CHAPTER 9

Impacts of Investment

Summary

This chapter serves two major purposes. The first is to discuss the impacts of historic investment, relating the condition and performance trends reported in Chapters 3 and 4 to the financial trends reported in Chapter 6. The second is to describe the impacts of future investment, exploring the impacts of investing at different levels of funding, building on the analysis in Chapters 7 and 8.

The highway portion of this chapter begins by examining the impacts that recent and historical funding patterns have had on highway conditions and performance. The section then discusses the impacts that different levels of future investment would be expected to have in five areas: pavement condition, operational performance, different types of highway user costs, future highway travel growth, and the bridge investment backlog. The impacts on conditions and performance in particular have been designed to project future values of some of the measures presented in Chapters 3 and 4.

The transit portion examines the historical relationship between funding levels and conditions and performance. Funding levels for transit between 2002 and 2004 have been sufficient to maintain conditions and performance. The chapter examines the impact of limiting rehabilitation and replacement expenditures to less than the amounts estimated to be sufficient to maintain transit asset conditions. The chapter also discusses the impact that transit investments have on transit ridership and provides estimates of ridership increases that will be generated by service improvements.

Impacts of Highway and Bridge Investment

The first part of this section compares recent trends in highway and bridge investments with the changes in conditions and operational performance described in Chapters 3 and 4. This includes an analysis of whether the gap identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges is consistent with recent condition and operational performance trends.

The subsequent parts explore some of the impacts that future levels of investment would be expected to have on highway conditions and performance, highway user costs, and future travel growth (derived solely from the Highway Economic Requirements System [HERS]) and the bridge investment backlog (derived from the National Bridge Investment Analysis System [NBIAS]). Impacts are presented for a variety of future investment levels, including the two key investment scenarios in Chapters 7 and 8 and other levels corresponding to certain condition and performance benchmarks. Total investment at the different levels was derived using the external adjustment procedures described in Chapter 7 for nonmodeled capital expenditures. Bridge rehabilitation and replacement investments from NBIAS were interpolated from the two NBIAS investment scenarios and current bridge spending levels. All future investment levels are stated in constant 2004 dollars, and the analysis of projected impacts for each particular investment level assumes that funding would be sustained at that level in constant dollar terms through the year 2024.

As in Chapters 7 and 8, the analyses presented in this section assume the continuation of the existing financing structure for highway improvements. Chapter 10 includes an analysis of the effects of moving toward more efficient congestion-based pricing.

Linkage Between Recent Condition and Performance Trends and Recent Spending Trends

As discussed in Chapter 6, capital spending by all levels of government has increased from 1997 to 2004 by 45.3 percent, from $48.4 billion to $70.3 billion. This equates to a 22.9 percent increase in constant dollar terms, as spending grew much faster than the rate of inflation. Over the same period, the percentage of total capital outlay used for system rehabilitation rose from 47.6 percent in 1997 to 51.8 percent in 2004. The combined result of this increase in total capital investment and the shift in the types of investments being made was a 58 percent increase in spending on system rehabilitation, from $23.0 billion to $36.4 billion. As indicated in Chapter 6, the term "system rehabilitation" is used in this report to describe capital improvement on existing roads and bridges intended to preserve or replace the existing pavement and bridge infrastructure.

The percentage of capital outlay used for system expansion fell from 44.4 percent in 1997 to 39.2 percent in 2004. Spending for system expansion grew more slowly than that for system rehabilitation over this period, rising 28 percent, from $21.5 billion dollars in 1997 to $27.5 billion in 2004.

Physical Conditions

The improved bridge conditions reported in Chapter 3 reflect the effects of the increased investment in system rehabilitation noted above. The percent of deficient bridges decreased from 1998 to 2004, falling from 29.6 percent to 26.7 percent. The impact on pavement conditions, however, has been more mixed. Ride quality has improved in some areas and on some functional classes, but has held steady or declined in other cases. Between 1997 and 2004, the share of vehicle miles traveled (VMT) on roads with good ride quality increased from 39.4 percent to 44.2 percent, but the share on roads with acceptable ride quality decreased from 86.4 percent to 84.9 percent. Both measures improved in rural areas (from 47.9 to 58.3 percent for good ride quality and 92.5 to 94.5 percent for acceptable ride quality), but the percentage of travel on roads in urbanized areas with acceptable ride quality declined from 82.6 to 79.2 percent. The share of travel on roads with acceptable ride quality essentially remained constant in small urban areas, increasing only slightly from 84.0 to 84.3 percent. The percentage of travel on roads with good ride quality increased in both small urban and urbanized areas over that period.

Operational Performance

While investment in system expansion has increased since 1997, it has declined as a share of total capital spending, as noted above. Based on the performance measures described in Chapter 4, congestion has continued to increase between 1997 and 2004. The Average Daily Percent of VMT Under Congested Conditions increased from 27.4 percent to 31.6 percent from 1997 to 2004, while the Average Length of Congested Conditions increased from 6.2 hours to 6.6 hours. The Travel Time Index increased from 1.30 in 1997 to 1.38 in 2004. The Annual Delay per Peak Period Traveler increased from 40.2 to 45.7 hours between 1997 and 2004, while Annual Delay per Capita in urbanized areas increased from 19.5 hours to 24.4 hours. However, the rate of change for each of these measures has decreased in recent years. In particular, smaller annual increases have been experienced since 1999 than was generally the case in the 5 years before 1999.

Q&A

Are the recent trends in conditions and performance consistent with the gaps identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges?

Yes. The operational performance measures described in this report show that congestion is getting worse in the Nation's urban areas. Increased investment would be necessary to maintain the overall conditions and performance of the highway system at a level at which user costs would stop rising in constant dollar terms.

As indicated in Chapter 8, spending on bridge rehabilitation has exceeded the estimated investment level for the bridge component of the "Cost to Maintain" scenario in recent years. This is consistent with the ongoing reduction in the percentage of deficient bridges.

While capital spending in general has been below the Cost to Maintain level in recent years, this has especially been true for spending in urban areas. Capital outlay on rural highways has actually been greater than the estimated Cost to Maintain in those areas. This is consistent with the trends shown in Chapter 3, which indicate that the percentage of travel on roads with good or acceptable ride quality has been improving significantly in rural areas, but has generally been steady or declined slightly in urban areas.

Impact of Future Investment on Highway Physical Conditions

Exhibit 9-1 shows how future measures of pavement conditions would vary at different investment levels. The second column shows the portion of the total investment at each level that is derived directly from HERS (only this portion of the total investment influences the pavement measures in the remaining columns). The third column, "Percent Change in Average IRI", is a measure of average pavement conditions (the International Roughness Index [IRI] is discussed in Chapter 3). The other two measures show the percentage of VMT on pavement having an IRI value below 95 and an IRI value below 170. These two IRI values were defined in Chapter 3 as the thresholds for rating pavement ride quality as good and acceptable, respectively.

At the funding level estimated in Chapter 7 as the Maximum Economic Investment for Highways and Bridges ($131.7 billion annually), the average pavement quality would improve by 21.1 percent, while the percentage of VMT on pavement rated as adequate or better would rise from 84.8 percent to 92.5 percent. At the Maintain User Costs level (labeled "Cost to Maintain" scenario in Exhibits 9-1 through 9-4 and 9-7), average IRI would decrease by 2.5 percent, and the VMT percentage on good pavement would increase from 45.2 percent to 57.7 percent.

Exhibit 9-1 also shows projections of pavement quality at other funding levels. The results indicate that an average annual expenditure level of $75.8 billion would be sufficient to maintain average IRI over the 20-year analysis period. If highway spending were to be held at 2004 levels (in constant dollars) through the year 2024, increasing only with inflation, average IRI would be projected to increase by 5.4 percent if improvements were implemented in the manner recommended by HERS. The percentage of VMT on roads with good ride quality would increase to 52.6 percent, while the percentage on adequate ride quality pavement would decrease to 80.0 percent.

Exhibit 9-1

Projected Changes in 2024 Highway Physical Conditions Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in Average	Percent of VMT on Roads with		
Total	HERS-Derived Component*	IRI	IRI<95	IRI<170	Funding Level Description
			45.2%	**84.8%**	**2004 Values**
$131.7	$90.9	-21.1%	68.3%	92.5%	Maximum Economic Investment scenario
$123.6	$85.1	-19.3%	67.3%	91.7%	
$116.6	$80.1	-17.9%	66.6%	90.9%	
$102.6	$70.1	-13.3%	64.0%	88.6%	
$89.7	$60.9	-8.6%	61.3%	86.4%	
$78.8	$53.1	-2.5%	57.7%	83.6%	Cost to Maintain scenario
$75.8	$50.1	**0.0%**	56.1%	82.5%	**Average IRI Maintained**
$70.3	$44.7	5.4%	52.6%	80.0%	Actual 2004 Capital Outlay

* The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

Source: Highway Economic Requirements System.

Impact of Future Investment on Highway Operational Performance

Exhibits 9-2 and *9-3* show how several indicators of highway operational performance would be affected at various levels of spending. The first of these is average speed of highway vehicles, a simple measure of average traffic flow, which also corresponds to one of the two transit performance measures used in the Transit Economic Requirements Model (TERM). Exhibit 9-2 indicates that an average annual investment of $89.7 billion would be sufficient to maintain average highway speeds at their 2004 level of 43.0 miles per hour. This dollar amount is higher than the amount identified as the Cost to Maintain Highways and Bridges, at which investment level the average speed would drop by 0.3 mile per hour. At the Maximum Economic Investment level of spending, average speeds would increase to 44.0 miles per hour.

The next two indicators show the estimated percentage of VMT occurring on roads with peak volume-to-service-flow (capacity) ratios above 0.80 and above 0.95. As indicated in Chapter 4, these levels are generally used to describe congested and severely congested operating conditions on highways, respectively. If 2004 highway spending levels were maintained in constant dollar terms through 2024, the percentage of VMT on congested roads would be projected to increase from 23.7 percent to 36.4 percent, while the percentage on severely congested roads would increase from 13.3 percent to 19.1 percent. The percentage of VMT on congested roads would be projected to increase (to 29.5 percent) even at the Maximum Economic Investment level, while the percentage of VMT on severely congested roads would decline (to 10.4 percent).

For a potential capacity improvement to be included in a particular HERS scenario, the improvement must meet the minimum benefit-cost ratio (BCR) test associated with that scenario. As a result, there may be some road segments in a given time period that meet or exceed the threshold for being considered congested, but which do not merit capacity expansion in HERS. The results in Exhibit 9-2 indicate that HERS is generally finding capacity improvements on severely congested roads to be more cost-beneficial than those on moderately congested routes, and is targeting investment accordingly.

Exhibit 9-2

Projected Changes in 2024 Highway Operational Performance Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Average Speed (mph)	Impact of HERS-Derived Investment on Roads Modeled in HERS		
			Percent of VMT on Roads with		
Total	HERS-Derived Component *		V/SF>.80	V/SF>.95	Funding Level Description
		43.0	23.7%	13.3%	**2004 Values**
$131.7	$90.9	44.0	29.5%	10.4%	Maximum Economic Investment scenario
$123.6	$85.1	43.9	29.9%	11.3%	
$116.6	$80.1	43.7	30.6%	12.3%	
$102.6	$70.1	43.4	32.4%	13.9%	
$89.7	$60.9	**43.0**	33.9%	15.9%	**Average Speed Maintained**
$78.8	$53.1	42.7	35.3%	17.7%	Cost to Maintain scenario
$75.8	$50.1	42.5	35.5%	18.1%	
$70.3	$44.7	42.3	36.4%	19.1%	Actual 2004 Capital Outlay

* The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.
V/SF = volume/service flow ratio

Source: Highway Economic Requirements System.

Exhibit 9-3 shows how the HERS projections of average delay per VMT would change at different funding levels, including separate projections for congestion delay and incident delay. HERS calculates these values as part of its determination of average speed and travel time costs. HERS estimates that an average annual expenditure level of $89.7 billion would be sufficient to maintain average total delay per VMT at 2004 levels. At current spending levels, average total delay would be projected to increase by 7.9 percent, while spending at the Maximum Economic Investment level would result in a decrease of 10.6 percent.

The impacts on congestion delay and incident delay at various funding levels differ somewhat. Congestion delay would be projected to decrease at higher funding levels, but would increase at lower investment levels, reaching 20.8 percent if spending remains at the 2004 level of $70.3 billion in constant dollar terms. Incident delay, however, would be projected to decrease at all funding levels, with significant reductions of over 30 percent at the Maximum Economic Investment level, and would increase slightly only at current spending levels. At the Maintain User Costs level, congestion delay would be projected to increase 14.2 percent, while incident delay would decrease by 7.8 percent. The level of future investments in operations and intelligent transportation systems assumed in these scenarios is expected to have a greater impact on reducing delay caused by incidents, making it possible to reduce average incident delay per VMT even at lower levels of funding.

It should be noted that these estimates are for average delay per VMT. Since highway travel is projected to increase over time under all of these scenarios, total hours of delay would likewise be expected to increase.

Exhibit 9-3

Projected Changes in 2024 Highway Travel Delay Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component *	Total Delay per VMT	Congestion Delay per VMT	Incident Delay per VMT	Funding Level Description
$131.7	$90.9	-10.6%	-6.4%	-30.4%	Maximum Economic Investment scenario
$123.6	$85.1	-9.2%	-4.3%	-28.4%	
$116.6	$80.1	-7.3%	-1.5%	-25.1%	
$102.6	$70.1	-4.4%	2.8%	-20.4%	
$89.7	$60.9	0.0%	9.1%	-13.3%	
$78.8	$53.1	3.4%	14.2%	-7.8%	Cost to Maintain scenario
$75.8	$50.1	4.8%	16.2%	-5.7%	
$70.3	$44.7	7.9%	20.8%	-0.6%	Actual 2004 Capital Outlay

* The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

Source: Highway Economic Requirements System.

Impact of Future Investment on Highway User Costs

The HERS model defines benefits as reductions in highway user costs, agency costs, and societal costs. Highway user costs are composed of travel time costs, vehicle operating costs, and crash costs. The HERS-derived portion of the "Cost to Maintain Highways and Bridges" scenario in Chapter 7 was based on maintaining average total user costs at 2004 levels. The analysis presented there estimates that an average annual investment of $78.8 billion in constant 2004 dollars for the period 2005 through 2024 would be sufficient to maintain highway user costs at their baseline 2004 levels.

Exhibit 9-4 describes how average total user costs, travel time costs, and vehicle operating costs are influenced by the total amount invested in highways. The overall average crash costs calculated by HERS do not vary significantly at different investment levels.

While an average annual highway investment of $78.8 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would rise by 0.7 percent, while average vehicle operating costs would fall by the same percentage. Average vehicle operating costs would increase at current funding levels, while travel time costs would decrease at annual average funding levels of $89.7 billion or higher.

Estimates of total user costs vary at different levels of future investment, rising by 1.1 percent at the current spending level and falling 2.8 percent at the Maximum Economic Investment level. Travel time costs show slightly greater variation, ranging from a 2.0 percent increase at current funding levels to a 3.1 percent decrease at the Maximum Economic Investment level.

Exhibit 9-4

Projected Changes in 2024 Highway User Costs Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component *	Total User Costs	Travel Time Costs	Vehicle Operating Costs	Funding Level Description
$131.7	$90.9	-2.8%	-3.1%	-3.1%	Maximum Economic Investment scenario
$123.6	$85.1	-2.5%	-2.7%	-2.9%	
$116.6	$80.1	-2.2%	-2.3%	-2.7%	
$102.6	$70.1	-1.6%	-1.4%	-2.1%	
$89.7	$60.9	-0.8%	-0.3%	-1.5%	
$78.8	$53.1	**0.0%**	0.7%	-0.7%	**Cost to Maintain scenario**
$75.8	$50.1	0.4%	1.1%	-0.3%	
$70.3	$44.7	1.1%	2.0%	0.4%	Actual 2004 Capital Outlay

* The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

Source: Highway Economic Requirements System.

Q&A

What is the significance of the relatively small changes in user costs presented in Exhibit 9-4?

While the projected changes in user costs at different investment levels are small in percentage terms, it is important to note that they are being applied to all travel on functional classes analyzed by HERS. While the 2.8 percent reduction in average user costs per VMT under the "Maximum Economic Investment" scenario appears relatively low, by the year 2024 it would translate into annual user costs savings of approximately $116 billion, based on projected future VMT under that scenario.

If spending were maintained at 2004 levels in constant dollar terms, and average user costs per VMT rose by 1.1 percent, by 2024 this would translate into additional user costs of approximately $45 billion per year, based on the projected future VMT at this level of investment.

To understand the significance of the relative size of these percentage changes, it is important to recognize that the total user costs and total travel time costs presented in this report include all travel time, not just the additional travel time that results from congestion. Most travel time is not directly related to delay, but rather is simply a function of the physical separation between trip origins and destinations. There is thus a limit on the ability of highway investment to cause dramatic reductions in this key component of user costs.

The percent change in user costs shown in Exhibit 9-4 is tempered by the operation of the elasticity features in HERS. The model assumes that, if user costs are reduced on a section, additional travel will shift to that section. This additional traffic volume tends to offset some of the initial reduction in user costs. Conversely, if user costs increase on a highway segment, drivers will be diverted away to other routes, other modes, or will eliminate some trips entirely. When some vehicles abandon a given highway segment, the remaining drivers benefit in terms of reduced congestion delay, which offsets part of the initial increase in user costs. The impact of different investment levels on highway travel is discussed in the next section.

Another important consideration is that the values reported in Exhibit 9-4 are for the economic costs associated with highway conditions and performance, and do not include user charges such as fuel taxes, motor-vehicle fees or tolls. As discussed in the "Introduction" to Part II and in Chapter 7, a key addition to the HERS analysis for this edition of the report is to connect increases in investment above base year 2004 levels with increases in user revenues to pay for them. As a result, actual user expenditures (including both user costs and user charges) would be higher in 2024 at the Maintain User Cost level than in 2004.

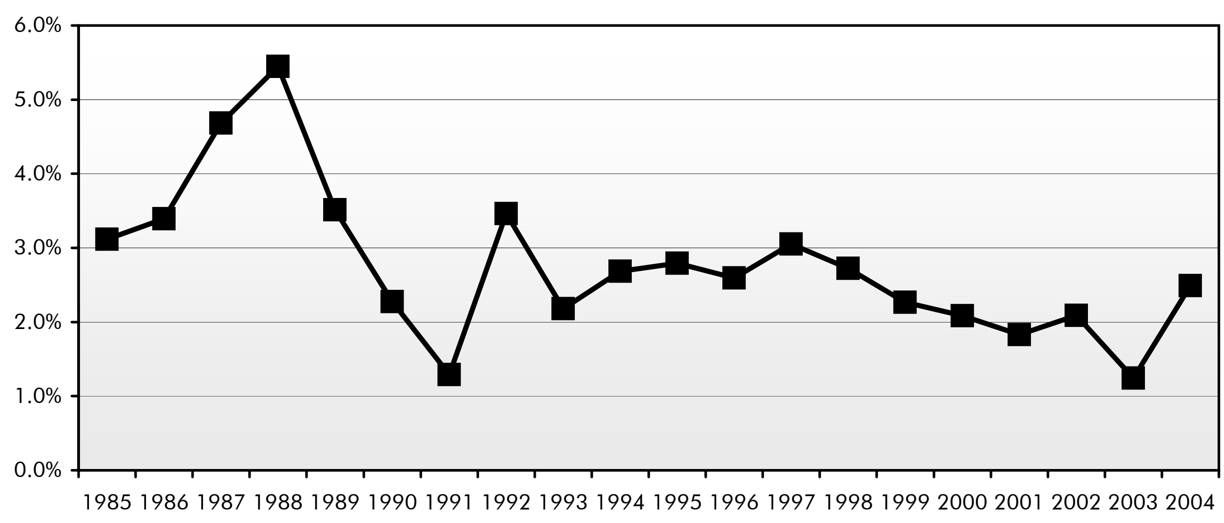
Impact of Future Investment on Travel Growth

Historic Travel Growth

From 1984 to 2004, annual highway VMT grew from 1.73 trillion to 2.98 trillion, an average annual growth rate of 2.76 percent. As shown in *Exhibit 9-5*, however, travel growth has varied somewhat from year to year, ranging from a high of 5.45 percent in 1988 to a low of 1.24 percent in 2003. Highway travel growth has typically been lower during periods of slow economic growth and/or higher fuel prices, and higher during periods of economic expansion. VMT growth was below average during recessions in the early 1990s and early 2000s, while annual VMT growth was higher than 3 percent in every year from 1985 through 1989. Exhibit 9-5 shows that travel grew more slowly during the economic expansion of the 1990s than in the 1980s, reflecting a long-term trend toward lower VMT growth rates.

Exhibit 9-5

Annual VMT Growth Rates, 1984 to 2004



Source: Highway Performance Monitoring System.

Travel Growth Forecasts

The Highway Performance Monitoring System (HPMS) data supplied by the States and used as the primary input in HERS include 20-year forecasts of future highway travel. The weighted average annual growth rate for all sample sections based on these forecasts in the 2004 data is 1.92 percent, which is significantly lower than the average growth rate over the prior 20 years. Projected growth in rural areas (2.15 percent average annual) is somewhat higher than in urban areas (1.79 percent). *Exhibit 9-6* shows projected year-by-year VMT for the period 2004 to 2024 derived from these forecasts under two different assumptions about future growth patterns: geometric growth (growing at a constant annual rate), and linear growth (growing by a constant amount annually, implying that rates would gradually decline over the forecast period). The HERS analyses presented in this report used the linear growth assumption.

Exhibit 9-6

Annual Projected Highway VMT Based on Highway Performance Monitoring System Forecasts

(VMT in Billions)

Growth Pattern	**Linear Growth (Constant Annual Amount)**	**Geometric Growth (Constant Annual Rate)**
2004 (actual)	**2,982**	**2,982**
2005	3,051	3,039
2006	3,120	3,098
2007	3,189	3,157
2008	3,258	3,218
2009	3,327	3,279
2010	3,396	3,342
2011	3,465	3,406
2012	3,533	3,472
2013	3,602	3,538
2014	3,671	3,606
2015	3,740	3,675
2016	3,809	3,746
2017	3,878	3,818
2018	3,947	3,891
2019	4,016	3,965
2020	4,085	4,042
2021	4,154	4,119
2022	4,223	4,198
2023	4,292	4,279
2024	**4,361**	**4,361**

Source: Highway Performance Monitoring System.

As discussed in Chapter 7, HERS predicts that the level of investment in highways will affect future VMT growth. The travel demand elasticity features in HERS assume that highway users will respond to increases in the cost of traveling a highway facility by shifting to other routes, switching to other modes of

Q&A

Do the travel demand elasticity features in HERS differentiate between the components of user costs based on how accurately highway users perceive them?

No. The model assumes that comparable reductions or increases in travel time costs, vehicle operating costs, or crash costs would have the same effect on future VMT. The elasticity values in HERS were developed from studies relating actual costs to observed behavior; these studies did not explicitly consider perceived cost.

Highway users can directly observe some types of user costs such as travel time and fuel costs. Other types of user costs, such as crash costs, can be measured only indirectly. In the short run, directly observed costs may have a greater effect on travel choice than costs that are harder to perceive. However, while highway users may not be able to accurately assess the crash risk for a given facility, they can incorporate their general perceptions of the relative safety of a facility into their decision-making process. The model assumes that the highway users' perceptions of costs are accurate, in the absence of strong empirical evidence that they are biased.

transportation, or forgoing some trips entirely. The model also assumes that reducing user costs (see above) on a facility will induce additional traffic on that route that would not otherwise have occurred. Future pavement and widening improvements would tend to reduce highway user costs and induce additional travel on the improved sections. If a highway section is not improved, highway user costs on that section would tend to rise over time because of pavement deterioration and/or increased congestion, thereby suppressing some travel on that section.

One implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. Since higher investment levels generally result in reduced highway user costs [*see Exhibit 9-4*], they will also tend to result in higher levels of VMT growth. Another implication is that any external projection of future VMT growth will be valid only for a single level of investment in HERS. Thus, the baseline HPMS forecasts would be valid only under a specific set of conditions. The HERS assumes that the HPMS forecasts represent the level of travel that would occur if a constant level of service were maintained. As indicated in Chapter 7, this implies that travel will occur at this level only if pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway user costs at current levels.

The assumption that the HPMS travel forecasts implicitly represent a constant price is supported by recent research done on behalf of the Federal Highway Administration (FHWA), which created a year-by-year forecast for future VMT at the national level based on forecasts of demographic and economic variables. The forecasts made by this model, which does not incorporate any information on future levels of service, imply an average annual VMT growth rate that is generally similar to the baseline growth rate implicit in the HPMS data.

Another feature of HERS, newly introduced for this report, links investment levels to highway user revenues. Specifically, the model assumes that increases in highway capital expenditures above base year levels will be accompanied by increases in highway user fees to cover them. This "surcharge," operating through the HERS travel demand elasticity procedures, will thus tend to limit future travel growth at higher levels of investment. See Chapter 7 and Appendix A for more on this feature of HERS.

Travel Growth and Investment

Exhibit 9-7 shows how the effective VMT growth rates in HERS are influenced by the total amount invested in highways, and the location of highway improvements in urban and rural areas.

If average annual highway and bridge capital outlay were to rise to $78.8 billion in constant 2004 dollars, HERS predicts that overall highway user costs in 2024 would remain at 2004 levels. The "Maintain User Costs" scenario derived from HERS attempts to maintain the average user costs at the end of the 20-year analysis period for the entire highway system, but user costs can vary on individual functional classes and on individual highway sections and in intermediate years. Importantly, the estimated user costs targeted in this scenario also do not include fuel taxes and other highway user fees. Since these fees automatically rise as funding levels in the HERS analysis are increased above base-year expenditures, they will tend to suppress some travel that might otherwise have occurred. This effect largely accounts for the fact that projected average annual VMT growth rates at this level of investment are slightly lower than those derived from the baseline HPMS data.

Exhibit 9-7

Projected Average Annual VMT Growth Rates, 2005–2024, for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Average Annual VMT Growth			
Total	HERS-Derived Component *	Total	Rural	Urban	Funding Level Description
		1.92%	**2.15%**	**1.79%**	**HPMS Baseline VMT Projection**
$131.7	$90.9	1.94%	2.08%	1.86%	Maximum Economic Investment scenario
$123.6	$85.1	1.91%	2.07%	1.83%	
$116.6	$80.1	1.91%	2.06%	1.82%	
$102.6	$70.1	1.90%	2.07%	1.81%	
$89.7	$60.9	1.89%	2.08%	1.78%	
$78.8	$53.1	1.88%	2.10%	1.77%	Cost to Maintain scenario
$75.8	$50.1	1.87%	2.09%	1.75%	
$70.3	$44.7	1.86%	2.09%	1.73%	Actual 2004 Capital Outlay

* The amounts shown represent the portion of the total investment for each scenario or alternative funding level shown that would be used for types of capital improvements and types of roads that are modeled in HERS.

Source: Highway Economic Requirements System

Implementing all of the cost-beneficial highway investments in the $131.7 billion "Maximum Economic Investment" scenario would reduce user costs overall, but these would again be offset to some degree by the increases in user fees that HERS assumes would be levied to fund this higher level of investment. In urban areas, the net impact of this is lower user expenditures (user costs plus user fees), resulting in higher travel growth rates in urban areas than are currently projected in HPMS. In rural areas, the net impact is an increase in user expenditures, leading to lower travel growth rates relative to the HPMS baseline.

In 2004, all levels of government spent $70.3 billion for highway capital outlay, corresponding to the "Actual 2004 Capital Outlay" row in Exhibit 9-7. At this level of investment, there are no increased user fees levied by HERS, so the only impact on travel growth is through user costs. If average annual investment remains at this level in constant dollar terms over the next 20 years, HERS projects that the increase in user costs would limit average annual VMT growth to 1.86 percent, somewhat below the baseline forecasts in HPMS.

While there is some variation in forecast future travel growth rates at different levels of investment, this range is relatively narrow, from 1.86 percent to 1.94 percent on an average annual basis. This again is largely a function of the procedures in HERS for assessing user fees to fund increased investment levels, in concert with the HERS travel demand elasticity procedures. VMT is projected to grow to between 4.3 trillion and 4.4 trillion by 2024 under all the investment scenarios (as well as under the HPMS baseline).

Impact of Investment on the Bridge Investment Backlog

Chapter 7 projects that funding bridge investments at approximately $12.4 billion annually over a 20-year period would eliminate the existing backlog and correct other deficiencies that are expected to develop by 2024, where it is cost-beneficial to do so. This is the "Maximum Economic Investment" scenario. Chapter 7 also projects that funding bridge investments at approximately $8.7 billion annually would ensure that the cost of addressing all bridge deficiencies in 2024 would remain the same as in 2004. This is the "Maintain Economic Backlog" scenario.

Exhibit 9-8 shows projected changes in the bridge backlog for different funding levels. The existing backlog is estimated at approximately $65.3 billion. If investment over the 20-year period were limited to $5.9 billion per year, the backlog would rise to $120.7 billion. If bridge investment were maintained at the 2004 funding level in constant dollars ($10.5 billion), the bridge backlog would be projected to decrease by 47 percent, to approximately $34.5 billion.

Exhibit 9-8

Projected Changes in 2024 Bridge Investment Backlog Compared with 2004 Levels for Different Possible Funding Levels

Average Annual Investment (Billions of 2004 Dollars)	Backlog	Percent Change from 2004	Funding Level Description
12.4	0.0	-100.0%	Maximum Economic Investment scenario
11.1	21.4	-67.2%	
10.5	34.5	-47.2%	2004 Spending on Existing Bridges*
9.4	53.6	-17.8%	
8.7	65.3	**0.0%**	**Maintain Economic Backlog**
8.2	75.2	15.2%	
7.0	97.8	49.8%	
5.9	120.7	84.9%	

* Includes spending on rehabilitation and reconstruction of existing bridges. Excludes construction of new bridges.

Source: National Bridge Investment Analysis System.

Transit Investment Impacts

This section first summarizes the effects of historical transit spending on current transit physical conditions and operating performance as experienced by passengers. It then examines the impact on transit asset conditions at the end of the forecast period in 2024, if future rehabilitation and replacement spending were to be lower than the maintain condition investment levels estimated by TERM. The section concludes with estimates of the effect of transit investment to improve performance on ridership.

Current Impacts

Physical Conditions

Funding levels between 2002 and 2004 have been adequate to maintain conditions. Total capital investment increased from $12.3 billion in 2002 to $12.6 in 2004. Bus vehicle conditions were about the same, declining marginally from an average of 3.09 in 2002 to 3.08 in 2004 within the adequate condition category. Over the same time period, the average age of a bus vehicle declined from 6.2 to 6.1 years. Average rail vehicle conditions improved from 3.47 in 2002 to 3.50 in 2004, and the average vehicle age declined from 20.4 to 19.7 years. Facility conditions have improved. The average bus facility condition increased from 3.34 in 2002 to 3.41 in 2004, and the average rail facility condition increased from 3.56 to 3.82. The average condition of stations (bus and rail) also increased from 2.99 in 2002 to 3.43 in 2004. The average condition of elevated structures increased from 4.27 in 2002 to 4.31 in 2004, the average condition of underground tunnels increased from 4.09 to 4.23, the average condition of track increased from 4.17 to 4.27, and the condition of yards increased from 3.64 to 3.80.

Operating Performance

Funding levels between 2002 and 2004 have been sufficient to maintain performance. There was a slight increase in the average speed of passengers traveling on transit between 2002 and 2004 from 19.9 to 20.1 miles per hour. The average speed of passenger travel on rail modes decreased from 25.3 miles per hour in 2002 to 25.0 miles per hour in 2004, and the average speed as experienced by passengers on bus modes increased from 13.7 to 14.0 miles per hour.

Future Impacts

Constrained Rehabilitation and Replacement Expenditures

Exhibit 9-9 shows the effect on transit asset conditions of reducing rehabilitation and replacement expenditures below the level estimated by the Transit Economic Requirements Model (TERM) under the "Maintain Conditions" scenario. This TERM analysis pertains to agencies covered by the National Transit Database (NTD) and therefore excludes rural and special service needs and the effect of spending constraints on asset conditions for these public transportation providers. Note that under the "Maintain Conditions" scenario TERM estimates the amount of investment that will make the average asset condition in 2024 the same as the average asset condition that existed in 2004 for all assets combined. The condition of each asset category, however, may be slightly different in 2024 than in 2004. As discussed in Chapter 7, the investment estimated by TERM to maintain conditions, which is provided in this report, assumes that an average condition of 3.6 will be reached in 2024, compared with an average condition of 3.9 in 2004. To reach an average condition of 3.9 in 2024 would require including replacement expenditures in the

Exhibit 9-9

Effect of Capital Spending Constraints on Transit Condition Estimates

	2004 Condition	Percent of TERM Estimates of Rehabilitation and Replacement Expenditures to Maintain Conditions			
Asset Type		**100%**	**90%**	**80%**	**70%**
Guideway Elements	4.4	4.1	4.0	4.0	3.9
Facilities	3.6	3.2	2.9	2.9	2.9
Systems	3.9	3.7	3.7	3.5	3.4
Stations	3.4	3.1	3.1	3.1	3.1
Vehicles	3.4	3.4	3.3	3.3	3.1
All Assets	**3.9**	**3.6**	**3.5**	**3.5**	**3.4**
Rehabilitation and Replacement Expenditure Scenarios*		$9.36	$8.89	$7.91	$6.92

*Excludes rural vehicles and facilities.

investment estimate total for some assets that will not need replacement, i.e., their conditions will not fall below their estimated replacement thresholds during the 20-year forecast period.

If the amount estimated by TERM under the "Maintain Conditions" scenario for the rehabilitation and replacement of transit assets in urban areas is reduced by 10 percent, from $9.88 billion annually to $8.89 annually, the average condition of transit assets is estimated by TERM to fall from 3.9 in 2004 to 3.5 in 2024. If the amount estimated by TERM (for the rehabilitation and replacement of transit assets in urban areas) is reduced by 30 percent, to $6.92 billion, TERM estimates that average asset conditions would fall to 3.4 in 2024.

Ridership Response to Investment

TERM considers, in its benefit-cost analysis, the effect of transit capital investment on user costs and the effect of the change in these costs on transit ridership. Transit user costs are composed of out-of-pocket costs and travel-time costs. Travel time-savings are realized in two ways, by adding new or expanding existing rail or bus rapid transit (BRT) service, or by adding vehicles to reduce crowding. Out-of-pocket savings occur when passengers switch from automobiles to transit.

The TERM estimates for improving performance in urban areas are $5.17 billion annually (compared with $6.52 billion annually in the 2004 report). Of this amount, $2.01 billion annually would be for asset expansion in new rail or BRT service to increase speed and $3.16 billion annually would be for asset expansion in new vehicles to reduce occupancy levels. The average increase in ridership estimated to result from speed improvements achieved by expanding or building new rail or BRT system capacity is 22.9 million passengers annually; the average increase in ridership estimated to result from decreasing occupancy levels by adding new vehicles is 51.6 million passengers annually. [Note the total amount estimated by TERM to improve performance is $5.2 billion annually. The additional investment to improve performance represents the cost of increasing the rural transit fleet by 3.5 percent per year.]

Q&A

How responsive is transit ridership to changes in user costs?

Transit riders are not highly sensitive to changes in user costs. Research has shown that transit riders demand for transit services is relatively "inelastic" and that the relationship between user costs and riders is an inverse one. This means that a 1 percent increase or decrease in transit user costs will lead to less than 1 percent decrease or increase, respectively, in the number of transit riders. The percentage change in ridership resulting by 1 percent change in user costs is known as the "elasticity" of ridership with respect to user costs. TERM assumes that this elasticity ranges in value from –0.22 to –0.40 depending on the mode (*see Appendix* C).