Chapter 4

Operational Performance

Summary

Exhibit 4-1 highlights the key highway and transit statistics discussed in this chapter and compares them with the values from the last Conditions and Performance Report in 1999. The first data column contains the values reported in the 1999 report, which were based on 1997 data. Revisions are shown in the second column. The third column reports 2000 values.

Exhibit 4-1

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

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

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

The Percent of Additional Travel Time is an indicator of the additional time required to make a trip during the congested peak travel period rather than at other times of the day. In 2000, a trip that would take 20 minutes during non-peak, non-congested conditions would typically require 30.2 minutes if taken during the peak period of travel or 51 percent longer. In 1997, that same trip would have required 29.0 minutes if taken during the peak travel period, 45 percent longer than under non-peak, non-congested conditions.

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

Percent of Travel Under Congested Conditions is defined as the percentage of traffic on the freeways and principal arterial streets in urbanized areas moving at less than free-flow speeds. This measure has increased from 31.7 percent in 1997 to 33.1 percent in 2000. Based on this measure, the average congested period or length of "Rush Hour" has increased more than 18 minutes from 1997 to 2000. For the purposes of this chapter, "Rush Hour" is defined as the combined periods of time for the A.M. and P.M. travel times when traffic is moving at less than free-flow speeds. The average "Rush Hour" in 2000 was approximately 5.3 hours; however, larger communities have the potential of experiencing average lengths of congested periods of 7 to 8 hours.

Travel density continues to increase on all functional classes as daily vehicle-miles traveled (DVMT) is growing faster than new lane miles are added. DVMT per lane-mile on Interstates in urbanized areas grew from 14,361 to 15,310 between 1997 and 2000. DVMT per lane-mile on Urbanized Other Freeways and Expressways grew from 11,217 to 12,210 over this period.

The highway information presented in this chapter are based on data from the Highway Performance Monitoring System (HPMS), work supplied by the Texas Transportation Institute (TTI), and statistics from the Federal Highway Administration Fiscal Year 2003 Performance Plan.

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

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

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

Highway Operational Performance

From the perspective of highway users, the ideal transportation system would move people and goods where they need to go when they need to get there, without damage to life and property, and with minimal costs to the user. Highway operational performance can be defined as how well the highway and street systems accommodate travel demand. Trends in congestion, speed, delay, and reliability are all potential metrics for measuring changes in operational performance over time.

While congestion is conceptually easy to understand, it has no widely accepted definition. The public's perception seems to be that congestion is getting worse, and by some measures it is. However, the perception of what constitutes congestion varies from place to place. What may be considered congestion in a city of 300,000 may be greatly different than perceived traffic conditions in a city of 3 million people, based on varying history and expectations. These differences of opinion make it difficult to arrive at a consensus of what congestion means, the affect it has on the public, its costs, how to measure it, and how best to correct or reduce it. Because of this uncertainty, transportation professionals examine congestion from several perspectives.

Three key aspects of congestion are severity, extent, and duration. The **severity** of congestion refers to the magnitude of the problem at its worst. The **extent** of congestion is defined by the geographic area or number of people affected. The **duration** of congestion is the length of time that the traffic is congested, often referred to as the "peak period" of traffic flow.

Daily vehicle miles of travel (DVMT) per lane mile is the most basic measure of how much travel is being accommodated on our highway systems, since it is directly based on actual counts of traffic rather than estimated from other data. An increase in this measure over time indicates that the density of traffic is increasing, but does not indicate how this affects speeds, delay, or user costs. The traditional congestion measure in this report has been volume service flow (V/SF) ratio, the ratio of the volume (V) of traffic using a road in the peak travel hour to the theoretical capacity or service flow (SF). V/SF is limited because it only addresses the peak hour and does not measure the duration of congestion. In many communities, the major operational performance issue is not that peak congestion is getting worse; it is that the peak period is spreading to occupy an increasing part of the travel day. Focusing on the V/SF measure alone can lead to erroneous conclusions about highway operational performance.

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

The Concern with Operational Performance

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

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

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

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

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

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

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

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

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

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

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

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

New Operational Performance Measures

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

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

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

Percent of Additional Travel Time

The Percent of Additional Travel Time is an indicator of the additional time required to make a trip during the congested peak travel period rather than at other times of the day. This measure accounts for the additional time required due to increased traffic volumes on the highway and the additional delay caused by crashes, poor weather, special events, or other non-recurring incidents. It is expressed as the percent of additional time required to make a trip during the congested period of travel.

Exhibit 4-2 shows the how the Percent of Additional Travel Time has grown over time. In 2000 an average peak period trip required 51 percent longer than the same trip under non-peak, non-congested, conditions. In 1987, an average 20-minute trip during non-congested periods required 25.8 minutes under congested conditions. The same trip in 2000 required 30.2 minutes or an additional 4.4 minutes. Note that while the values for different years are generally comparable, they are based on data for different numbers of areas in different years as shown in Exhibit 4-2. The same number of communities was used in the determination of the remaining two performance measures.

Exhibit 4-2

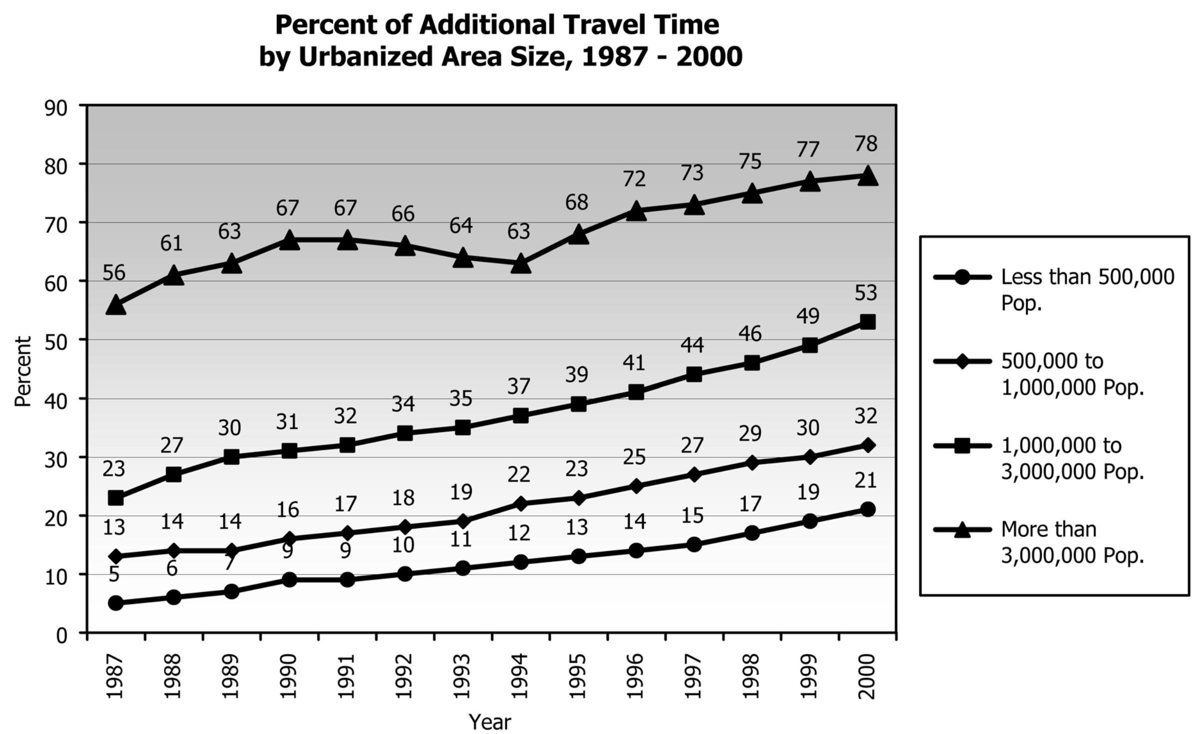
Percent of Additional Travel Time, 1987-2000

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

Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

Exhibit 4-3



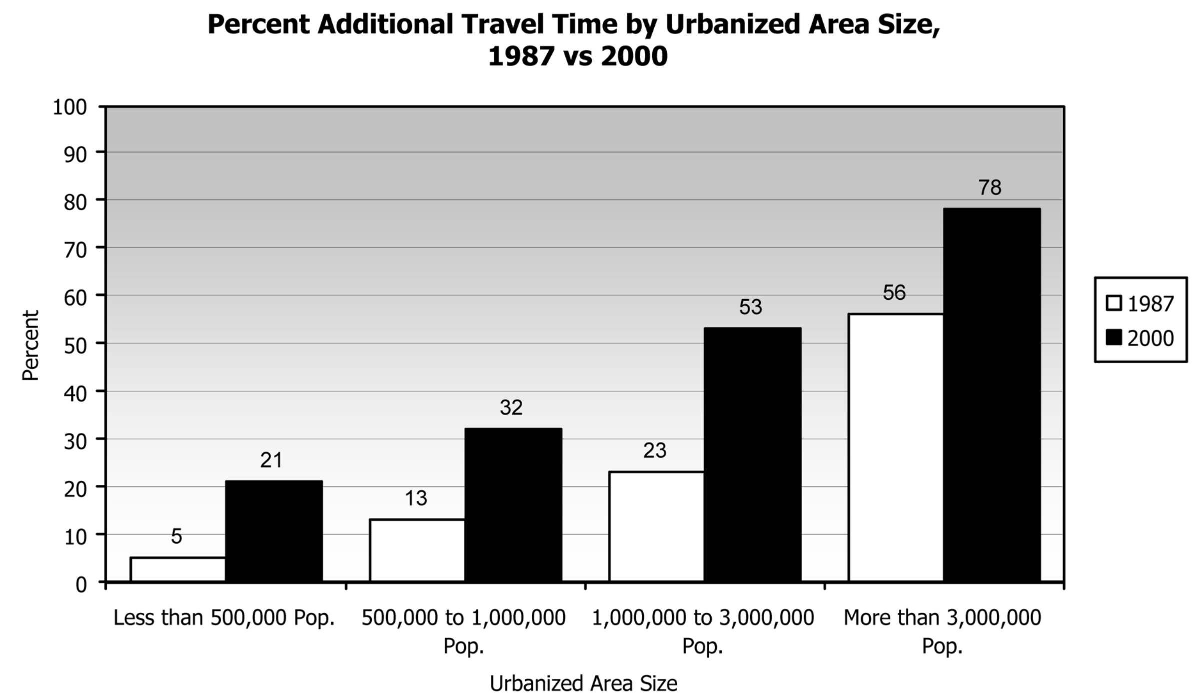
Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

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

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

Exhibit 4-4

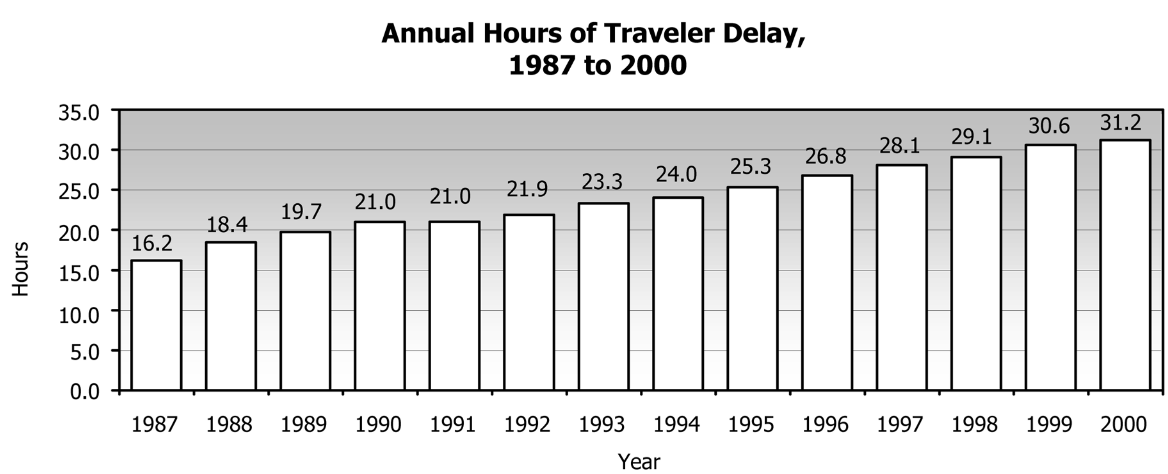


Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Annual Hours of Delay

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

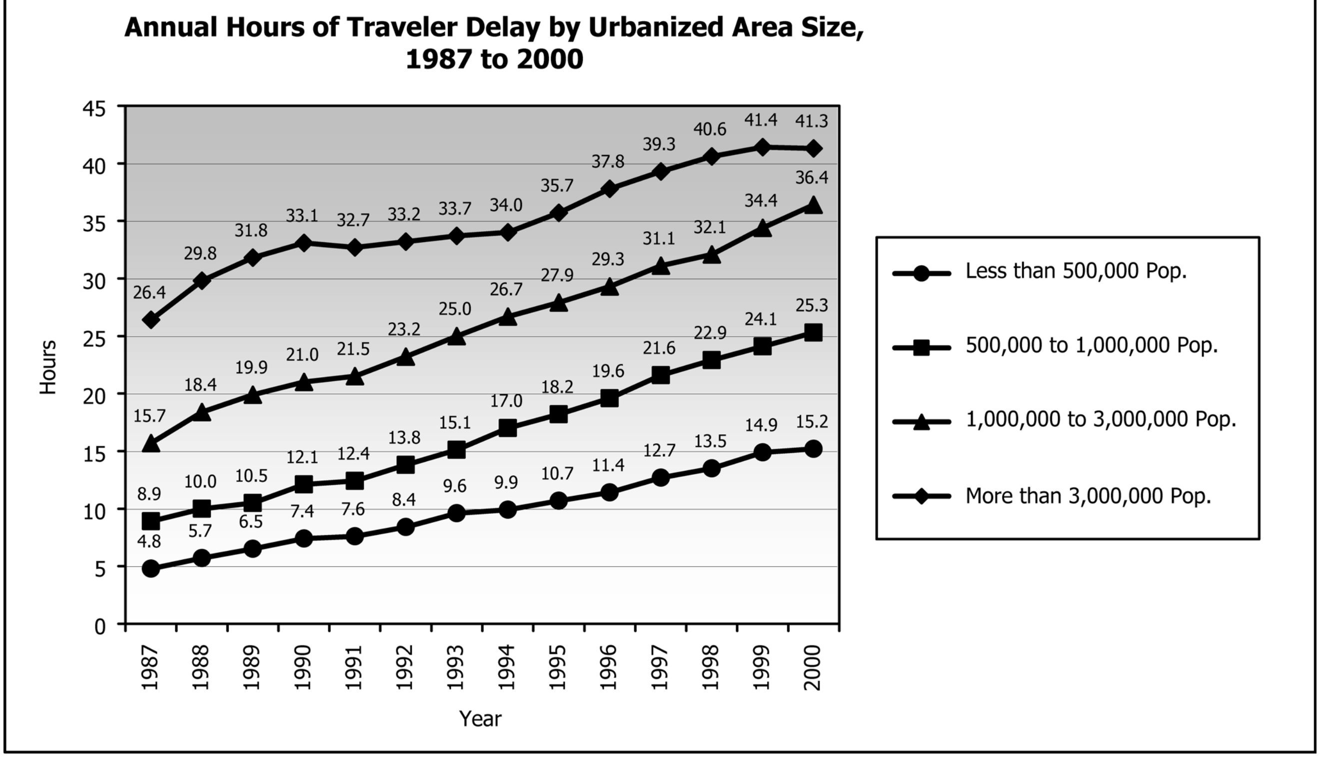
Exhibit 4-5



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

Exhibit 4-6



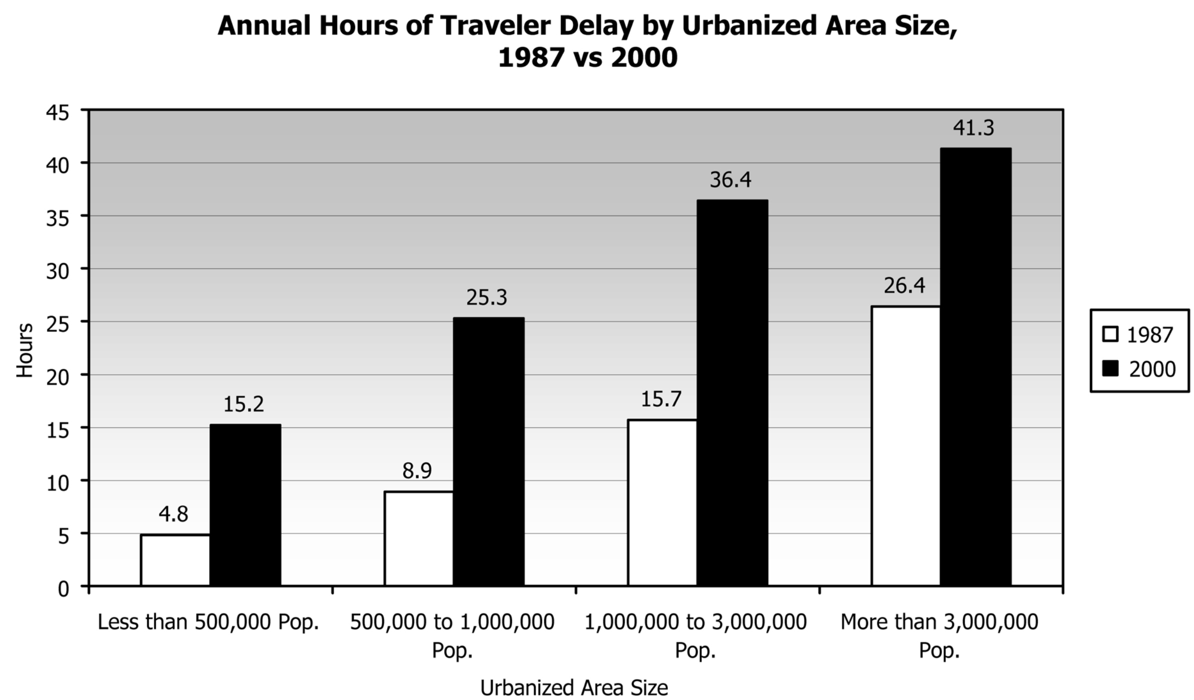
Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

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

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

Exhibit 4-7

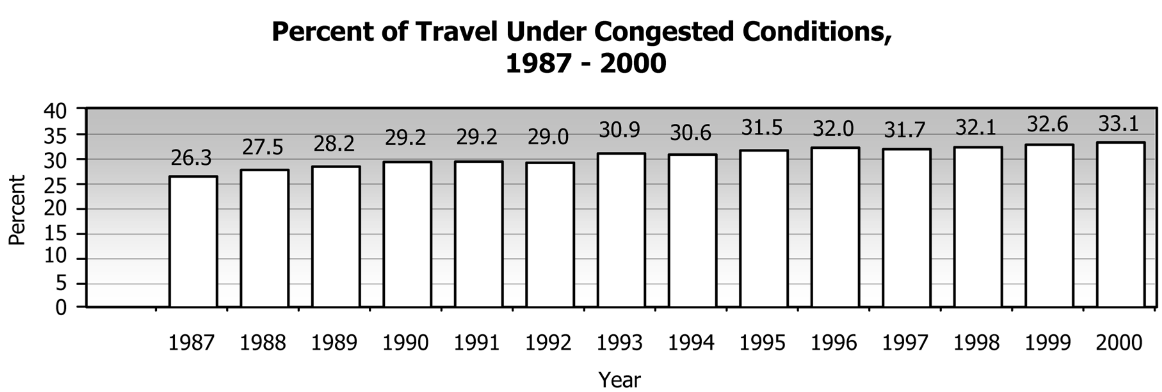


Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Percent of Travel Under Congested Conditions

The Percent of Travel Under Congested Conditions is defined as the percentage of daily traffic on freeways and principal arterial streets in urbanized areas moving at less than free-flow speeds. Exhibit 4-8 shows that this percentage has increased from 31.7 percent in 1997 to 33.1 percent in 2000. The average congested travel period has increased from approximately 5 hours in 1997 to approximately 5.3 hours in 2000—an increase in length of 18 minutes.

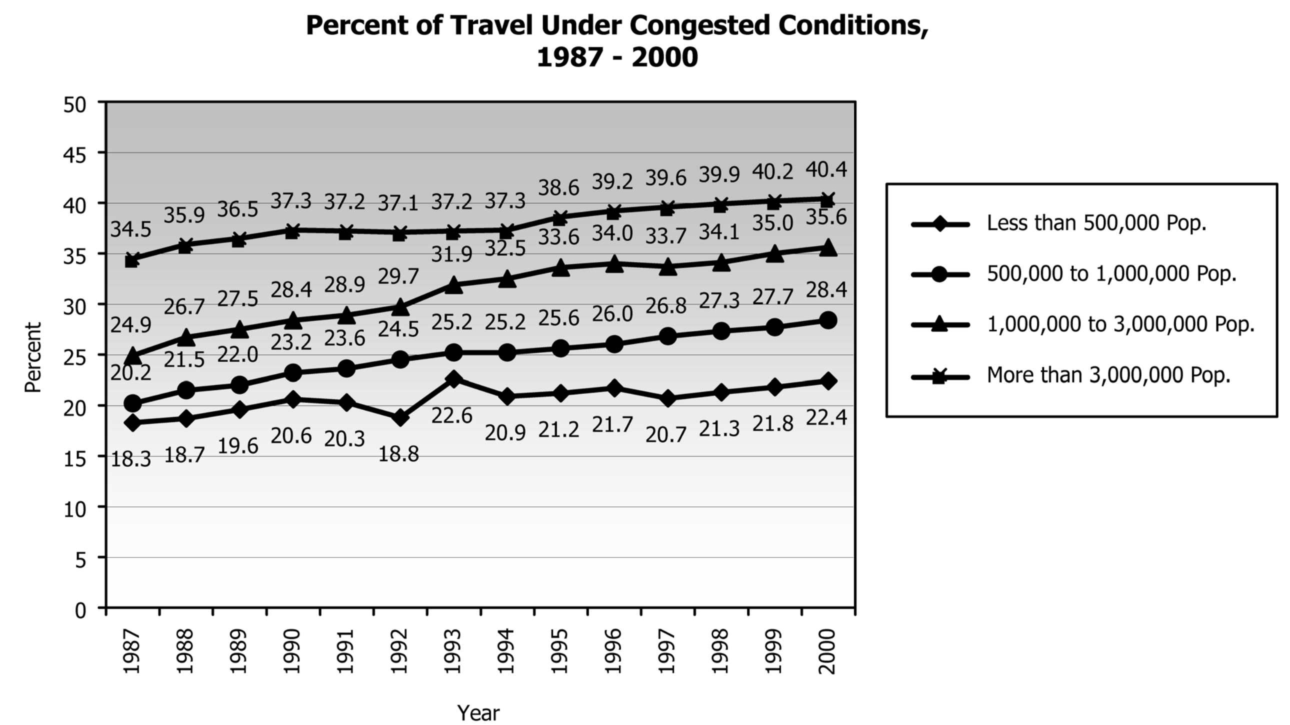
Exhibit 4-8



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

Exhibit 4-9



Source: Texas Transportation Institute, 2001 Urban Mobility Study.

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

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

Not only are congestion periods lengthening but more roads and lanes are affected at any one time. In the past, recurring congestion tended to occur only in one direction—toward downtown in the morning and away from it in the evening. Today, two-directional congestion is common, particularly in the most congested metropolitan areas.

Cost of Congestion

Congestion has an adverse impact on the American economy, which values speed, reliability, and efficiency. Transportation is a critical link in the production process for many businesses as they are forced to spend money on wasted fuel and drivers' salaries that might otherwise be invested in research and development, firm expansion, and other activities. The problem is of particular concern to firms involved in logistics and distribution. As just-in-time delivery increases, firms need an integrated transportation network that allows for the reliable, predictable shipment of goods. Congestion, then, is a major hurdle for businesses in the developing economy.

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

Exhibit 4-10

Annual Cost of Congestion - Top 20 Urban Areas

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

Source: Texas Transportation Institute, 2001 Urban Mobility Study.

Safety Effects of Congestion

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

Other Operational Performance Measures:

Length of Time of Trip and Average Trip Speed

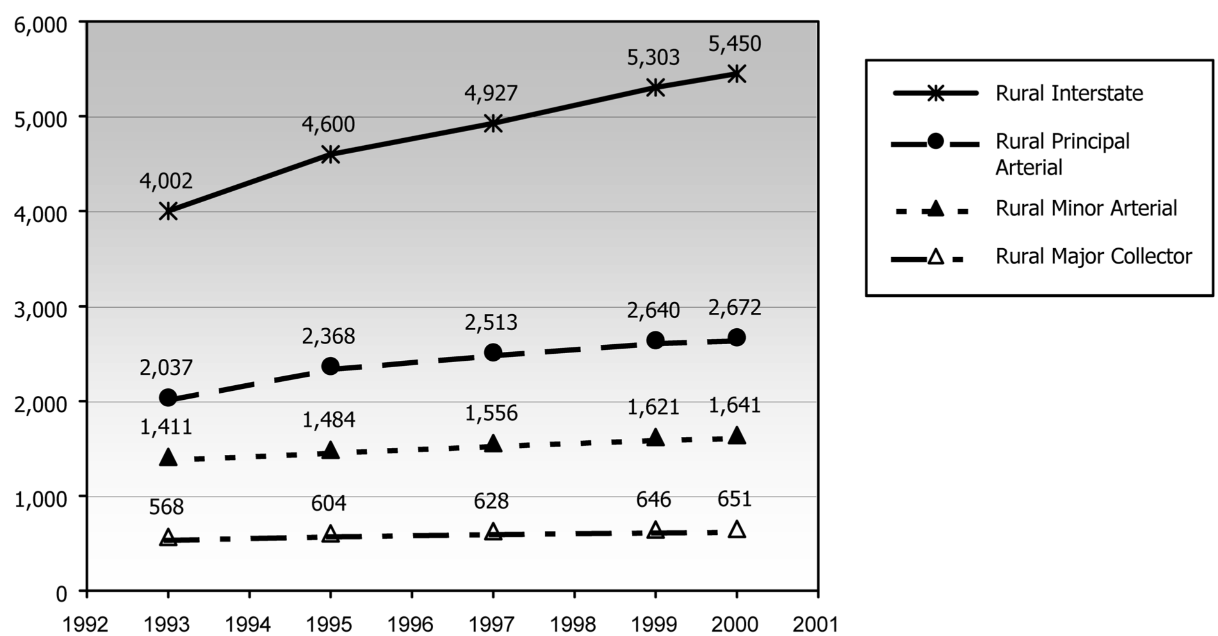
Whereas the new FHWA operational performance measures suggest that congestion is getting worse on average, the individual traveler's experience of congestion may be very different. The Nationwide Personal Transportation Survey (NPTS) reports from a sample of U.S. households that the average commute took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

DVMT per Lane-Mile

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

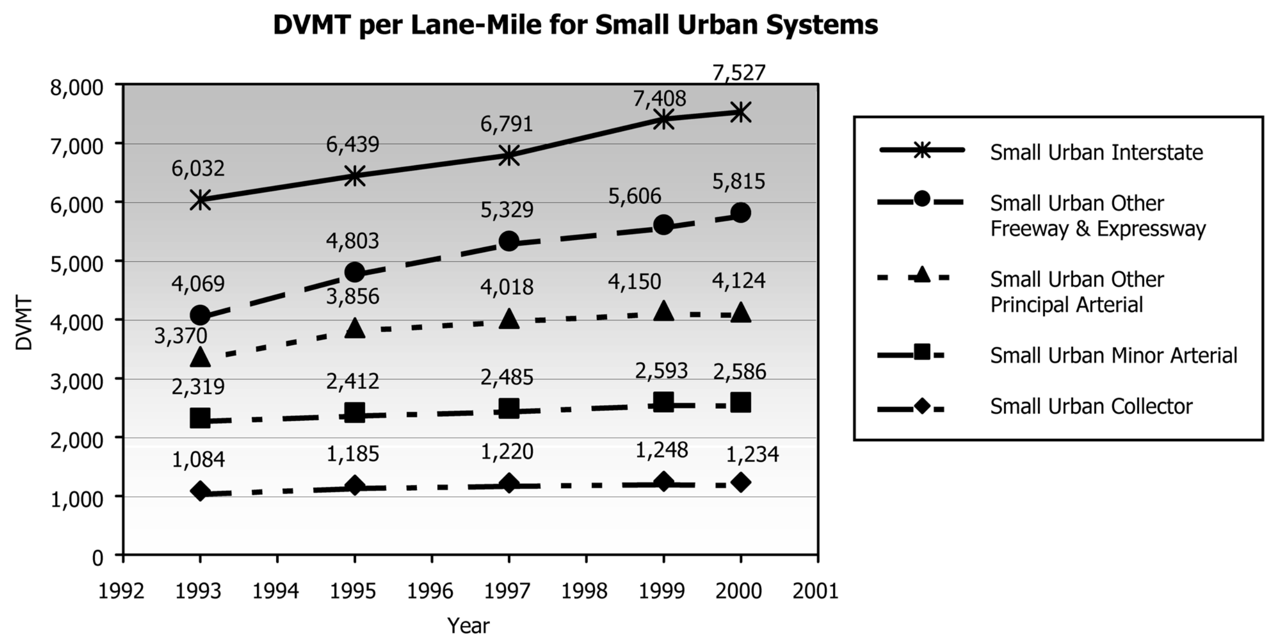
Exhibit 4-11

DVMT per Lane-Mile for Rural Systems



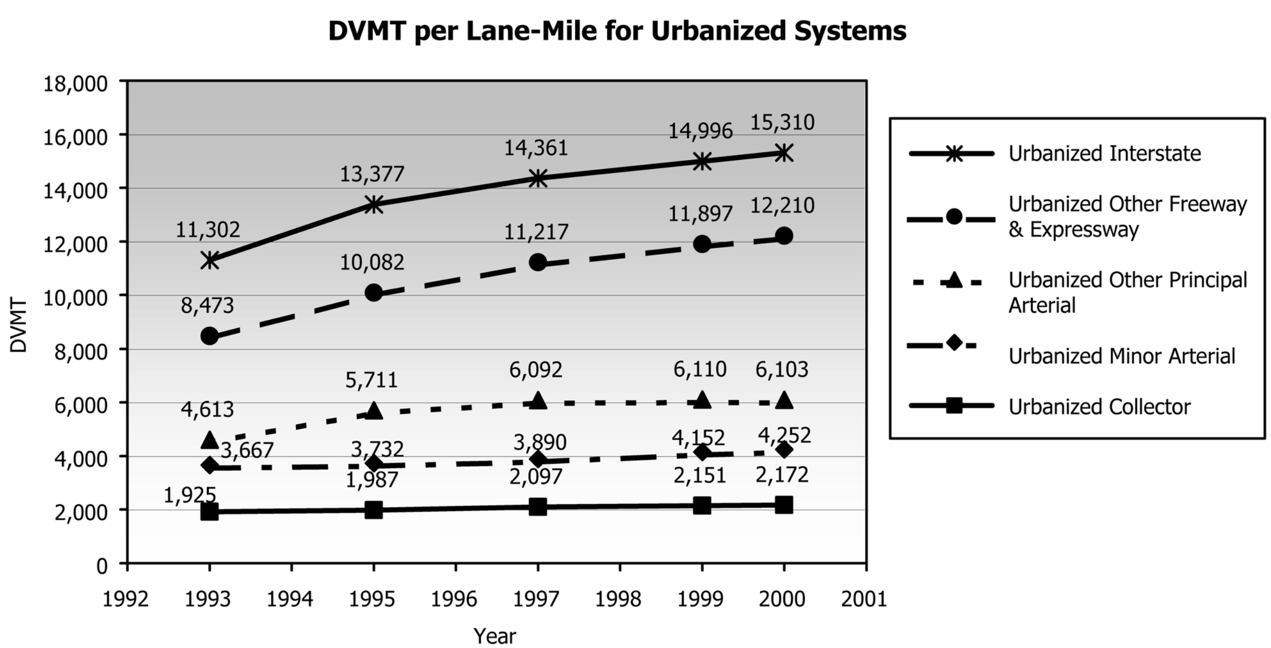
Source: Highway Performance Monitoring System.

Exhibit 4-12



Source: Highway Performance Monitoring System.

Exhibit 4-13



Source: Highway Performance Monitoring System.

V/SF Ratio

As discussed earlier in this chapter, the V/SF ratio compares the number of vehicles (V) traveling in a single lane in one hour with the theoretical saturation flow (SF), or the theoretical maximum number of vehicles that could utilize the lane in an hour. The major shortcoming of the V/SF ratio is that it is a single-time indicator of congestion; in other words, it provides a snapshot of what is occurring on a highway section at a particular time, but does not provide a measure of the length of time of a congested period. Also, it does not provide an indication of the effect on congestion caused by emergency situations, adverse weather conditions, construction activities, or other congestion-creating events other than those caused by additional traffic on a facility.

Exhibit 4-14 shows the percentage of peak-hour travel meeting or exceeding a V/SF of 0.80 and 0.95. A level of 0.80 is frequently used as a threshold for classifying highways as "congested" while a level of 0.95 is frequently described as "severely congested." For urbanized Interstates, 33.4 percent had peak-hour travel with a V/SF ratio of 0.80 or higher. Not surprisingly, the values for small urban and rural Interstates were lower.

This measure of congestion severity shows mixed results, as the values for some functional classes have increased since 1997 while others have declined. This indicates that the increases in congestion indicated by broader measures such as the Annual Hours of Traveler Delay, cited earlier, may be a function of increases in the duration and extent of congestion, which are aspects of the problem that the V/SF ratio does not capture.

Exhibit 4-14

Percent of Peak-Hour Travel Exceeding V/SF Thresholds

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

Source: Highway Performance Monitoring System.

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

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

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

Future Research

Measurement of congestion is still a difficult problem. Substantial research has supported the use of delay as the definitive measure of congestion, and delay is certainly important. It exacts a substantial cost from the traveler and consequently from the consumer. However, it does not tell the complete story. Moreover, we currently have no direct measure of delay that is inexpensive and reliable to collect. Reliability is another important characteristic of any transportation system, one that industry in particular requires for efficient production. If a given trip requires one hour on day one and one and a half hours on day two, an industry that is increasingly relying on "just in time" delivery suffers. It cannot plan effectively for variable trip times. Additional research is needed to determine what measures should be used to describe congestion and what data will be required to supply these measures.

System Reliability

The FHWA Fiscal Year 2003 Performance Plan adopted a new measure of reliability—the Buffer Index. This index measures the percentage of extra time travelers allow for congestion in order to arrive at a location on-time 95 percent of the time. Data are currently available for 10 cities, but efforts are underway to expand the sample. This measure and other measures currently under development will be refined and applied to additional cities as detectors are deployed and data are accumulated.

Bottlenecks

A November 1999 report prepared by Cambridge Systematics for the American Highway Users Alliance entitled *Unclogging America's Arteries: Prescriptions for Healthier Highways* listed 167 locations in urban areas that it classified as bottlenecks. These were areas where traffic congestion occurs due to sudden reduction in number of lanes or a major increase in traffic volume for a specific freeway section beyond its capacity. The report estimated the benefits resulting from eliminating the 18 worst bottleneck locations. Improvements to these locations were estimated to prevent 287,000 crashes including 1,150 fatalities and 141,000 injuries. Major reductions in pollutants were also cited as a benefit. User delay was estimated to be reduced by 71 percent, which translates to approximately 40 minutes each day per commuter.

Further research into bottlenecks and the benefits of addressing them could be of significant value in determining the best ways to address growing congestion in the Nation's urbanized areas.

Deployment of ITS Systems

The deployment of intelligent transportation systems (ITS) technologies provides opportunities for improved measurement of performance. For example, speeds and travel time could be measured directly and unobtrusively by sensors in or beside roadways, rather than through rough approximations based on vehicle counts or surveys. To obtain valid performance measures from ITS technology, methods are needed to compile sensor data into databases, and to aggregate and analyze the data into useful statistics.

Transit Operational Performance

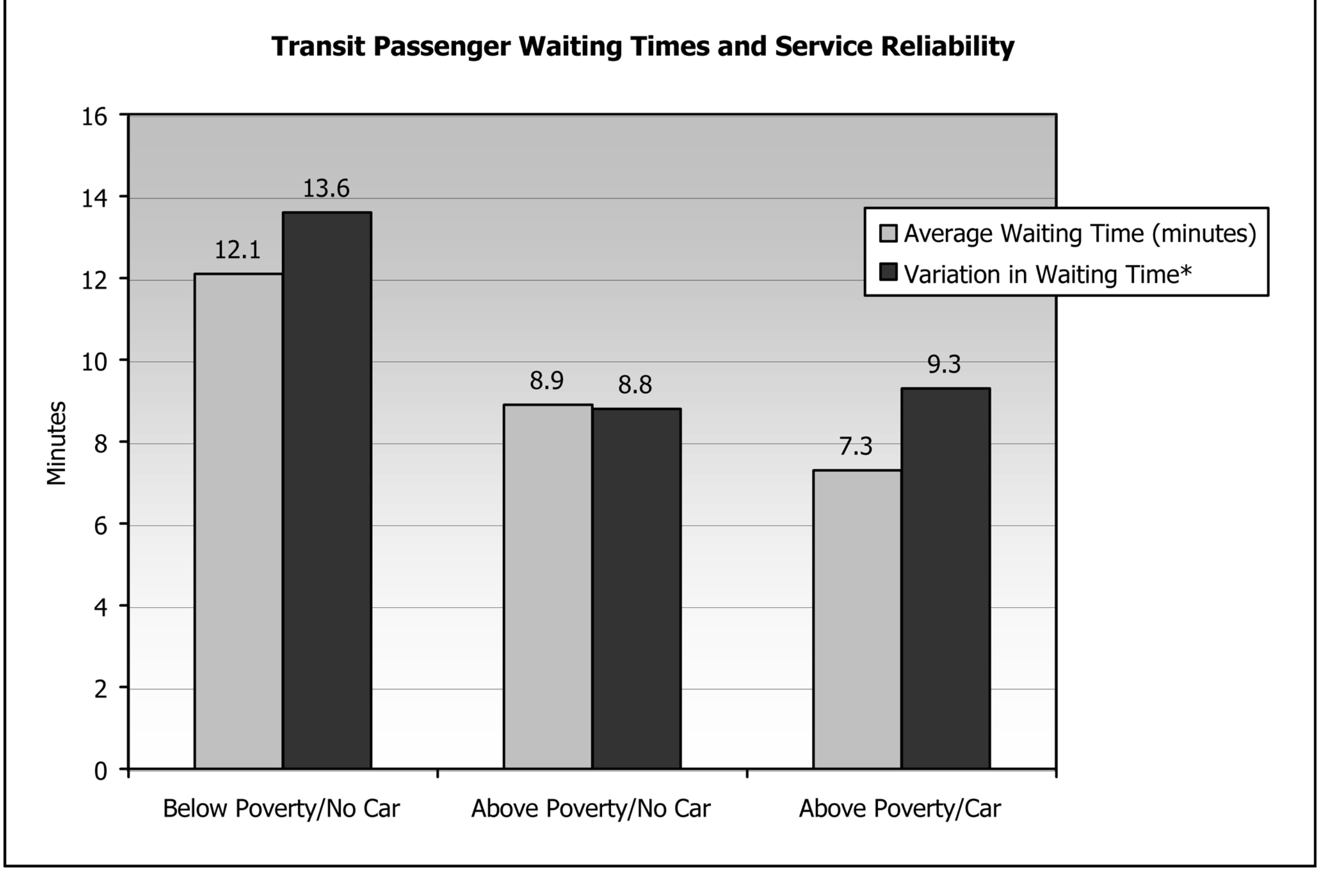
The operational performance of transit affects its attractiveness as a means of transportation. People will be more inclined to use transit that is frequent and reliable, travels more rapidly, has adequate seating capacity, and is not too crowded. When vehicles become too crowded, the quality of a transit trip decreases and may provide an incentive to riders to shift to a different transportation mode.

Frequency and Reliability of Services

The frequency of transit services varies considerably according to location and time of day. Transit service is more frequent in urban areas and during rush hours, in locations and during times when the demand for transit is highest. Studies have found that transit passengers consider the time spent waiting for a transit vehicle to be less well spent than the time spent traveling in a transit vehicle. The higher the degree of uncertainty in waiting times, the less attractive transit becomes as a means of transportation, and the fewer users it will attract.

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

Exhibit 4-15



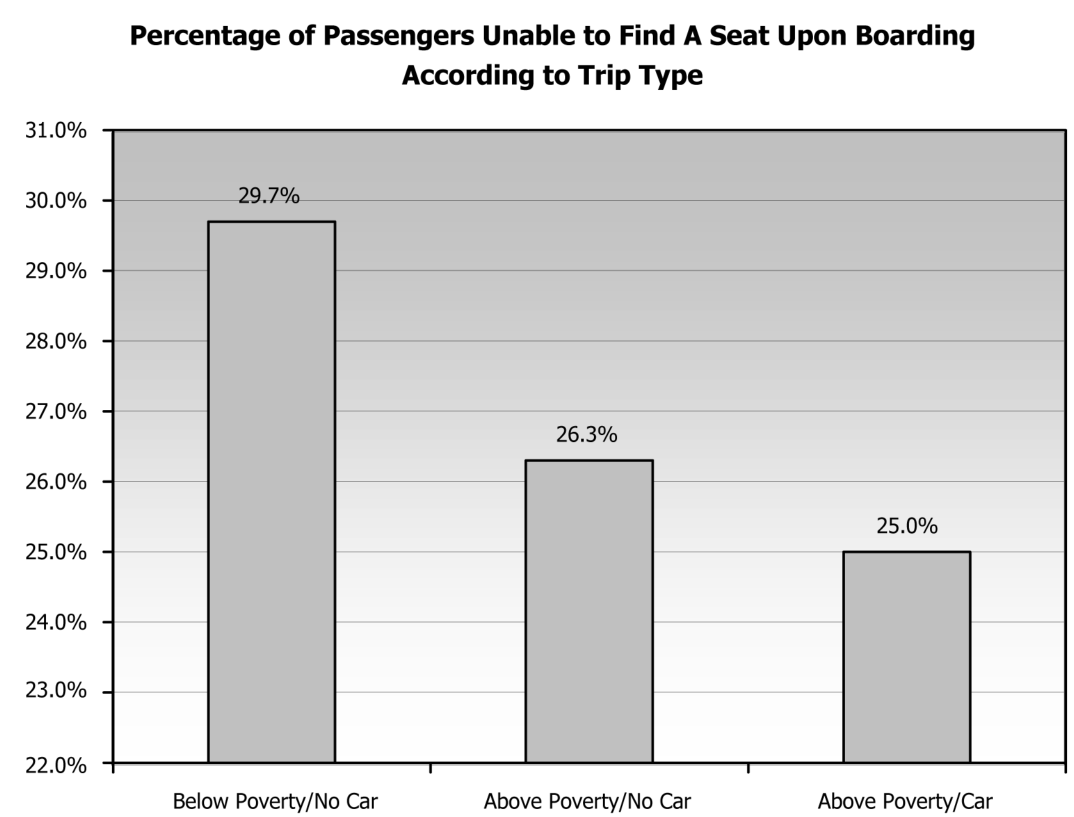
Source: 1995, Nationwide Personal Transportation Survey, FHWA.

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

Seating Conditions

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

Exhibit 4-16



Source: 1995, Nationwide Personal Transportation Survey, FHWA.

Average Operating Speeds

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

Exhibit 4-17

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

	RAIL	NON-RAIL	TOTAL
1987	23.7	13.2	19.3
1988	24.4	13.8	19.1
1989	24.3	13.5	19.1
1990	24.8	13.4	19.2
1991	27.6	13.4	20.4
1992	27.0	13.5	20.3
1993	26.3	13.7	19.9
1994	26.7	13.8	20.4
1995	26.6	13.7	20.4
1996	26.0	13.8	20.4
1997	26.1	13.8	20.3
1998	25.6	14.0	20.5
1999	25.5	14.0	20.1
2000	24.9	13.7	19.6
Average	**25.7**	**13.7**	**19.9**

Source: National Transit Database.

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

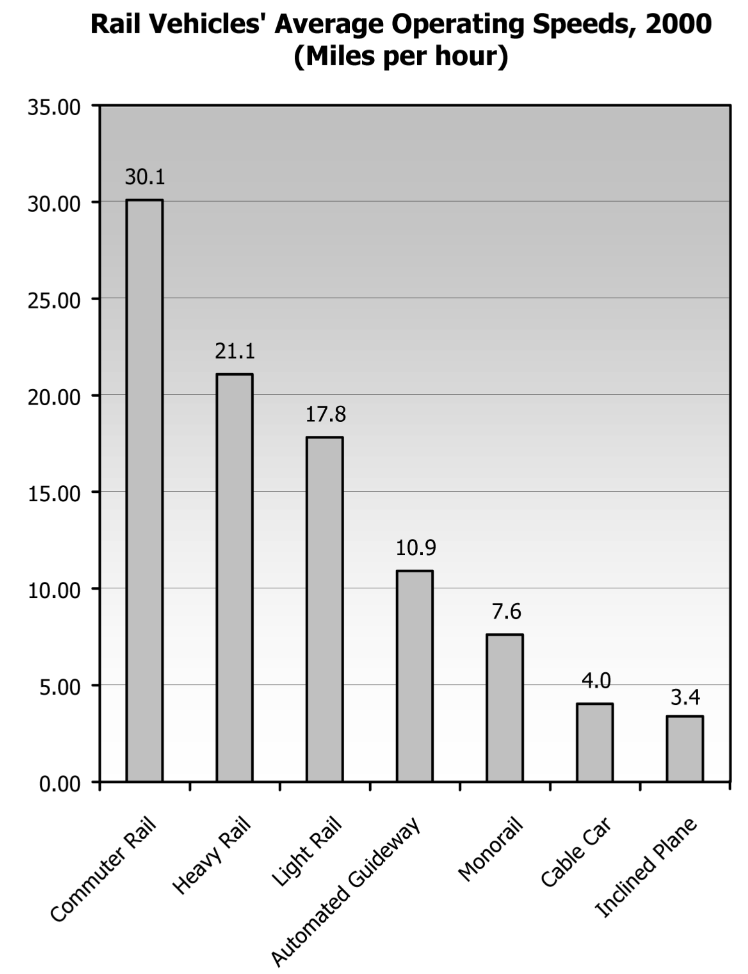
As Exhibit 4-18 shows, the average operating speed of rail vehicles differs considerably from one type to another. Commuter rail provides the fastest service with an average passenger-weighted operating speed of 30.1 miles per hour in 2000. Heavy rail and light rail travel more slowly with average speeds,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

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

Q. What is publico service?

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

Exhibit 4-18

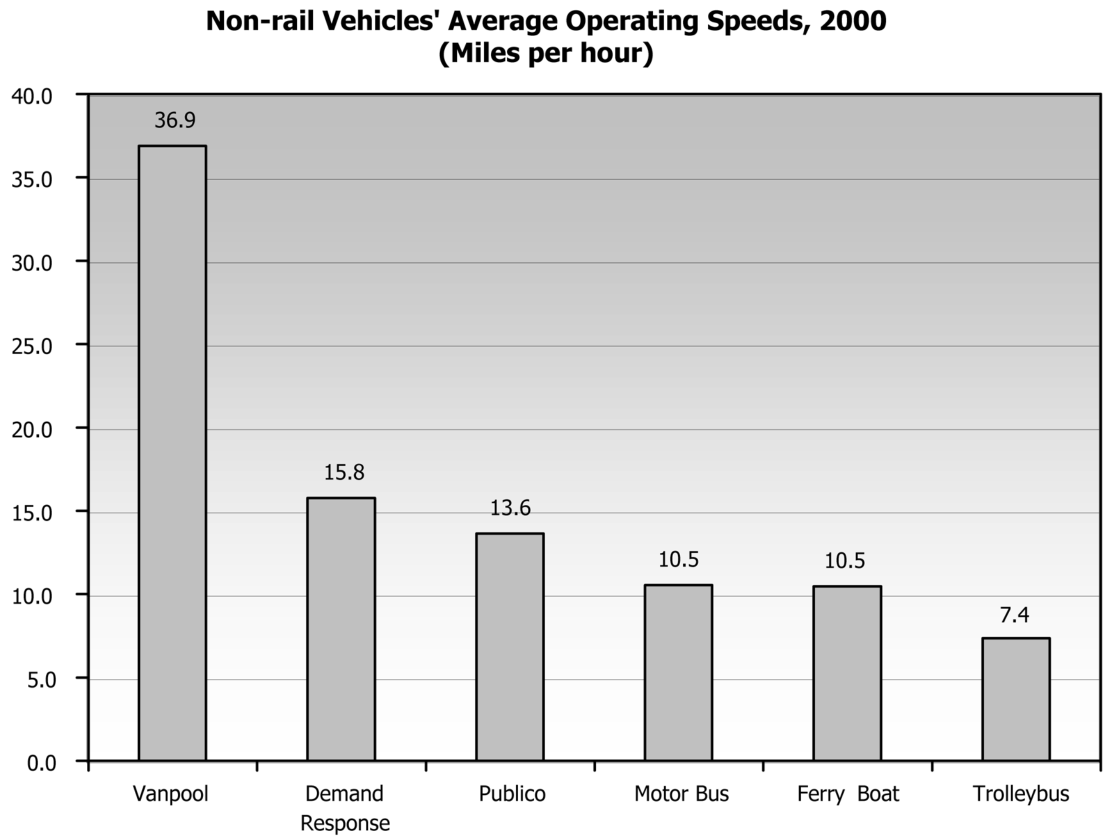


Source: National Transit Database.

Vehicle Utilization

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

Exhibit 4-19



Source: National Transit Database.

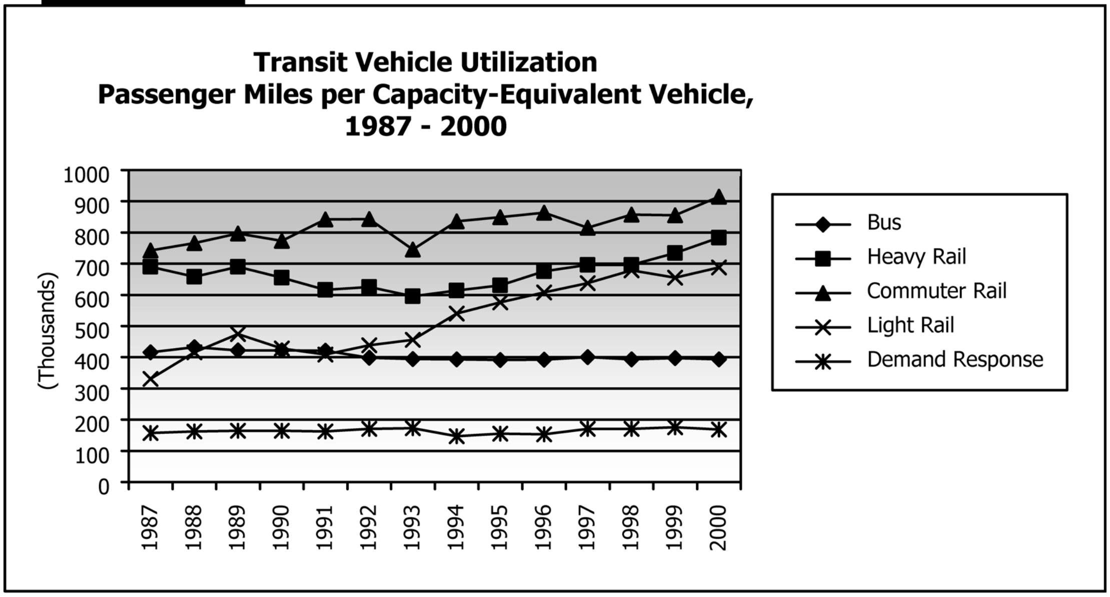
Exhibit 4-20

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

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

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

Exhibit 4-21



Source: National Transit Database.