estimated infrastructure size.

Q. Why has the amount required under the "Maintain Conditions" scenario to rehabilitate and replace rail vehicles in urbanized areas with populations greater than 1 million to maintain conditions declined by 28 percent since the 2002 edition of this report?

A. The estimated amount needed to rehabilitate and replace rail vehicles in large urbanized areas has decreased since the last edition of this report, in part, due to the revision in the deterioration schedule for commuter rail vehicles. The conditions of commuter rail vehicles were found to decline more gradually after the age of 22 years, the average age of commuter rail vehicles in 2002, than previously estimated. (See *Exhibit 3-45* in Chapter 3.) The amount estimated to be needed to rehabilitate and replace rail vehicles also declined due to the revisions in the benefit-cost analysis, which set a more rigorous benefit standard. These revisions more than offset the 6 percent increase in rail vehicle rehabilitation and replacement costs that occurred between 2000 and 2002.

Nonrail Needs in Urban Areas with Populations over 1 Million—The cost of maintaining the conditions of the nonrail infrastructure (buses, vans, and ferryboats) in urban areas with populations over 1 million is considerably less than the cost of maintaining the rail infrastructure in these areas. Thirty-four percent of the total investment requirement in these larger urban areas, or about $4.5 billion annually, would be needed to maintain the conditions and performance of this nonrail infrastructure. Seventy-four percent of the $4.5 billion, or $3.3 billion annually, would be used to rehabilitate and replace assets to maintain conditions, and 26 percent, or $1.2 billion, would be needed to purchase new assets to maintain performance. It is estimated that 68 percent of rehabilitation and replacement expenditures and 55 percent of asset expansion expenditures would be for vehicles. The incremental costs to improve nonrail conditions are estimated to be $481 million annually, of which $455 million would be needed for vehicle rehabilitation and replacement. The incremental costs to improve performance are estimated to be $705 million annually, of which 47 percent ($331 million) would be spent on new vehicles (principally buses) and 53 percent ($373 million) on new nonvehicle assets. Expenditures on nonvehicle assets include investments for the purchase or construction of dedicated highway lanes for bus rapid transit (BRT). A total of $5.7 billion annually is estimated to be needed to improve both conditions and performance of the nonrail assets in these more heavily populated areas.

Rail Needs in Urban Areas with Populations over 1 Million—Sixty-six percent of the total transit investment requirements of large urban areas, or about $9.0 billion annually, is estimated to be needed to maintain conditions and performance of the transit rail infrastructure, 27 percent less than the $9.6 billion reported in the 2002 report. [See Q & A on bottom left of page.] Fifty-eight percent, or $5.2 billion annually, would be required to rehabilitate and replace rail assets to maintain conditions, and 42 percent, or $3.7 billion, would be required for rail asset expansion to maintain performance as ridership increases. The incremental cost to improve rail asset conditions so that they achieve an average condition rating of "good" by 2022 is estimated to be $710 million annually, $253 million for vehicle and $457 million for nonvehicle asset rehabilitation and replacement. The incremental costs to improve performance of these rail systems are estimated to be $5.1 billion annually, including the cost of purchasing rights-of-way. Eighty-seven percent of this amount, or $4.5 billion, would be needed for the expansion of the nonvehicle rail infrastructure. This split between vehicle and nonvehicle investment for performance improvement is within the range of what is typical for new heavy and light rail infrastructure development projects. A total of $14.8 billion annually is estimated to be needed to improve both conditions and performance of rail in these more heavily populated, urbanized areas.

Nonrail Needs in Areas with Populations of Under 1 Million—Ninety-eight percent of the transit investment requirements in areas with populations under 1 million is projected to be for nonrail transit. The annual cost to maintain conditions and performance of the nonrail transit infrastructure in these less-populated areas is estimated to be $2.0 billion annually. The total amount needed to improve both conditions and performance of nonrail transit in these areas is estimated to be $3.4 billion annually. The incremental investment required to improve nonrail conditions in these areas is estimated to be $346 million annually and the investment needed to improve performance is estimated to be $1 billion. Of the $1 billion incremental annual investment to improve performance, 46 percent, or $461 million, would be needed to acquire new vehicles and 54 percent, or $538 million, would need to be invested in the new nonvehicle infrastructure. The estimated investment needed for nonrail performance enhancements has increased considerably since the last report for methodological reasons. The current report assumes that investment required to improve speed will be in the form of BRT rather than light rail, except in systems where light rail already exists. The last edition of this report assumed that all investment to increase speeds in these less populous areas would be in light rail. Twenty-eight percent of the expansion in investment needed to improve performance, or $283 million annually, is assumed to be necessary to improve service to rural areas, that now have limited or no service.

Rail Needs in Areas with Populations of Under 1 Million—Rail needs in areas with populations of less than 1 million are minimal. Currently, only three light rail systems operate in these less-populated areas. Maintaining conditions and performance of the rail assets in these areas would require an estimated $40 million annually, of which $33 million, or 83 percent, would be needed for investment in nonvehicle rail infrastructure. The amount needed to improve performance is estimated to be $67 million annually. This amount declined from $112 million in 2000 because of the revision in TERM to increase speed with investment in BRT instead of light rail. The 2002 $67 million amount is for improvements in the three existing light rail systems only.

Q. What would the investment requirements be if performance improvements in areas with populations of less than 1 million were made by shifting bus investment to light rail instead of to BRT as was done in earlier reports?

A. This change would increase the annual amount to improve performance by $49 million annually. The amount of rail investment in these areas would increase by $518 million and the amount of bus investment in these areas would decrease by $469 million.

Requirements by Asset Type

Exhibit 7-12 provides disaggregated annual investment requirements to maintain conditions and performance and to improve conditions and performance for rail and nonrail transportation modes by asset type for the following:

- Asset replacement and rehabilitation
- Asset expansion
- Performance improvement.

Assets are disaggregated into five categories—facilities, guideway elements, stations, systems, and vehicles. The annual funding requirements for services to support investment in new transit capacity are provided under "Other Project Costs." These costs include expenditures for project design, project management and oversight, right-of-way acquisition and site preparation. In the 2002 report, some costs for vehicles, stations, facilities and other "hard assets" were improperly reported as system design or right-of-way acquisition. These costs are now correctly allocated to the asset category to which they correspond. Under the "Improve" scenario, this revision has contributed to the larger investment requirements for each asset than reported in the last edition of the report.

Rail Infrastructure

Fifty-eight percent of the total amount needed to maintain conditions and performance ($9.0 billion dollars annually) and 62 percent of the total amount needed to improve conditions and performance ($14.9 billion annually) are estimated to be for rail infrastructure. As shown in *Exhibit 7-13*, vehicles and guideway elements are estimated to require the largest amount of the total capital investment of all rail assets between 2003 and 2022, followed in descending order of investment requirements by stations, power systems, and facilities.

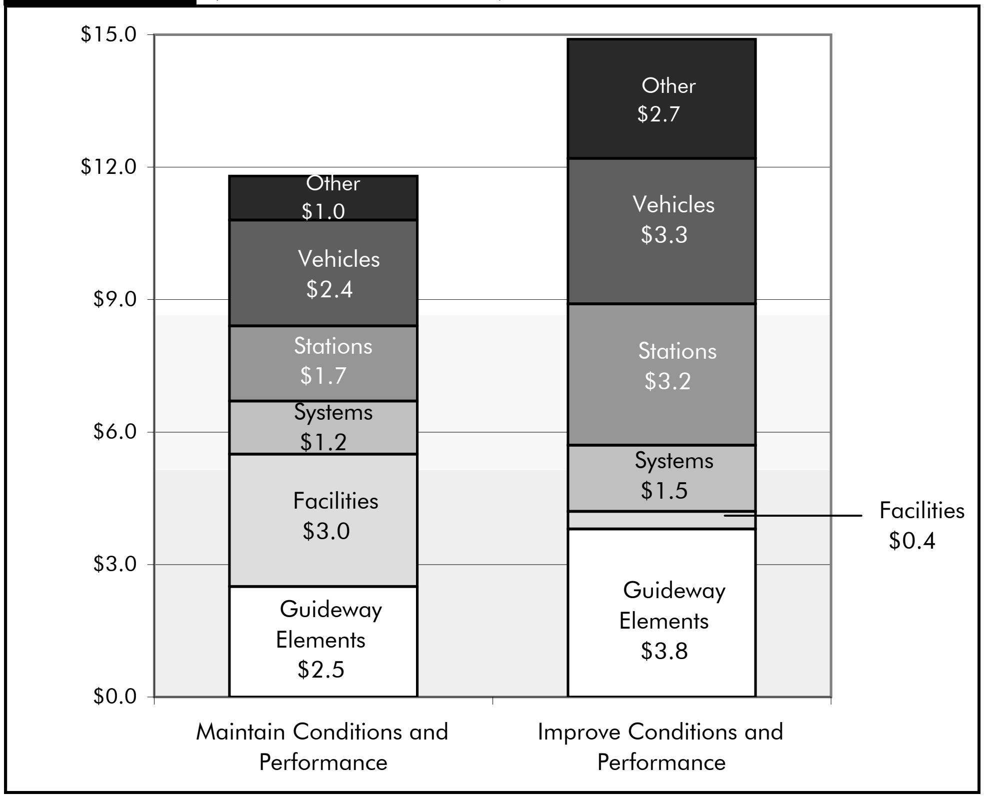
G*uideways* are estimated to account for 49 percent of the total value of the Nation's rail infrastructure. (The estimated value of transit infrastructure in 2002 by type of asset is provided in Exhibit 3-51.) Slightly more than one-quarter of the total amount estimated to be required to maintain and to improve the conditions and performance of the Nation's transit rail assets will be needed for investment in guideway elements. Guideway elements are composed of elevated structures, systems structures, and track. The annual amount needed to maintain the conditions and performance of rail guideway is estimated to be $2.5 billion, and the annual amount needed to improve the conditions and performance of rail guideways is estimated to be $3.8 billion. Annual rehabilitation and replacement costs are estimated to be $1.4 billion to maintain conditions; annual asset expansions are estimated to cost $1.1 billion to maintain performance and $1.4 billion to improve performance. The estimated average condition of guideway improved slightly, from 3.21 in 2000 to 3.56 in 2002, principally based on data from the ACM and the New York MTA. The estimated value of the Nation's rail guideway asset base increased by 14 percent in current dollar values between 2000 and 2002, largely as a result of the substantial increases in the estimated unit costs of at-grade ballast and elevated structures, with upward revisions ranging from 100 to 300 percent. However, the estimated amount needed for investment in guideway elements has declined since the 2002 report due to the a higher estimated guideway condition and the increased rigor of the benefit-cost test, coupled with higher replacement costs and lower projected passenger miles traveled (PMT) growth. (The 2002 report estimated that $3.7 billion annually was needed to maintain guideway conditions and performance and $4.8 billion annually to improve guideway conditions and performance.)

Exhibit 7-12	*Transit Infrastructure Average Annual Investment Requirements by Asset Type, 2003–2022*			
Maintain Conditions and Performance				
(Millions of 2002 Dollars) **Asset Type**	**Rehabilitation and Replacement**	**Asset Expansion**	**Improve Performance**	**Total**
Rail				
Guideway Elements	$1,395	$1,069		$2,464
Facilities	206	102		307
Systems	922	237		1,159
Stations	1,278	461		1,738
Vehicles	1,469	920		2,389
Other Project Costs		954		954
Subtotal Rail	**5,270**	**3,742**	**0**	**9,012**
Nonrail				
Guideway Elements	29	182		212
Facilities	1,255	330		1,584
Systems	132	48		180
Stations	46	54		100
Vehicles	3,553	876		4,429
Other Project Costs		35		35
Subtotal Nonrail	**5,016**	**1,524**	**0**	**6,540**
Total Maintain Conditions	**10,285**	**5,266**	**0**	**15,551**
Improve Conditions and Performance				
Asset Type	**Rehabilitation and Replacement**	**Asset Expansion**	**Improve Performance**	**Total**
Rail				
Guideway Elements	1,395	1,069	1,382	3,845
Facilities	205	102	117	424
Systems	924	237	330	1,491
Stations	1,635	560	968	3,163
Vehicles	1,722	920	662	3,304
Other Project Costs		954	1,740	2,693
System Design and Right-of-Way Acquisition				0
Subtotal Rail	**5,881**	**3,842**	**5,198**	**14,921**
Nonrail				
Guideway Elements	29	182	244	456
Facilities	1,246	329	305	1,880
Systems	128	48	9	185
Stations	66	54	230	350
Vehicles	4,354	1,178	510	6,042
Other Project Costs		35	124	158
Subtotal Nonrail	**5,824**	**1,826**	**1,421**	**9,071**
Total Improve Conditions	**11,705**	**5,667**	**6,620**	**23,992**

Source: Transit Economic Requirements Model and FTA staff estimates.

Vehicles are estimated to account for 19 percent of the total value of the Nation' rail infrastructure. Twenty-seven percent of the amount needed to maintain rail assets conditions and performance, or $2.4 billion annually, and 22 percent of the amount needed to improve rail assets conditions and performance, or $3.3 billion annually, are estimated to be for vehicles. Annual vehicle rehabilitation and replacement costs are estimated to be $1.5 billion to maintain conditions and $1.7 billion to improve conditions. Annual asset expansion costs are estimated to be $920 million to maintain performance and $662 million to improve

Exhibit 7-13 *Annual Rail Investment Requirements, 2003–2022 (Billions of 2002 Dollars)*



Source: Transit Economic Requirements Model and FTA staff estimates.

performance. Actual conditions of rail vehicles are estimated to have declined very minimally from 3.55 in 2000 to 3.48 in 2002. However, the estimated amount of capital investment required for rail vehicles has decreased substantially since the 2002 report. Although the estimated total value of the rail vehicle fleet increased by 24 percent in current dollar terms between 2000 and 2002, this was largely a result of revisions in unit costs. Any increases in investment needs from this increased valuation were more than offset by the increased rigor of the benefit-cost analysis, revisions to the commuter rail decay curves, and reduction in projected passenger growth. (The 2002 report estimated that $3.1 billion annually was needed to maintain rail vehicle conditions and performance and $3.3 billion annually to improve rail vehicle conditions and performance.)

Stations are estimated to account for 16 percent of the total value of the Nation's rail infrastructure. Nineteen percent of the amount required to maintain the conditions and performance of rail assets, or $1.7 billion annually, and 21 percent of the annual amount required to improve the conditions and performance of rail assets, or $3.2 billion annually, are estimated to be for stations. The amount needed for rehabilitation and replacement to maintain conditions is estimated to be $1.3 billion annually, and the amount needed to improve conditions is estimated to be $1.6 billion annually. The annual amount needed for asset expansion to maintain performance is estimated to be $461 million, and the annual amount needed to improve performance is estimated to be $1.5 billion. The amount of estimated capital investment for stations has increased substantially since the 2002 edition of this report. The data collected by the ACM and from the New York MTA indicated that the value or size of rail station assets was larger than previously estimated and their conditions worse. Estimated conditions of rail stations fell from 3.52 in 2000 to 2.87 in 2002, principally as a result of new information. However, the estimated value of the Nation's rail station infrastructure for 2002 is 81 percent higher than for 2000. This higher asset valuation of stations, combined with a decrease in their estimated condition level and lower replacement costs, has led to considerably higher estimates of future capital investment requirements, and outweighed any decreases in investment requirements resulting from the strengthened benefit-cost test and lower projected growth in passenger travel. (The 2002 report estimated that $692 million annually was needed to maintain station conditions and performance and $981 million annually to improve station conditions and performance.)

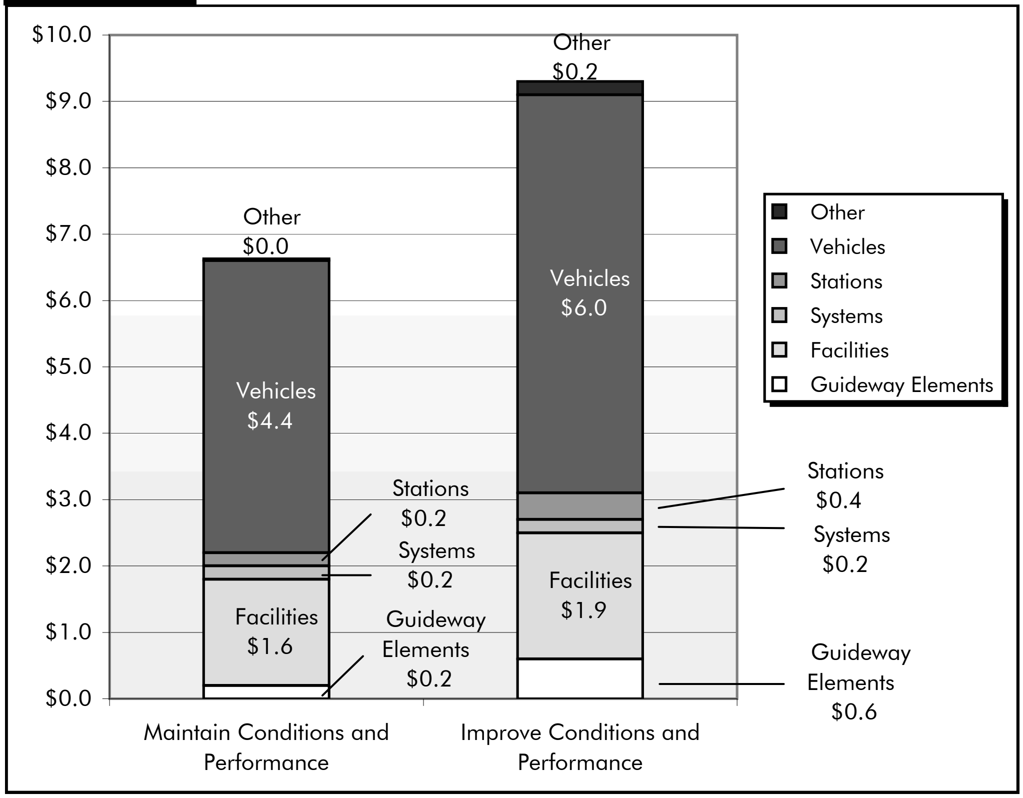
Rail power systems, comprising substations, overhead wire, and third rail, are estimated to account for 13 percent of the total value of the Nation's rail asset base. Thirteen percent of the amount needed to maintain the conditions and performance of rail assets or $1.2 billion annually, and 10 percent of the amount needed to improve the conditions and performance of rail assets, or $1.5 billion annually, are estimated to be for rail power systems. Annual rehabilitation and replacement costs are estimated to be $922 million to maintain conditions and $924 million to improve conditions. Annual asset expansion costs are estimated to be $237 million to maintain rail power system performance and an additional $330 million to improve performance. The estimated condition of rail power systems increased slightly from 3.96 in 2000 to 4.08 in 2002. Although the value of the rail power systems infrastructure is estimated to be 27 percent higher in 2002 than in 2000, estimated investment requirements for rail power systems have not changed significantly. This is because any increase in investment requirements stemming from a higher asset valuation was more than offset by decreases in investment requirements resulting from the strengthened benefit-cost test, lower projected growth in passenger travel, and lower estimated replacement costs. (The 2002 report estimated that $1.2 billion annually was needed to maintain rail power systems conditions and performance and $1.4 billion annually to improve rail power systems conditions and performance.)

Facilities for rail vehicles (maintenance facilities and yards) are estimated to account for 2 percent of the total value of the Nation's rail transit asset base. Three percent of the amount needed to maintain conditions ($307 million annually) and 3 percent of the amount needed to improve conditions and performance ($424 million annually) are estimated to be for facilities. Annual rehabilitation and replacement costs are estimated to be $206 million to maintain conditions and $205 million to improve conditions. Asset expansion costs are estimated to be $102 million annually to maintain performance and $117 million annually to improve performance. The estimated value of facilities in current dollars is 155 percent higher in 2002 than in 2000, as a result of new data collected by the ACM and from the New York MTA as well as updated information from the NTD. Estimated replacement costs for commuter rail and heavy facilities increased and those for light rail decreased. Data collected by the ACM revealed the average age of rail maintenance facilities was lower, and the average condition higher, than previously estimated. The estimated average condition of facilities increased from 3.21 in 2000 to 3.56 in 2002. In summary, the substantially higher asset valuation of maintenance facilities has led to higher estimates of future capital investment requirements, which have outweighed any decreases in investment requirements resulting from the strengthened benefit-cost test, increase in estimated condition, and slight decrease in the growth of projected use. (The 2002 report estimated that $235 million annually was needed to maintain rail facilities conditions and performance and $294 million annually to improve rail facilities conditions and performance.)

Nonrail Assets

Forty-two percent of the total amount needed to maintain conditions and performance, or $6.5 billion dollars annually, and 39 percent of the total amount needed to improve conditions and performance, or $9.1 billion annually, are estimated to be for nonrail infrastructure. Vehicles are estimated to require the largest amount of the total capital investment in nonrail assets between 2003 and 2022, as shown in *Exhibit 7-14,* followed in descending order of investment requirements by facilities, guideway elements (dedicated lanes for buses), power systems, and stations.

Exhibit 7-14 *Nonrail Annual Investment Requirements, 2003–2022 (Millions of 2002 Dollars)*



Source: Transit Economic Requirements Model and FTA staff estimates.

Vehicles are estimated to account for 36 percent of the total value of the Nation's nonrail assets in 2002, excluding vehicles in rural areas. However, they account for substantially more of projected nonrail investment requirements because they depreciate much more quickly than nonvehicle assets. The estimated investment in nonrail vehicles required to maintain conditions and performance is $4.4 billion annually, and the estimated investment required to improve conditions and performance is $6.0 billion annually. The bulk (70 to 75 percent) of estimated nonrail rehabilitation and replacement expenditures is for vehicles. Vehicles are also estimated to account for the largest proportion, about 60 percent, of nonrail asset expansion investments to maintain performance and 36 percent of the amount required to improve performance. The investment requirements for nonrail vehicles increased since the 2002 report as a result of the expansion in the number of nonrail vehicles, slightly lower condition levels, and an increase in unit costs. (The 2002 report estimated that $3.1 billion annually was needed to maintain the conditions and performance of nonrail vehicles and $4.8 billion annually to improve the conditions and performance of nonrail vehicles.)

Facilities are estimated to account for 57 percent of the total value of the Nation's nonrail assets, excluding facilities in rural areas. [Note that asset value is estimated by TERM, which does not include rural operators.] In total, the most recent data collected revealed that the valuation of nonrail facilities was underestimated in the 2000 report and has, therefore, increased by about 100 percent between 2000 and 2002. Although facilities account for more than half of the nonrail assets, they represent only about a quarter of future nonrail investment requirements because external structures and many of the facility components depreciate slowly. Facilities are estimated to need $1.6 billion annually to maintain the conditions and performance and $1.9 billion annually to improve nonrail conditions and performance. While the conditions of bus maintenance facilities increased from 3.29 in 2000 to 3.34 in 2002, the substantially higher asset valuation of maintenance facilities has led to higher estimates of future capital investment requirements and has outweighed any decreases in investment requirements resulting from the strengthening of the benefit-cost test and reduction in passenger growth. (The 2002 report estimated that $1.1 billion annually was needed to maintain the conditions and performance of nonrail facilities and $1.4 billion annually was needed to improve the conditions and performance of nonrail facilities.)

Guideway elements account for 4 percent of the Nation's nonrail assets, *stations* account for 2 percent, and *power systems* account for 1 percent. Limited revisions were made to the valuation of these nonrail assets. Nonrail guideway elements are estimated to require an annual investment of $212 million to maintain conditions and performance and $456 million annually to improve conditions and performance (compared with $353 million annually and $460 million annually in the 2002 report). Nonrail stations are estimated to require an annual investment of $100 million to maintain conditions and performance and $350 million annually to improve conditions and performance (compared with $162 million annually and $199 million annually in the 2002 report). Nonrail power systems are estimated to require $180 million annually to maintain conditions and performance and $185 million annually to improve conditions and performance (compared with $207 million annually and $209 million annually in the 2002 report).

Rural Transit Vehicles and Facilities

Investment requirements in rural areas have been estimated using the same information and methodology as in the 2002 edition of the report *[see Appendix C]*. The most recent information on rural systems was published by the Community Transportation Association of America (CTAA) in 2000 and was also used to project investment requirements for the 2002 edition of this report. The changes in estimated requirements since the last report result from revisions in estimated vehicle and facility replacement costs. The amount needed to maintain conditions and performance increased by 19.1 percent in current dollars, from $237 million in 2000 to $277 in 2002. The amount needed to improve conditions and performance decreased by 5.2 percent, from $758 million in 2000 to $681 million in 2002. The amount needed to maintain conditions and performance increased as a result of increases in the estimated replacement costs ranging between 13 and 26 percent for buses and nonaccessible vans. Combined, these vehicles are estimated to account for 84 percent of the rural fleet. The replacement cost of maintenance facilities was also estimated to be 18 percent higher than in the 2002 report. The amount needed to improve conditions and performance decreased because the costs of accessible small vehicles and vans used to calculate investment requirements in the last edition of the report were too high. The "Improve Conditions and Performance" scenario assumes that all small vehicles and vans are replaced with models that are ADA accessible. As in the last edition of the report, the number of rural vehicles is assumed to increase at an average annual rate of 3.5 percent to improve performance.

Special Service Vehicles

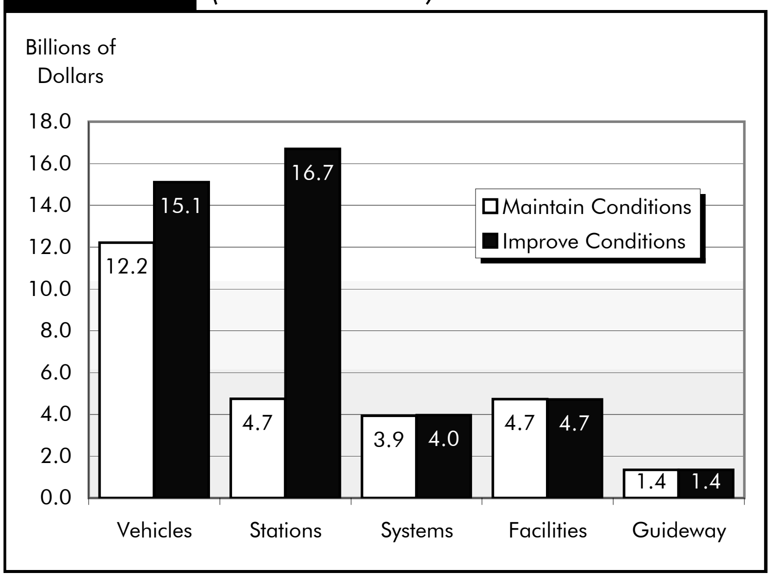
Estimated investment requirements for special service vehicles are 48 percent higher than they were in the 2002 edition of this report as a result of the increase in fleet size and higher vehicle replacement costs. The number of special service vehicles, as reported in the FTA Trends Report FY2002 on the use of Section 5310 Elderly and Persons with Disabilities Program funds, increased from 28,664 in 2000 to 37,720 in 2002, an increase of 30 percent. Based on information reported to FTA by grantees, the average replacement price of a special service vehicle was assumed to have increased from $43,498 in 2000 to $46,985 in 2002. Note that the investment needed to maintain and improve the conditions of vehicles funded by FTA accounts for 43 percent of the amount needed to maintain and improve the conditions of the entire 37,720 special service vehicle fleet.

Existing Needs in the Transit Infrastructure

TERM estimates the amount of investment that would be required to correct existing needs in the Nation's transit infrastructure. The "backlog" is the level of investment needed to replace all assets with conditions below the condition replacement thresholds specified by TERM and is similar to the backlog requirement calculated by the HERS for highways. TERM assumes that the backlog is eliminated over a 20-year period, meaning that the average annual investment requirements calculated by TERM include one-twentieth of the backlog *[see Appendix C].* TERM estimates that the Nation's transit infrastructure has an existing backlog of $27.0 billion if assets are replaced at the threshold levels specified by TERM to maintain conditions (compared with $16.4 billion in the 2002 report) and a $41.8 billion backlog if assets are replaced at the threshold level specified by TERM to improve conditions (compared with $30.7 billion in the 2002 report). The increase in backlog to maintain conditions comes principally from an $8.2 billion increase in the replacement backlog for vehicles. Because the conditions of vehicles have increased since the last report, a higher level of investment is needed to maintain these conditions. The increase in the backlog to improve conditions principally resulted from a $12.3 billion increase in the backlog for stations. Between 2000 and 2002, the estimate for station conditions dropped from 3.44 to 2.99, primarily as a result of new information. These numbers do not include the costs of upgrading assets or eliminating the backlog for deficiencies in rural or special service transit services.

Exhibit 7-15 shows the backlog according to asset type. Forty-five percent of the backlog under the replacement thresholds set by the "Maintain" scenario, or $12.2 billion, is estimated to be needed to replace vehicles; 18 percent, or $4.7 billion each, is estimated to be needed to replace stations and facilities; 15 percent, or $3.9 billion, is estimated to be needed to replace systems; and 5 percent, or $1.4 billion, is estimated to be needed to replace guideway. Under the thresholds set by the "Improve" scenario, 40 percent of the backlog, or $16.7 billion, is for stations and 36 percent, or $15.1 billion, is for vehicles.

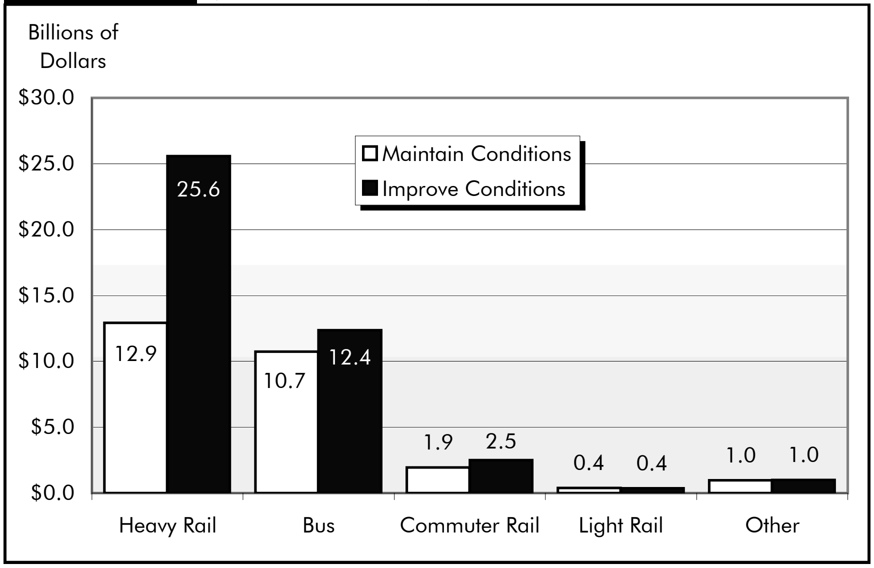
Exhibit 7-15 ***Estimated Backlog Transit Asset Type (Billions of Dollars)***



Source: Transit Economic Requirements Model.

The backlog by mode is provided in *Exhibit 7-16.* Eighty-five percent of the backlog is estimated to be for heavy rail and bus assets, which is consistent with the strong backlog identified for both vehicles and stations. The backlog for heavy rail is estimated to be $12.9 billion using replacement thresholds set by the "Maintain" scenario, and $25.6 billion using replacement thresholds set by the "Improve" scenario. The backlog for buses is estimated to be $10.7 billion using maintain thresholds and $12.4 billion using improve thresholds.

Exhibit 7-16 *Estimated Backlog in 2002 by Transit Mode (Billions of Dollars)*



Source: Transit Economic Requirements Model.

Summary of Revisions Since the Last Edition (2002) of this Report

In some cases, the amounts of capital investment requirements by asset type provided in Exhibits 7-10 and 7-11 have been considerably revised from the amounts presented in the 2002 edition of this report. As discussed earlier, these revisions are based on new data collected since the last edition of this report, including new asset inventory data provided by the NTD ACM and New York MTA. They also reflect updated information on rail asset costs, revisions to the benefit-cost analysis component of TERM, and revisions to projected PMT growth.

Data—As previously discussed, data collected by the ACM and from the New York MTA have led to more comprehensive transit asset coverage and improved asset condition estimates. Substantial revisions were also made to replacement cost estimates for rail assets based on information collected by two recent FTA studies, *Light Rail Transit Capital Cost Survey, October 2003,* and *Heavy Rail Transit Capital Cost Survey, June 2004,* which updated earlier studies undertaken in 1991 and 1994, respectively. Capital investment requirements are now based on asset replacement costs that are unique to each rail mode. Projected capital investment requirements in earlier editions of this report used the same asset replacement costs for commuter rail, light rail, and heavy rail assets because insufficient information was available on the costs for each mode.

The new FTA capital cost studies also found that rail construction costs have increased more rapidly than general construction costs since the 1991 and 1994 surveys, as a result of the increasing sophistication of rail systems. Prior editions of the C&P report relied heavily on the cost estimates for rail infrastructure gathered in the 1991 and 1994 studies, inflated to current dollars based on the Means Construction Index, a price index for general construction.

Bus Decay Curve—Engineering surveys of bus physical conditions, performed in 2001 and 2002, found that bus conditions decline slightly more rapidly during the first three years of life than previously estimated, and slightly less after age 15. This finding had virtually no impact on bus condition estimates.

Q. Could U.S. Federal Lands benefit from additional investment in transit?

A. Growth in public recreational use of Federal Lands has created a need for additional investment in alternative Transportation Systems (ATS), i.e., transit and transit enhancements, on Federal Lands. Transit investment requirements on Federal Lands been estimated outside the scope of the TERM framework and are discussed in more detail in Chapter 20. In 2004, a joint FTA and FHWA study was completed, which estimated ATS on U.S. Forest Service (USFS) lands. The USFS is part of the U.S. Department of Agriculture. This study identified 30 USFS sites that would benefit from new or supplemental ATS investments and estimated that approximately $698 million ($687 million or $34.4 million in 2002 dollars per year) would be needed in these areas between 2003 and 2022. An earlier joint FTA/FHWA study, undertaken in 2001, estimated ATS investment needs on National Park Service (NPS), Bureau of Land Management (BLM), and U.S. Fish and Wildlife Service (USFWS) lands, which are all part of the U.S. Department of the Interior (DOI). Total DOI needs for the period 2002 to 2020 were estimated to be $1.71 billion in 1999 dollars ($1.82 billion in 2002 dollars). Ninety-one percent of these needs were estimated to be required by the NPS, 7 percent by the USFWS, and 2 percent by BLM.

Commuter Rail Decay Curve—Engineering surveys of commuter rail vehicle physical conditions were performed in 2002. These surveys found that the conditions of commuter rail vehicles deteriorate considerably more rapidly in the first 5 years of their life, plateau between the ages of 5 and 22 years, and then decline again although very gradually. The fact that commuter rail vehicles are estimated to deteriorate more gradually in later years than previously estimated contributed to a decrease in rail vehicle investment requirements.

Projected PMT—Projected annual PMT growth has been reduced from an average annual rate of 1.6 percent to 1.5 percent, based on a survey of 76 agencies, compared with 33 agencies surveyed for the 2002 edition of this report. Projected PMT growth rates have decreased for most FTA regions since the last survey of PMT forecasts was made for the 2002 edition of this report, including those with the largest share of national PMT. This slight decrease in the projected demand for transit services exerted downward pressure on the amounts needed for asset expansion to maintain and improve performance. Projected PMT growth rates varied according to region, ranging from 0.95 to 3.15 percent.

Speed Improvements—The performance enhancement module of TERM was revised to shift investment in areas with populations of less than 1 million from regular bus modes to BRT in order to improve the speed of passenger travel. TERM previously increased speed in these areas by shifting investment from bus to light rail.

Benefit-Cost Analysis—The benefit-cost analysis component of TERM was revised by removing the imputation of fare box revenues as a benefit. Fare box revenues represent a transfer to transit agencies from another part of the economy and not a benefit. This revision exerted downward pressure on capital investment requirements for all rail and nonrail modes.

Reclassification of System Design and Right-of-Way Acquisition Costs—In the 2002 report, some costs for vehicles, stations, facilities and other "hard assets" were improperly reported as system design or right-of-way acquisition. These costs are now correctly allocated to the asset category to which they correspond. This revision has contributed to the larger investment requirements for each asset under the "Improve Performance" scenario than what was reported in the 2002 edition.