CHAPTER 9

Impacts of Investment

Summary

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

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

The transit portion examines the historical relationship between funding levels and conditions and performance. Funding levels for transit between 2000 and 2002 have been sufficient to maintain conditions and performance, although increases in funding will be needed to maintain an expanded transit infrastructure and meet projected ridership demand. The chapter examines the impact of limiting rehabilitation and replacement expenditures to less than the amounts estimated to be required to maintain transit asset conditions. The chapter also discusses the impact that transit investments have on transit ridership and provides estimates of ridership increases that will be generated by service improvements.

Impacts of Highway and Bridge Investment

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

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

Linkage Between Recent Condition and Performance Trends and Recent Spending Trends

As discussed in Chapter 6, capital spending by all levels of government has increased from 1997 to 2002 by 41.0 percent, from $48.4 billion to $68.2 billion. This equates to a 24.5 percent increase in constant dollar terms, as spending grew much faster than the rate of inflation. Over the same period, the percentage of total capital outlay used for system preservation rose from 47.6 percent in 1997 to 52.6 percent in 2002. The combined result of this increase in total capital investment and the shift in the types of investments being made was a 56 percent increase in spending on system preservation, from $23.0 billion to $35.8 billion. As indicated in Chapter 6, the term "system preservation" is used in this report to describe capital improvement on existing roads and bridges intended to preserve the existing pavement and bridge infrastructure.

The percentage of capital outlay used for system expansion fell from 44.4 percent in 1997 to 38.8 percent in 2002. Spending for system expansion grew more slowly than that for system preservation over this period, rising 23 percent from $21.5 billion dollars in 1997 to $26.5 billion in 2002.

Physical Conditions

The improved highway and bridge conditions reported in Chapter 3 reflect the effects of the increased investment in system preservation noted above. The share of vehicle miles traveled (VMT) on the National Highway System routes with "acceptable" ride quality increased from 89.1 percent to 90.6 percent from 1997 to 2002. Acceptable miles on Interstate highways in urbanized areas rose from 90.0 percent to 91.7 percent over this period. The percent of urbanized Interstates meeting the stricter criteria for "good" ride quality increased from 39.3 percent to 48.7 percent over this same period. While pavement conditions

Q. **Are the recent trends in condition and performance consistent with the gap identified in Chapter 8 between current funding and the Cost to Maintain Highways and Bridges?**

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

While there has been an increase in the number of miles of acceptable pavement on the National Highway System and the Interstate System, the positive impacts on highway users of improved ride quality on these systems are outweighed by the negative impacts on drivers of increasing congestion.

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

declined on some of the lower-ordered functional systems, the overall percentage of road miles with good ride quality rose from 42.8 percent to 46.6 percent between 1997 and 2002. The percent of deficient bridges decreased from 1998 to 2002, falling from 29.6 percent to 27.5 percent.

Operational Performance

While investment in system expansion has increased since 1997, it has declined as a share of total capital spending, as noted above. Based on the performance measures described in Chapter 4, congestion has continued to increase between 1997 and 2002. The Percent of Travel Under Congested Conditions increased from 27.4 percent to 30.4 percent from 1997 to 2002, while the Percent Additional Travel Time increased from 30 percent to 37 percent. The Average Annual Hours of Traveler Delay in urbanized areas increased from 19.4 hours to 23.8 hours between 1997 and 2002. However, the rate of change for each of these measures has decreased in recent years. In particular, smaller annual increases have been experienced since 1999 than was generally the case in the five years before 1999.

Impact of Future Investment on Highway Physical Conditions

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

At the funding level estimated in Chapter 7 as the Maximum Economic Investment for Highways and Bridges ($118.9 billion annually), the average pavement quality would improve by 16.5 percent, while the percentage of VMT on pavement rated as adequate or better would rise from 84.9 percent to 92.6 percent. At the Cost to Maintain level, average IRI would decrease by 7.0 percent, and the VMT percentage on good pavement would increase from 44.8 percent to 54.3 percent.

Exhibit 9-1 also shows projections of pavement quality at other funding levels, including the actual 2002 capital outlay level. If highway spending would be held at 2002 levels (in constant dollars), increasing only with inflation, average IRI would be projected to decrease by 2.7 percent if improvements were implemented in the manner recommended by HERS. The percentage of VMT on roads with good pavement would

Exhibit 9-1	Projected Changes in 2022 Highway Physical Conditions Compared with 2002 Levels for Different Possible Funding Levels				
Average Annual Investment (Billions of 2002 Dollars)		**Impact of HERS-Derived Investment on Roads Modeled in HERS**			
		Percent Change in Average IRI	**Percent of VMT on Roads with**		
Total	**HERS-Derived Component** [1]		**IRI<95**	**IRI<170**	**Funding Level Description**
			44.8%	84.9%	2002 Values
$118.9	$81.2	-16.5%	60.9%	92.6%	Maximum Economic Investment scenario
$110.2	$75.1	-16.4%	61.7%	92.1%	
$103.2	$70.1	-15.3%	61.0%	91.4%	
$96.1	$65.1	-13.9%	59.9%	90.6%	
$89.1	$60.1	-12.0%	58.4%	89.6%	
$79.8	$53.5	-9.1%	56.2%	88.1%	
$73.8	$49.3	-6.8%	54.3%	86.8%	Cost to Maintain scenario
$70.3	$45.1	-4.5%	52.6%	85.5%	
$68.2	$42.4	-2.7%	51.2%	84.5%	Actual 2002 Capital Outlay

Source: Highway Economic Requirements System.

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

increase to 51.2 percent, while the percentage on adequate pavement would be virtually unchanged. Such results are consistent with the recent improvements in pavement quality brought on by increased spending noted above. Note, however, that these values from HERS assume a slightly higher share of capital spending being devoted to preservation improvement than is currently the case.

Impact of Future Investment on Highway Operational Performance

Exhibits 9-2 and *9-3* show how several indicators of highway operational performance would be affected at various levels of spending. The first of these is average speed of highway vehicles, a simple measure of average traffic flow, which also corresponds to one of the two transit performance measures used in the Transit Economic Requirements Model (TERM) [*see Chapter 7*]. Exhibit 9-2 indicates that an average annual investment of $79.8 billion would be sufficient to maintain average highway speeds at their 2002 level of 42.2 miles per hour. This dollar amount is higher than the amount identified as the Cost to Maintain Highways and Bridges, at which investment level average speed would drop by 0.7 miles per hour. At the Maximum Economic Investment level of spending, average speeds would increase to 43.1 miles per hour.

The next two indicators show the estimated percentage of VMT occurring on roads with peak volume-to-service-flow (capacity) ratios above 0.80 and above 0.95. As indicated in Chapter 4, these levels are generally used to describe congested and severely congested operating conditions on highways, respectively. If 2002 highway spending levels were maintained through 2022, the percentage of VMT on congested roads would be projected to increase from 23.8 percent to 36.8 percent, while the percentage on severely congested roads would increase from 13.7 percent to 19.7 percent. The percentage of VMT on congested roads would be projected to increase (to 31.4 percent) even at the Maximum Economic Investment level of investment, while the percentage of VMT on severely congested roads would decline slightly.

Exhibit 9-2 *Projected Changes in 2022 Highway Performance Compared with 2002 Levels for Different Possible Funding Levels*

Average Annual Investment (Billions of 2002 Dollars)			Impact of HERS-Derived Investment on Roads Modeled in HERS		
			Percent of VMT on Roads with		
Total	HERS-Derived Component [1]	Average Speed (mph)	V/SF>.80	V/SF>.95	Funding Level Description
		42.2	23.8%	13.7%	2002 Values
$118.9	$81.2	43.1	31.4%	13.3%	Maximum Economic Investment scenario
$110.2	$75.1	43.0	32.1%	14.0%	
$103.2	$70.1	42.8	32.6%	14.5%	
$96.1	$65.1	42.6	33.2%	15.2%	
$89.1	$60.1	42.4	34.1%	16.2%	
$79.8	$53.5	**42.2**	35.1%	17.4%	**Average Speed Maintained**
$73.8	$49.3	41.9	35.8%	18.3%	Cost to Maintain scenario
$70.3	$45.1	41.7	36.3%	19.2%	
$68.2	$42.4	41.5	36.8%	19.7%	Actual 2002 Capital Outlay

Source: Highway Economic Requirements System.

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

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

Exhibit 9-3 shows how the HERS projections of average delay per VMT would change at different funding levels, as well as separate projections for congestion delay and incident delay. The HERS calculates these values as part of its determination of average speed and travel time costs (see the 2002 edition of the C&P report for a more complete description). At current spending levels, average total delay per VMT would be projected to increase by 9.2 percent, while spending at the Maintain Highways and Bridges level would result in an increase of 6.6 percent. If all cost-beneficial improvements were implemented, then average total delay would be projected to decline slightly, by 1.0 percent.

The impacts on congestion delay and incident delay at various funding levels differ significantly. Congestion delay would be projected to increase by 7.4 percent even at the Maximum Economic Investment level, with larger decreases at lower investment levels, reaching 23.4 percent at the Maintain Current Spending level. Incident delay, however, would be projected to decrease significantly at this higher investment level, by 15.7 percent, and would increase slightly only at the lower levels. At the Cost to Maintain level, congestion delay would be projected to increase 19.2 percent, while incident delay would decrease by 2.3 percent.

Exhibit 9-3 *Projected Changes in 2022 Highway Performance Compared with 2002 Levels for Different Possible Funding Levels*

Average Annual Investment (Billions of 2002 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component [1]	Total Delay per VMT	Congestion Delay per VMT	Incident Delay per VMT	Funding Level Description
$118.9	$81.2	-1.0%	7.4%	-15.7%	Maximum Economic Investment scenario
$110.2	$75.1	0.2%	9.3%	-13.5%	
$103.2	$70.1	1.5%	11.0%	-11.1%	
$96.1	$65.1	2.5%	12.8%	-9.3%	
$89.1	$60.1	3.7%	14.8%	-7.5%	
$79.8	$53.5	5.4%	17.3%	-4.2%	
$73.8	$49.3	6.6%	19.2%	-2.3%	Cost to Maintain scenario
$70.3	$45.1	8.2%	21.8%	0.1%	
$68.2	$42.4	9.2%	23.4%	1.8%	Actual 2002 Capital Outlay

Source: Highway Economic Requirements System.

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

The divergent results for projected congestion and incident delay reflect differences in the impact that highway investment has on these two types of delay in the procedures used by the HERS model. The additional travel projected to occur over the next 20 years is likely to increase recurring congestion delay, even with significant investments in new capacity. However, the level of future investments in operations and intelligent transportation systems assumed in these scenarios is expected to have a greater impact on reducing delay owing to incidents, making it possible to reduce average incident delay per VMT.

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

Impact of Investment on Different Types of Highway User Costs

The HERS model defines benefits as reductions in highway user costs, agency costs, and societal costs. Highway user costs are composed of travel time costs, vehicle operating costs, and crash costs. The HERS-derived portion of the "Cost to Maintain Highways and Bridges" scenario in Chapter 7 was based on maintaining average total user costs at 2002 levels. The analysis presented there estimates that an average annual investment of $73.8 billion would be required to maintain highway user costs at their baseline 2002 levels.

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

While an average annual highway investment of $73.8 billion would maintain overall user costs, the effect on individual user cost components would vary. Travel time costs would rise by 0.6 percent, whereas average vehicle operating costs would fall by 0.7 percent. The 2002 capital investment level of $68.2 billion would be sufficient to maintain vehicle operating costs. Travel time costs would be maintained or decreased only if average annual investment exceeded $79.8 billion for highways and bridges.

Exhibit 9-4 *Projected Changes in 2022 Highway User Costs Compared with 2002 Levels for Different Possible Funding Levels*

Average Annual Investment (Billions of 2002 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Percent Change in			
Total	HERS-Derived Component [1]	Total User Costs	Travel Time Costs	Vehicle Operating Costs	Funding Level Description
$118.9	$81.2	-2.1%	-2.6%	-2.2%	Maximum Economic Investment scenario
$110.2	$75.1	-1.9%	-2.1%	-2.1%	
$103.2	$70.1	-1.5%	-1.6%	-1.9%	
$96.1	$65.1	-1.2%	-1.2%	-1.7%	
$89.1	$60.1	-0.9%	-0.7%	-1.4%	
$79.8	$53.5	-0.4%	0.0%	-1.0%	
$73.8	$49.3	**0.0%**	0.6%	-0.7%	**Cost to Maintain scenario**
$70.3	$45.1	0.5%	1.3%	-0.3%	
$68.2	$42.4	0.8%	1.7%	0.0%	Actual 2002 Capital Outlay

Source: Highway Economic Requirements System.

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

Q. What is the significance of the relatively small changes in user costs presented here?

A. While the projected changes in user costs at different investment levels are small in percentage terms, it is important to note that they are being applied to all travel on functional classes analyzed by HERS. A 1 percent change would thus correspond to roughly $20 billion in estimated total user costs at current traffic levels.

Estimates of total user costs vary at different levels of future investment, rising by nearly 1 percent at the current spending level and falling 2.1 percent at the maximum economic level of investment. Travel time costs show slightly greater variation, ranging from a 1.7 percent increase at current funding levels to a 2.6 percent decrease at the Maximum Economic Investment level.

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

Impact of Investment Levels on Future Travel Growth

As discussed in Chapter 7, HERS predicts that the level of investment in highways will affect future VMT growth. The travel demand elasticity features in HERS assume that highway users will respond to increases in the cost of traveling a highway facility by shifting to other routes, switching to other modes of transportation, or forgoing some trips entirely. The model also assumes that reducing user costs (see above) on a facility will induce additional traffic on that route that would not otherwise have occurred.

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

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

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

Future pavement and widening improvements would tend to reduce highway user costs and induce additional travel. If a highway section is not improved, highway user costs on that section would tend to rise over time because of pavement deterioration and/or increased congestion, thereby suppressing some travel.

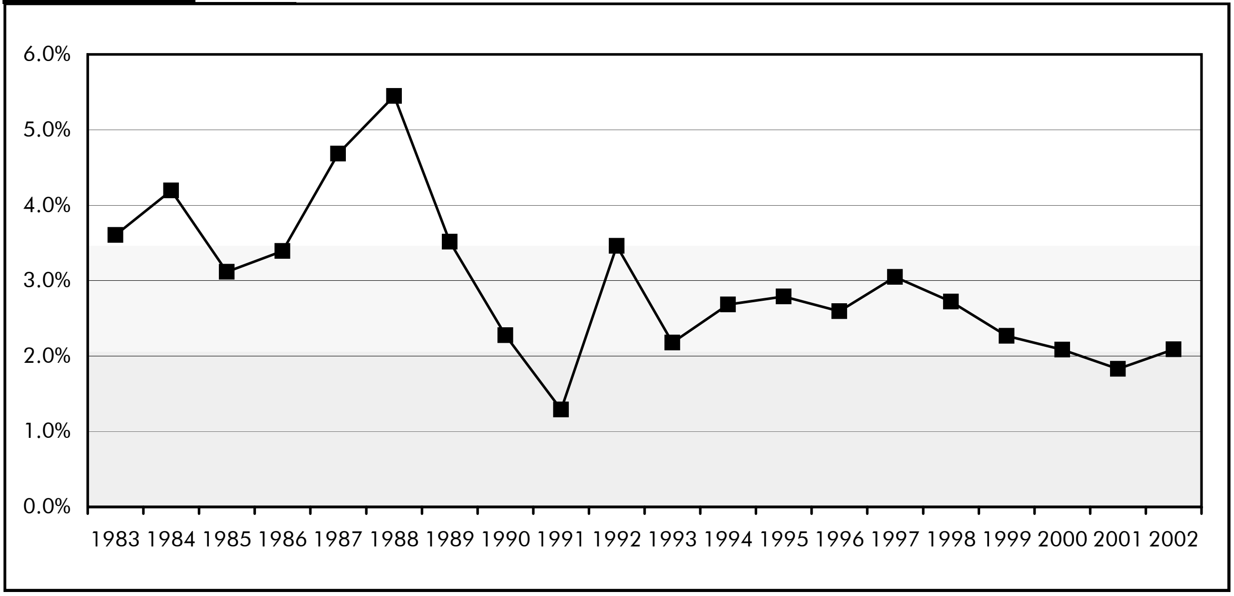
One implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. The higher the overall investment level, the higher the projected travel will be. Another implication is that any external projection of future VMT growth will be valid only for a single level of investment in HERS. Thus, the State-supplied 20-year growth forecasts in the Highway Performance Monitoring System (HPMS) would be valid only under a specific set of conditions. The HERS assumes that the HPMS forecasts represent the level of travel that would occur if a constant level of service were maintained. As indicated in Chapter 7, this implies that travel will occur at this level only if pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway user costs at current levels.

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

Historic Travel Growth

Exhibit 9-5 shows annual VMT growth rates for the 20-year period from 1982 to 2002. The average annual VMT growth rate over this period was 2.96 percent. Travel growth has varied somewhat from year to year, ranging from a high of 5.45 percent in 1988 to a low of 1.29 percent in 1991. Highway travel growth is typically lower during periods of slow economic growth and/or higher fuel prices, and higher during periods of economic expansion. VMT growth was below average during recessions in 1990–1991 and 2000–2002, while annual VMT growth was higher than 3 percent in every year from 1983 through 1989. Exhibit 9-5 shows that travel grew more slowly during the economic expansion of the 1990s than in the 1980s, reflecting a long-term trend toward lower VMT growth rates.

Exhibit 9-5 *Annual VMT Growth Rates, 1982–2002*



Source: Highway Performance Monitoring System.

Projected Travel Growth

Exhibit 9-6 shows how the effective VMT growth rates in HERS are influenced by the total amount invested in highways, and the location of highway improvements in urban and rural areas.

Based on the baseline future travel forecasts in HPMS, the weighted average annual growth rate for all sample sections is 2.07 percent. Projected growth in rural areas (2.29 percent average annual) is somewhat larger than in urban areas (1.93 percent).

If average annual highway and bridge capital outlay rose to $73.8 billion in constant 2002 dollars, HERS predicts that overall highway user costs in 2022 would remain at 2002 levels. The “Maintain User Costs” scenario derived from HERS attempts to maintain the average user costs at the end of the 20-year analysis period for the entire highway system, but user costs can vary on individual functional classes and on individual highway sections and in intermediate years. In this particular analysis, the resulting average annual VMT growth rates in urban areas and in the Nation as a whole at this level of investment are slightly higher than those derived from the baseline HPMS data, while rural VMT growth rates would be just slightly lower than the baseline.

Implementing all of the cost-beneficial highway investments in the $118.9 billion Maximum Economic Investment scenario would reduce user costs, resulting in higher travel growth rates than currently projected in HPMS, because of the travel demand elasticity features in HERS. Total VMT would grow at an average annual rate of 2.21 percent, while rural and urban VMT would grow at 2.34 and 2.12 percent, respectively. Note, however, that even these elevated levels are well below the average annual growth rates experienced over the last 20 years.

In 2002, all levels of government spent $68.2 billion for highway capital outlay, corresponding to the “Maintain Current Spending” row in Exhibit 9-6. If average annual investment remains at this level in constant dollar terms over the next 20 years, HERS projects that the increase in user costs would limit average annual urban VMT growth to 2.05 percent, below the baseline forecasts in HPMS.

Exhibit 9-6 *Projected Average Annual VMT Growth Rates, 2003–2022, for Different Possible Funding Levels*

Average Annual Investment (Billions of 2002 Dollars)		Impact of HERS-Derived Investment on Roads Modeled in HERS			
		Average Annual VMT Growth			
Total	HERS-Derived Component [1]	Total	Rural	Urban	Funding Level Description
		2.07%	**2.29%**	**1.93%**	**HPMS Baseline VMT Projection**
$118.9	$81.2	2.21%	2.34%	2.12%	Maximum Economic Investment scenario
$110.2	$75.1	2.19%	2.33%	2.09%	
$103.2	$70.1	2.17%	2.33%	2.07%	
$96.1	$65.1	2.15%	2.32%	2.05%	
$89.1	$60.1	2.14%	2.31%	2.03%	
$79.8	$53.5	2.11%	2.30%	1.99%	
$73.8	$49.3	2.09%	2.28%	1.97%	Cost to Maintain scenario
$70.3	$45.1	2.07%	2.27%	1.94%	
$68.2	$42.4	2.05%	2.26%	1.92%	Actual 2002 Capital Outlay

Source: Highway Economic Requirements System.

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

The future travel growth projections in HPMS indicate future levels of VMT, but provide no information as to how travel will grow year by year within the 20-year forecast period. As discussed in Chapter 7, the HERS model assumes that VMT growth will be linear (growing by a constant amount annually rather than at a constant rate), implying that rates will gradually decline over the forecast period. *Exhibit 9-7* shows projected year-by-year VMT derived from HERS under this assumption for three different funding levels. If average annual investment were to reach the Maximum Economic Investment level, VMT would be expected to grow to 4.44 trillion in 2022. If average annual investment remains at 2002 levels in constant dollar terms, VMT would grow to only 4.31 trillion, while VMT growth at the Cost to Maintain level of investment would reach 4.35 trillion. Note that projected travel growth for each of these funding levels is well below the historic growth rate over the last 20 years.

Impact of Investment on the Bridge Preservation Backlog

Chapter 7 projects that funding bridge investments at approximately $12.5 billion annually over a 20-year period would eliminate the existing backlog and correct other deficiencies that are expected to develop by 2022, where it is cost-beneficial to do so. This is the "Maximum Economic Investment" scenario. Chapter 7 also projects that funding bridge investments at approximately $8.9 billion annually would ensure that the cost of addressing all bridge deficiencies in 2022 would remain the same as in 2002. This is the "Maintain Economic Backlog" scenario.

Exhibit 9-8 shows projected changes in the bridge backlog for different funding levels. The existing backlog is estimated at approximately $62.6 billion. If investment over the 20-year period were limited to $5.9 billion per year, the backlog would rise to $120.1 billion. If bridge investment were maintained at the 2002 funding level in constant dollars ($11.3 billion), the bridge backlog would be projected to decrease by 69.9 percent, to approximately $18.9 billion. However, it should be noted that 2002 appears to have been an unusually high year for bridge preservation spending; preliminary information available for 2003 suggests that bridge preservation spending is likely to decline relative to 2002.

Exhibit 9-7 *Annual Projected Highway VMT at Different Funding Levels (VMT in Billions; Funding in Billions of 2002 Dollars)*

Funding Level Description	Maximum Economic Investment	Cost to Maintain Highways and Bridges	Actual 2002 Capital Outlay
Funding Level	**$118.9**	**$73.8**	**$68.2**
2002 (actual)	**2,874**	**2,874**	**2,874**
2003	2,953	2,947	2,946
2004	3,031	3,021	3,018
2005	3,110	3,095	3,090
2006	3,189	3,168	3,162
2007	3,267	3,242	3,234
2008	3,346	3,316	3,306
2009	3,425	3,389	3,378
2010	3,503	3,463	3,450
2011	3,582	3,537	3,522
2012	3,661	3,610	3,594
2013	3,739	3,684	3,665
2014	3,818	3,757	3,737
2015	3,897	3,831	3,809
2016	3,975	3,905	3,881
2017	4,054	3,978	3,953
2018	4,133	4,052	4,025
2019	4,211	4,126	4,097
2020	4,290	4,199	4,169
2021	4,369	4,273	4,241
2022	**4,447**	**4,346**	**4,313**

Source: Highway Economic Requirements System.

Exhibit 9-8 *Projected Changes in 2022 Bridge Preservation Backlog Compared with 2002 Levels for Different Possible Funding Levels*

Average Annual Investment (Billions of 2002 Dollars)	Backlog	Percent Change from 2002	Funding Level Description
12.5	0.0	-100.0%	Maximum Economic Investment scenario
11.3	18.9	-69.9%	2002 Bridge Preservation Spending
10.5	32.0	-48.9%	
9.4	52.5	-16.1%	
8.9	62.6	0.0%	Maintain Economic Backlog
8.2	74.4	18.9%	
7.0	96.3	53.9%	
5.9	120.1	92.0%	

Source: National Bridge Investment Analysis System.

Transit Investment Impacts

Impacts of Transit Investment

Transit investment leads to improved transit access, an increase in ridership, improved air quality, and improved accessibility to jobs and other local resources.

For example, total transit investment from Federal, State, and local sources of $21.6 billion in 20 existing and proposed new starts projects under Full Funding Grant Agreements, with a proposed Federal share of $8.5 billion (39 percent), is expected to:

Q. **How are the effects of New Starts projects on ridership, automobile use, travel time savings, and transit accessibility measured?**

A. The methodology used to calculate these impacts is described in *Reporting Instructions for the Section 5309 New Starts Criteria,* FTA, April 2004. http://www.fta.dot.gov/documents/pt_I_FY07_NS_Reporting.pdf.

- Carry over 641,000 riders each day.
- Carry 194 million riders annually, of which approximately 74.2 million riders will have formerly used an automobile for their trip.
- Improve air quality by reducing 40 billion tons of CO_2 emissions annually;
- Save over 95 million hours of travel-time annually; and
- Provide fixed guideway access to an additional 721,300 households, of which 87,000 are low income. (Households with accessibility are assumed to be ½ mile or less from a transit station.)

If operating today, these projects would provide households with access to 9.3 million jobs located within ½ mile of the proposed transit stations.

Impact of Investment on Conditions

Historical Investment and Rehabilitation and Replacement Needs

As shown in *Exhibit 9-9,* current capital spending in urban areas reached its highest level relative to estimated rehabilitation and replacement needs in 2002 ($12.3 billion in spending compared with $10.3 billion estimated for rehabilitation and replacement), 19 percent higher than required. Since 1993, capital investment in transit assets has been equal to or slightly higher than the pure replacement and rehabilitation levels necessary to maintain conditions. Rehabilitation and replacement expenditures are always lower than total capital investment because a portion of the amount allocated to capital investment in each year is invested in new system capacity. Based on FTA's budgetary history, about half of FTA's capital assistance has been allocated to rehabilitation and replacement expenditures and about half has gone to asset expansion, which also contributes to higher average condition levels through the purchase of new assets.

Exhibit 9-9 *Current Transit Capital Spending Levels Versus Rehabilitation and Replacement Needs, 1993–2002*

(Billions of Current Dollars)		
Analysis Year	**Capital Spending**	**Estimated Replacement and Rehabilitation Needs**
1993	$5.7	$5.1
1995	$7.0	$7.0
1997	$7.6	$7.0
2000	$9.1	$9.2
2002	$12.3	$10.3

Maintain Conditions—Funding levels between 2000 and 2002 have been adequate to maintain conditions. Total capital investment increased from $9.1 billion in 2000, to $10.8 billion in 2001, and $12.3 billion in 2002. Bus vehicle conditions improved, increasing from an average of 3.05 in 2000 to an average of 3.21 in 2002 (based on comparable vehicle categories as explained in the section on Bus Conditions on page 3-17). Over the same time period, the average age of a bus vehicle declined from 6.8 to 6.2 years. Average rail vehicle conditions improved from 3.38 in 2000 to 3.47 in 2002 and the average vehicle age declined from 21.8 to 20.4 years. The amount required to maintain transit asset conditions will continue to increase as the size of the transit infrastructure base increases.

Maintain Performance—Funding levels between 2000 and 2002 have been sufficient to maintain and slightly improve performance. (Performance improved because ridership did not grow as rapidly over this period as in earlier years.) There was a slight increase in the average speed of passengers traveling on transit between 2000 and 2002 from 19.9 to 20.1 miles per hour. The average speed of passenger travel on rail modes increased from 24.9 miles per hour in 2000 to 25.8 miles per hour in 2002; the average speed as experienced by passengers on bus modes was unchanged at 13.7 miles per hour. TERM estimates that for urban areas $5.3 billion annually will be needed to maintain current performance if PMT increases annually at the projected rate of 1.5 percent, or about 158 million new passengers per year.

Future Impacts of Constrained Rehabilitation and Replacement Expenditures

Exhibit 9-10 shows the effect on transit asset conditions of constraining rehabilitation and replacement expenditures below the level estimated by TERM (Transit Economic Requirements Model) to be required to maintain conditions. This TERM analysis pertains to agencies covered by the National Transit Database (NTD) and therefore excludes rural and special service needs and the effect of spending constraints on asset conditions for these public transportation providers. Note that TERM estimates the amount of investment required to make the average asset condition in 2022 the same as the average asset condition that existed on in 2002 for all assets combined. However, the condition of each asset category is slightly different in 2022 than in 2002. [TERM assumes investment will be made so that assets with relatively lower conditions in 2002 (e.g., stations) will have more improvement in conditions between 2002 and 2022, and that assets with relatively higher conditions in 2002 (e.g., guideway elements) will have a slight deterioration in conditions between 2002 and 2022.]

If the amount estimated to be needed to maintain conditions (rehabilitation and replacement expenses) in urban areas is reduced by 10 percent from $9.69 billion annually to $8.72 annually, TERM estimates that the average condition of transit assets would fall from 3.7 in 2002 to 3.6 in 2022. If the amount estimated to be need for rehabilitation and replacement expenses in urban areas is reduced by 30 percent to $6.78 billion, TERM estimates that average asset conditions would fall to 3.4 in 2022.

Exhibit 9-10 *Effect of Capital Spending Constraints on Transit Condition Estimates*

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

* *Excludes rural vehicles and facilities.*

Impact of Investment Levels on Future Transit Use (PMT Growth)

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

Q. How responsive is transit ridership to changes in user costs?

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

TERM estimates that $6.52 billion annually will be needed to improve performance in urban areas. Of this amount, $1.65 billion annually will be required for asset expansion in new rail or BRT service to increase speed and $4.87 billion annually for asset expansion in new vehicles to reduce occupancy levels. The average ridership estimated to result from speed improvements achieved by expanding or building new rail or BRT system capacity is 22.2 million passengers annually; the average annual ridership estimated to result from decreasing occupancy levels by adding new vehicles is 36.7 million passengers annually. (Note that total "Improve Performance" requirements are $6.6 billion annually. The additional investment required represents the cost of increasing the rural transit fleet by 3.5 percent per year.)