CHAPTER 4

Operational Performance

Summary

Exhibit 4-1 compares the key highway and transit statistics discussed in this chapter with the values shown in the last report. The first data column contains the values reported in the 2004 C&P report, which were based on 2002 data. Where the 2002 data have been revised, updated values are shown in the second column. The third column contains comparable values, based on 2004 data.

Exhibit 4-1

Comparison of Highway and Transit Operational Performance Statistics with Those in the 2004 C&P Report

Statistic	2002 Data: 2004 C&P Report	2002 Data: Revised	2004 Data
Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions [1]	30.5%	30.7%	31.6%
Average Length of Congested Conditions (Hours) [2]	6.6		6.6
Travel Time Index [3]	37%	1.37	1.38
Annual Delay per Peak Period Traveler (Hours) [4]	NA	45.4	45.7
Annual Delay per Capita (Hours) [5]	23.8		24.4
Passenger-mile Weighted Average Operating Speed (miles per hour)			
Total	19.9		20.1
Rail	25.3		25.0
Nonrail	13.7		14.0
Annual Passenger Miles per Capacity-equivalent Vehicle (thousands) [6]			
Motorbus	390	389	373
Heavy Rail	675	655	652
Commuter Rail	831	769	755
Light Rail	528	533	468
Demand Response	178	168	181

[1] Equivalent to Percent Travel under Congested Conditions in 2004 C&P report.
[2] Equivalent to Average Congested Travel Period in 2004 report.
[3] Equivalent to Percent of Additional Travel Time in 2004 report, but stated in different units. (37% equates to 1.37)
[4] New metric.
[5] Equivalent to Annual Hours of Traveler Delay in 2004 report.
[6] Revised due to a new methodology for calculating capacity factors. See Chapter 2 for details.

Highways

The Texas Transportation Institute (TTI) collects data related to congestion from approximately 400 communities across the Nation on a yearly basis. This information is used in the development and calculation of performance measures used by the Federal Highway Administration (FHWA). To examine highway operational performance, this chapter looks at five metrics developed at TTI to measure congestion on the Nation's highways. These are the Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions, Average Length of Congested Conditions, Travel Time Index, Annual Delay per Peak Period Traveler, and Annual Delay per Capita. Several of these measures were included in previous reports, but have been renamed to line up with the terminology used in TTI's annual Urban Mobility Study. It is important to recognize that, while these same metrics are used in that study, TTI's study is based on a smaller set of urbanized areas and are computed based on more detailed data not available for all areas. The urbanized areas reflected in that study tend to be larger than average and experience more congestion than the average urbanized area reflected in this report. Therefore, the values shown in TTI's study for these same metrics would tend to show higher levels of congestion.

The "Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions" is defined as the portion of the total VMT in an urbanized area occurring during periods of less than free-flow conditions. This metric has increased from 30.7 percent in 2002 to 31.6 percent in 2004. [Note that this measure was called the Percent of Travel Under Congested Conditions in the 2004 C&P report.]

The "Average Length of Congested Conditions" represents the number of hours during a 24-hour period during which travel at less than free-flow speeds occurs on a portion of the road system of an urbanized area. This metric remained constant at 6.6 hours between 2002 and 2004.

The "Travel Time Index," defined as the percentage of additional time needed to make a trip during a typical peak travel period in comparison to traveling at free-flow speeds, increased from 1.37 to 1.38 since 2002. In 2004, an average peak period trip required 38 percent longer than the same trip under nonpeak, noncongested conditions. For example, a trip that takes 20 minutes on average during non-congested periods would require 27.6 minutes during congested periods in 2004. [Note that this measure was described as the Percent of Additional Travel Time in the 2004 C&P report and stated as a percentage rather than a ratio.]

The "Annual Delay per Peak Period Traveler," defined as the total delay experienced by an average traveler under congested conditions during peak travel times, increased from 45.4 hours in 2002 to 45.7 hours. This is a new metric that measures the annual lost time per traveler during the congested period.

The "Annual Delay per Capita" relates the average hours of travel delay experienced by a resident of an urbanized area because of recurring congestion and incidents, such as vehicle breakdowns and crashes. Approximately 24.4 hours per capita were lost in 2004 because of congestion. This is an increase of 0.6 hour over the amount of annual delay in 2002, or an increase of approximately 2.5 percent.

Transit

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.

Vehicle utilization is one indicator of service effectiveness that measures how well a service output attracts passenger use. It is also a measure of vehicle crowding. Vehicle utilization is calculated as the ratio of the total number of passenger miles traveled annually on each mode to total number of vehicles operated in maximum scheduled service in each mode, adjusted for the passenger-carrying capacity of the mode in relation to the average capacity of the Nation's motorbus fleet. As shown in Exhibit 4-1, vehicle utilization rates have been revised using new capacity-equivalent factors as discussed in Chapter 2. These factors are based on seating and standing capacities as reported to the National Transit Database and are unique to each year. Utilization rates for the three primary rail modes have all decreased from 2002 to 2004. Motorbus and trolleybus utilization rates were lower in 2004 than in 2002; while demand response, vanpool, and ferryboat utilization rates were higher. Utilization in all modes peaked in either 2000 or 2001 and remained below peak levels in 2004.

Average transit operating speeds remained relatively constant between 1995 and 2004 and were slightly higher in 2004 than in 2002. Average operating speed measures the average speed that a passenger will travel on transit rather than the pure operational speed of transit vehicles. These speeds exclude waiting time and the time spent transferring, but are affected by changes in vehicle dwell times to let off and pick up passengers. In 2004, the average speed was 20.1 miles per hour, up from 19.9 miles per hour in 2002, and equal to the 10-year average of 20.1 miles per hour. The average operating speed as experienced by passengers on rail modes was 25.0 miles per hour in 2004, compared with 25.3 miles per hour in 2002, and a 10-year average of 25.6 miles per hour. The average operating speed of nonrail vehicles, which is affected by traffic, road, and safety conditions, was 14.0 miles per hour in 2004, up from 13.7 in 2002, and above the 10-year average of 13.8.

Most transit passengers do not experience unacceptably long waiting times. The 2001 National Household Travel Survey (NHTS) conducted by the FHWA, the most recent nationwide survey of passenger travel, found that 49 percent of all passengers who ride transit wait 5 minutes or less and 75 percent wait 10 minutes or less. Wait times are correlated with incomes. Higher-income passengers are more likely to be choice riders and ride only if transit is frequent and reliable. In contrast, passengers with lower incomes are more likely to use transit for basic mobility, have more limited alternative means of travel, and therefore, use transit even when the service is not as frequent or reliable as they may prefer.

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.

This chapter focuses primarily on measuring operational performance trends from a broad perspective. Chapter 14 addresses operational issues that relate specifically to freight transportation, while Chapter 15 discusses operations strategies more broadly. Safety performance measures are discussed separately in Chapter 5. Issues relating to improving the measurement of operational performance are discussed in more depth in the Part IV "Afterword" section.

Highway congestion results when traffic demand approaches or exceeds the available capacity of the highway system. While this concept is straightforward, quantifying congestion is complicated by the fact that both travel demand and available capacity are variable rather than constant. It is clear that traffic demands vary significantly by time of day, day of week, season of the year, and for special events. While capacity is often thought of as a constant, the available capacity at any given time can vary because of weather, work zones, traffic incidents, or other nonrecurring events. Of the total congestion experienced by Americans, it is estimated that roughly half is "recurring congestion" caused by an imbalance of routine daily demand with typical available capacity. The other half is due to nonrecurring congestion caused by temporary disruptions in traffic demand or in available capacity.

There is no universally accepted definition or measurement of exactly what constitutes a congestion "problem." The public's perception seems to be that congestion is getting worse, and by many measures it is. However, the perception of what constitutes a congestion problem varies from place to place. Traffic conditions that may be considered a congestion problem in a city of 300,000 may be perceived differently 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 effect 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.

The purpose of this chapter is to measure operational performance, rather than to list strategies for combating congestion problems. The Department of Transportation's ***National Strategy to Reduce Congestion on America's Transportation Network***, released in May 2006, provides a blueprint for Federal, State and local officials to follow in addressing critical operational performance issues. Several of the topics identified in the plan are also discussed in this report. Chapter 15 identifies a number of potential operations strategies to combat congestion, while Chapter 10 projects the potential impact that a more aggressive deployment of certain intelligent transportation systems (ITS) and operations strategies could have on future operational performance. Chapter 10 also includes some preliminary quantification of the possible impacts of **congestion pricing**, a potentially highly effective strategy for reducing peak period congestion. Congestion pricing is discussed in more depth in the "Introduction" to Part II of this report and is referenced in several other locations as well. Chapter 13 identifies various ongoing initiatives to reduce or remove barriers to private sector investment in the construction, ownership and operation of transportation infrastructure, and to encourage formation of **public-private partnerships**.

Operational Performance Measures

Daily vehicle miles traveled (DVMT) per lane mile is the most basic measure of the relationship between highway travel and highway capacity, 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 speed, delay, or user cost. The traditional congestion measure in this report has been the ratio of volume to service flow (V/SF), 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 addresses only the severity and not the duration or extent 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.

In order to overcome the shortcomings of DVMT and V/SF as measures of congestion, the FHWA has worked in conjunction with the Texas Transportation Institute (TTI) to determine a group of metrics that provides a better indication of the level of congestion on the Nation's highways. These measures are still a work in progress; but taken together, they provide a broader view of operational performance than our traditional measures can provide.

In computing these metrics for the FHWA, the TTI includes approximately 400 communities across the Nation on a yearly basis. Information was collected for 428 communities in 2004. TTI divides these

Q&A

Which metrics computed for the FHWA by the TTI are presented in this report?

This report presents five main performance measures computed by TTI for the FHWA. In describing these measures, this report will use the names TTI has designated for them in its most recent annual Urban Mobility Study, which are different than those used in the 2004 C&P report. These names are longer, but more precise, and have been adopted to reduce confusion as to exactly what the measures mean.

The "Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions" is defined as the portion of the total VMT in an urbanized area occurring during periods of less than free-flow conditions. (This measure was identified as the "Percent Congested Travel" in the 2004 C&P report.)

The "Travel Time Index" is defined as the percentage of additional time needed to make a trip during a typical peak travel period in comparison to traveling at free-flow speeds. (This measure was identified as the "Percent of Additional Time" in the 2004 C&P report.)

The "Average Length of Congested Conditions" is the number of hours during a 24-hour period where travel at less than free-flow speeds occurs on a portion of the road system of an urbanized area. (This measure was described as the "Average Congested Travel Period" in the 2004 C&P report.)

The "Annual Delay per Peak Period Traveler" is defined as the total delay experienced by an average traveler under congested conditions over the course of a year. (This measure was not included in the 2004 C&P report.)

The "Annual Delay per Capita" relates the average hours of travel delay experienced by a resident of an urbanized area over the course of a year. (This measure was identified as the "Annual Hours of Travel Delay" in the 2004 C&P report.)

communities into four groups, based on population size: the 357 urbanized areas with less than 500,000 population are classified as "Small," the 31 areas with population from 500,000 to 999,999 are classified as "Medium," the 27 areas with population of 1 million to 3 million are classified as "Large," and the 13 with population greater than 3 million are classified as "Very Large." These shorthand terms have been adopted in this section for clarity. However, it should be noted that they are not consistent with the population break of 200,000 frequently used in other FHWA applications to distinguish "Small Urbanized Areas" from "Large Urbanized Areas."

Q&A

How do the values of the metrics shown in this report compare to those reported by the TTI in its annual Urban Mobility Study?

The values shown in this report are calculated by TTI on behalf of the FHWA for performance planning purposes, using data from the Highway Performance Monitoring System (HPMS) for more cities/urbanized areas ranging in population from less than 500,000 to over 3 million.

In contrast, the Urban Mobility Study concentrates on a smaller number of areas (85 in the 2005 edition) and could be considered a subset of the cities used in the work for the Performance Plan Congestion/Mobility Measures. TTI's analysis of these cities incorporates additional data sources beyond those in HPMS, which allows for a more detailed analysis. The urbanized areas in the survey do not represent a random sample of all urbanized areas, and instead include most of the largest areas, which tend to have more severe congestion problems than smaller areas.

Consequently, one should not expect the values for these metrics in the Urban Mobility Study to equal the values computed based on the larger set of urbanized areas for the FHWA.

Average Daily Percent of Vehicle Miles Traveled Under Congested Conditions (Percent Congested Travel)

The Average Daily Percent of Vehicles Miles Traveled (VMT) Under Congested Conditions is defined as the percentage of daily traffic on freeways and principal arterials in urbanized areas moving at less than free-flow speeds. *Exhibit 4-2* shows that this measure of the **extent** and **duration** of congestion has increased from 25.9 percent in 1995 to 31.6 percent in 2004 for all urbanized areas combined, an increase of 5.7 percentage points or approximately 0.633 percentage points annually. However, from 2002 to 2004, this percentage increased by only 0.45 percentage points per year (from 30.7 percent to 31.6 percent), suggesting that the extent of congestion may be growing more slowly over time.

Exhibit 4-2

Average Daily Percent of VMT Under Congested Conditions, by Urbanized Area Size, 1995–2004

Urbanized Area Population	Year					
	1995	1997	1999	2000	2002	2004
Less Than 500,000	11.0	12.6	13.7	14.2	15.4	16.6
500,000 to 999,999	19.0	20.6	22.4	22.6	23.8	24.8
1,000,000 to 3,000,000	26.0	27.5	29.8	30.5	31.2	31.7
Over 3,000,000	34.4	36.7	38.2	38.5	39.6	40.7
All Urbanized Areas	**25.9**	**27.5**	**29.1**	**29.6**	**30.7**	**31.6**

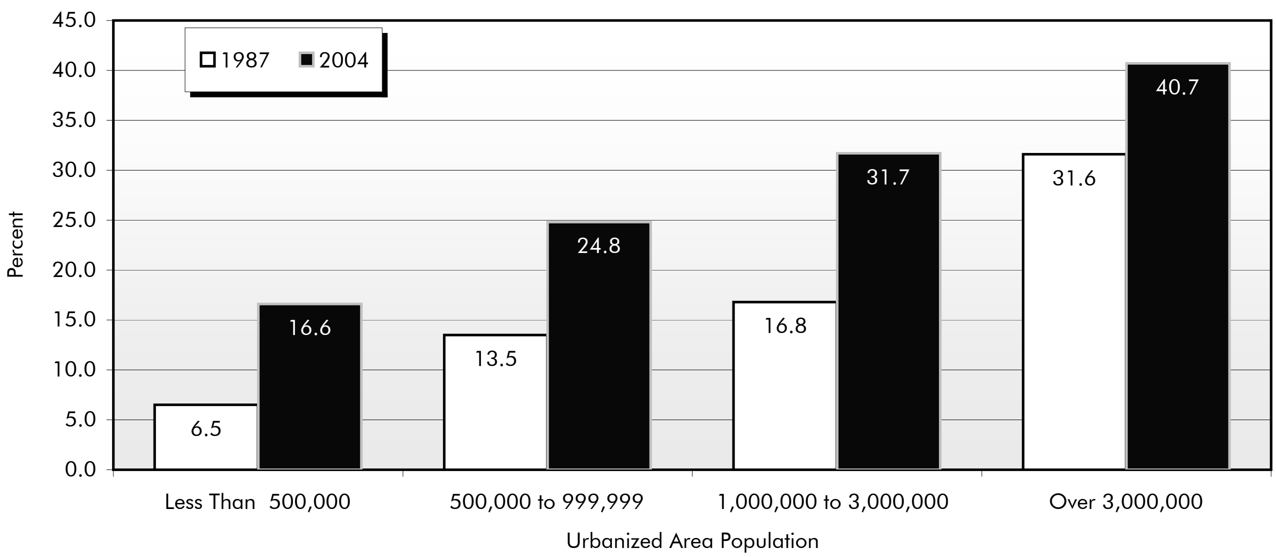
Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures

In absolute terms, this metric increased by about the same amount from 1995 through 2004 in each of the four population groups identified in Exhibit 4-2, with increases ranging from 5.6 percentage points to 6.3 percentage points. However, in relative terms, this was much more significant in the Small (population <500,000) category, since its starting point in 1995 was much lower; its increase from 11.0 percent in 1995 to 16.6 percent in 2004 exceeds 50 percent in relative terms. As was the case for urbanized areas overall, the increase for the Small (population <500,000) category for the period of 1995 to 2004 of 0.62 percentage points per year (5.6 percentage points over 9 years) was higher than the increase from 2002 to 2004 of 0.6 percentage points per year (1.2 percentage points over 2 years).

Exhibit 4-3 compares the Average Daily Percent Vehicle Miles Traveled Under Congested Conditions for each of the population groups for the years 1987 and 2004. (The year 1987 was used as a point of comparison in recent C&P reports and has been retained in this edition for consistency). A comparison between the 2 years shows communities in the Small (population <500,000) category are confronting approximately the same level of problem in 2004 as communities in the Large (population 1 million to 3 million) category were dealing with in 1987. In addition, communities in the Medium (population 500,000 to 999,999) category in 2004 are faced with a problem (24.8 percent congested travel) almost half again as great as that faced by communities in the Large category in 1987 (16.8 percent congested travel). These trends highlight that the problem of congestion does not just affect the largest cities; it is increasing in communities of all sizes across the entire Nation.

Exhibit 4-3

Average Daily Percent Vehicle Miles Traveled Under Congested Conditions, by Urbanized Area Size, 1987 vs. 2004



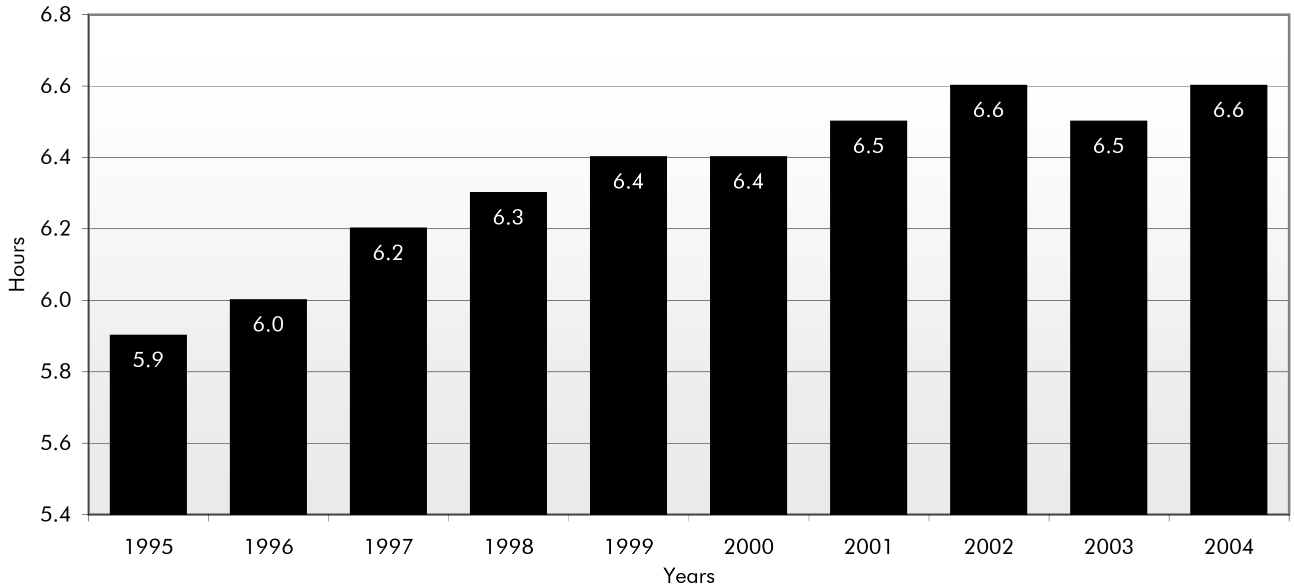
Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Average Length of Congested Conditions

The Average Length of Congested Conditions is a measure of the **duration** of congestion. As shown in *Exhibit 4-4*, the average congested travel period for all urbanized areas combined has increased from 5.9 hours in 1995 to 6.6 hours in 2004—an increase in length of 42 minutes, or almost 12 percent, over a period of 9 years. The rate of increase has stabilized in recent years, as this metric has fluctuated between 6.5 hours and 6.6 hours per 24-hour period since 2001.

Exhibit 4-4

Average Length of Congested Conditions, All Urbanized Areas

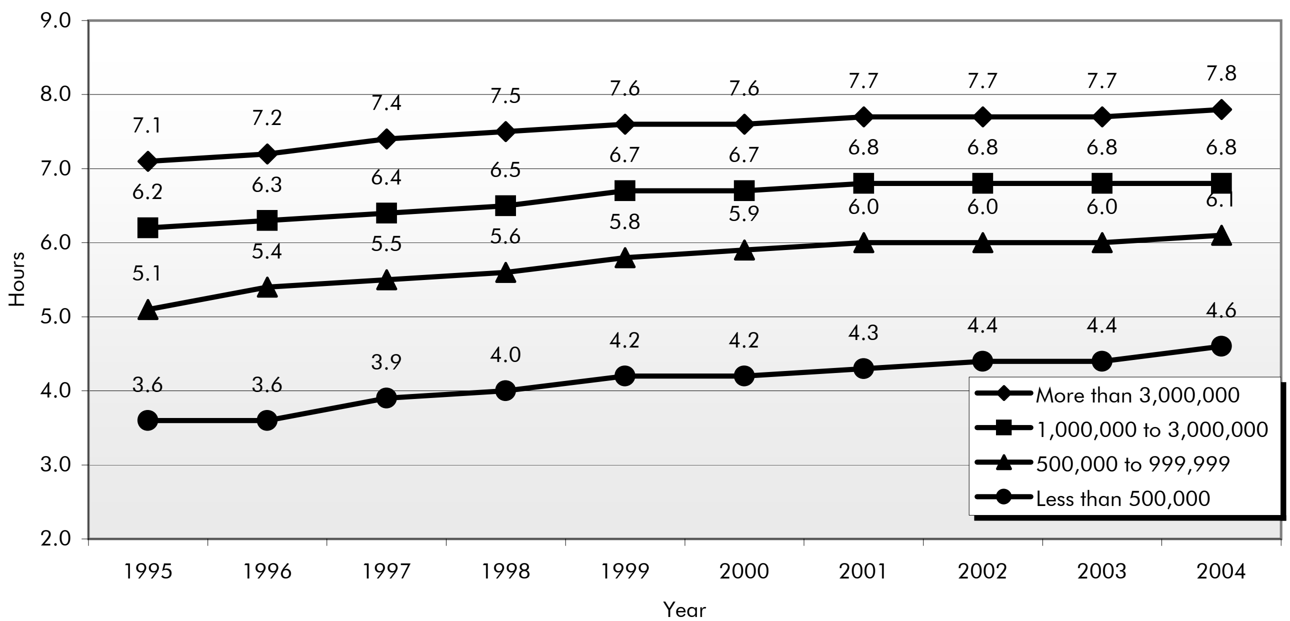


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

The pattern observed in the Average Length of Congested Conditions in each of the four urbanized area population categories, broken down in *Exhibit 4-5*, is similar to the overall averages shown in Exhibit 4-4; the average congested travel period has increased since 1995, but has grown more slowly in recent years. However, from 2003 to 2004, there was an increase of 0.2 hours or 12 minutes, in the average congested travel period for the 357 communities in the Small (population <500,000) category, or for 357 urbanized areas.

Exhibit 4-5

Average Length of Congested Conditions by Urbanized Area, 1995 –2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

This leveling in the growth in duration of congestion is a positive development; however, the length of congested conditions, particularly in the communities in the Large (population 1 million to 3 million) and Very Large (population > 3 million) categories is a major problem. The length of the congested period in these communities is such that it is extending to a major portion of a normal workday. Recurring congestion is now no longer restricted to the traditional peak commuting periods but extends throughout the workday, resulting in continuous travel delays for highway users. Recurring congestion also occurs on heavily traveled routes on Saturdays and Sundays so that even shopping and recreational travel is adversely impacted in urbanized areas.

As an example, the 7.8 average hours of congested conditions identified in Exhibit 4-5 for Very Large (population > 3 million) communities could translate into congestion buildup during the morning period extending from 6:00 a.m. to 9:48 a.m. or 3.8 hours. Buildup during the afternoon period could begin at 3:30 p.m. and extend to approximately 7:30 p.m. (4 hours). 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 on lateral or circumferential routes in the most congested metropolitan areas.

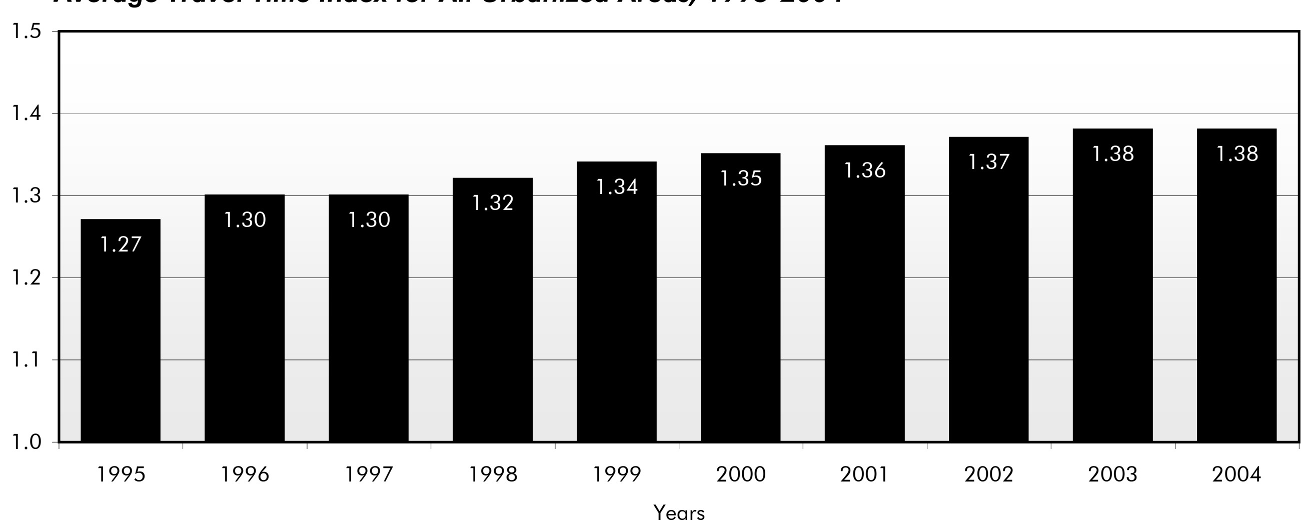
Travel Time Index

The Travel Time Index is an indicator of the **severity, duration, and extent** of congestion, measuring the additional time required to make a trip during the congested peak travel period rather than at other times of the day. The additional time required is a result of increased traffic volumes on the roadway and the additional delay caused by crashes, poor weather, special events, or other nonrecurring incidents. It is expressed as the percent of additional time required to a make a trip during the congested period of travel.

Exhibit 4-6 shows the growth of the national average of the Travel Time Index since 1995. In 1995, a trip that would take 20 minutes during off-peak noncongested periods would take 27 percent (5.4 minutes) longer on average during the peak period. The same trip in 2004 would require 27.6 minutes during the peak period, 38 percent longer than during off-peak noncongested conditions. This difference of 2.2 minutes per trip between the peak period in 1995 and the peak period in 2004 is extremely significant, if multiplied by the total number of such trips that are made on a daily basis.

Exhibit 4-6

Average Travel Time Index for All Urbanized Areas, 1995-2004

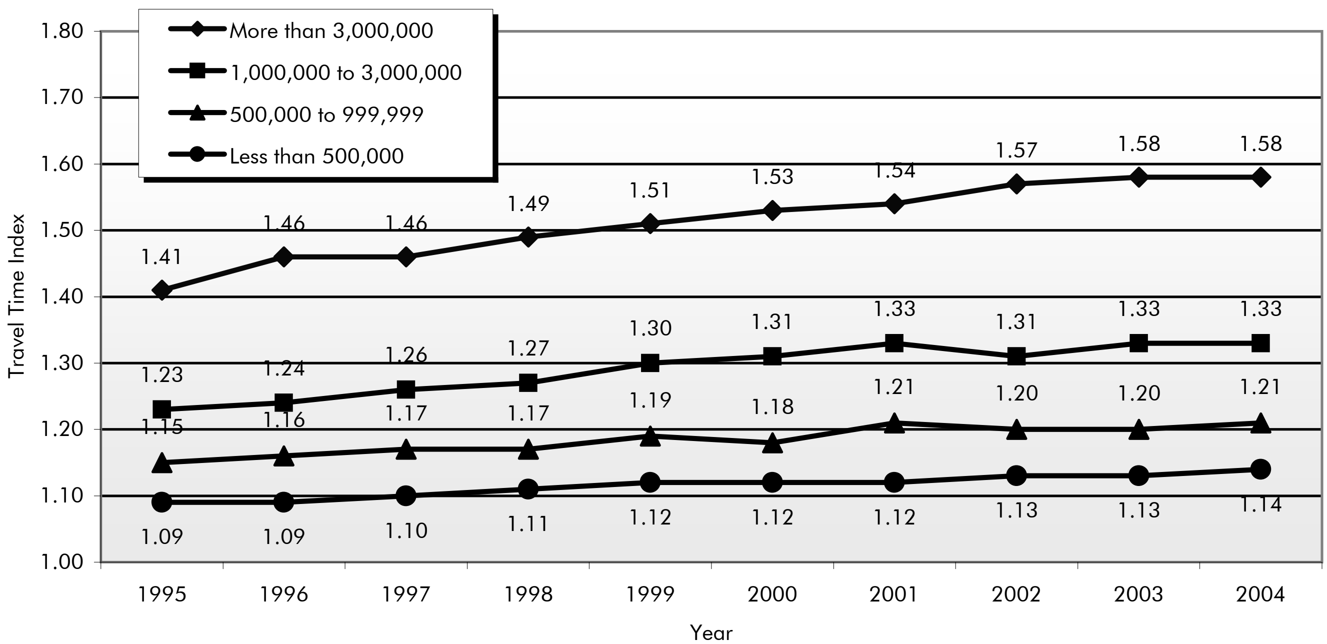


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-7 demonstrates that the additional travel time required because of congestion tends to be higher in larger urbanized areas than smaller ones. The largest increase from 1995 to 2004 occurred in urbanized areas with populations over 3 million, where the Travel Time Index increased from 1.41 to 1.58. This equates to a 3.4-minute increase (from 28.2 to 31.6 minutes) for an average trip that would require 20 minutes during noncongested periods.

Exhibit 4-7

Travel Time Index by Urbanized Area Size, 1995 –2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

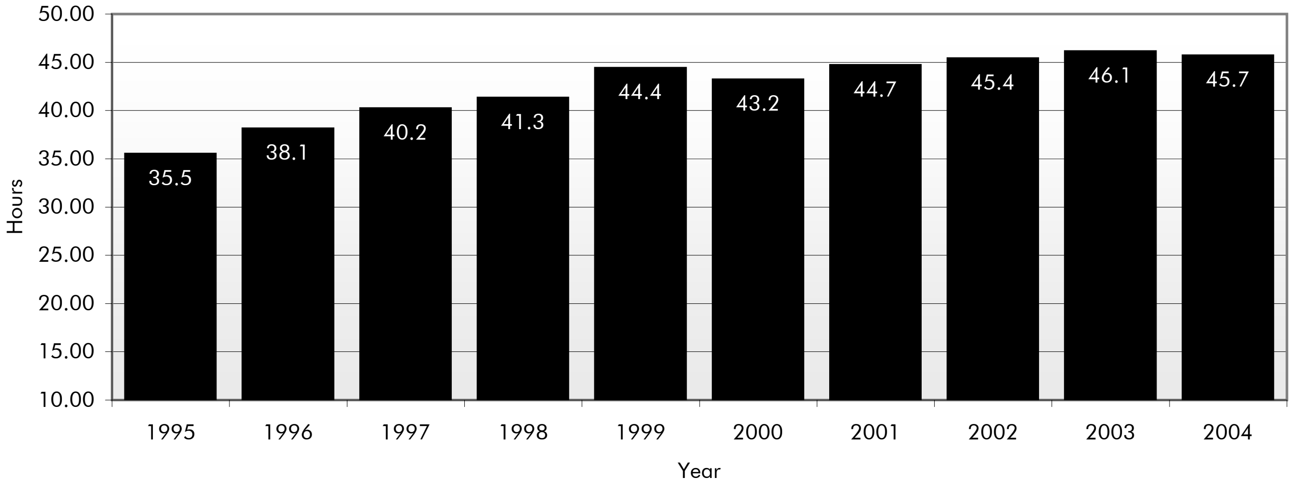
Annual Delay per Peak Period Traveler

Annual Delay per Peak Period Traveler (hours) is another measure of the **severity, duration, and extent** of congestion, defined as the total delay experienced by an average traveler under congested conditions. As shown in *Exhibit 4-8*, Annual Delay per Peak Period Traveler for all urbanized areas combined has increased from 35.5 hours in 1995 to 45.7 hours in 2004. This translates into an average annual increase of approximately 2.9 percent. The value of this metric in 2004 is 0.3 hour, or 18 minutes, higher than the value in 2002 of 45.4 hours.

Exhibit 4-9 presents the values of this metric by population category. All four population categories experienced an increase in this metric in this period. The largest increase in this metric was experienced by peak period travelers in communities in the Medium (population 500,000 to 999,999) category from 27.9 hours in 2002 to 29.9 hours in 2004, an increase in 2.0 hours. Peak period travelers in communities in the Small (population <500,000) category experienced an increase of 1.6 hours, from 14.3 hours of 15.9 hours. The communities in the Large (population 1 million to 3 million) category experienced an increase in the number of hours of Annual Delay per Peak Period Traveler from 37.6 hours in 2002 to 38.4 hours in 2004, a difference of 1.2 hours. Peak period travelers in communities in the Very Large (population > 3 million) group experienced the smallest increase of 0.3 hour, from 74.6 hours in 2002 to 74.9 hours in 2004. [Exhibit 4-9]

Exhibit 4-8

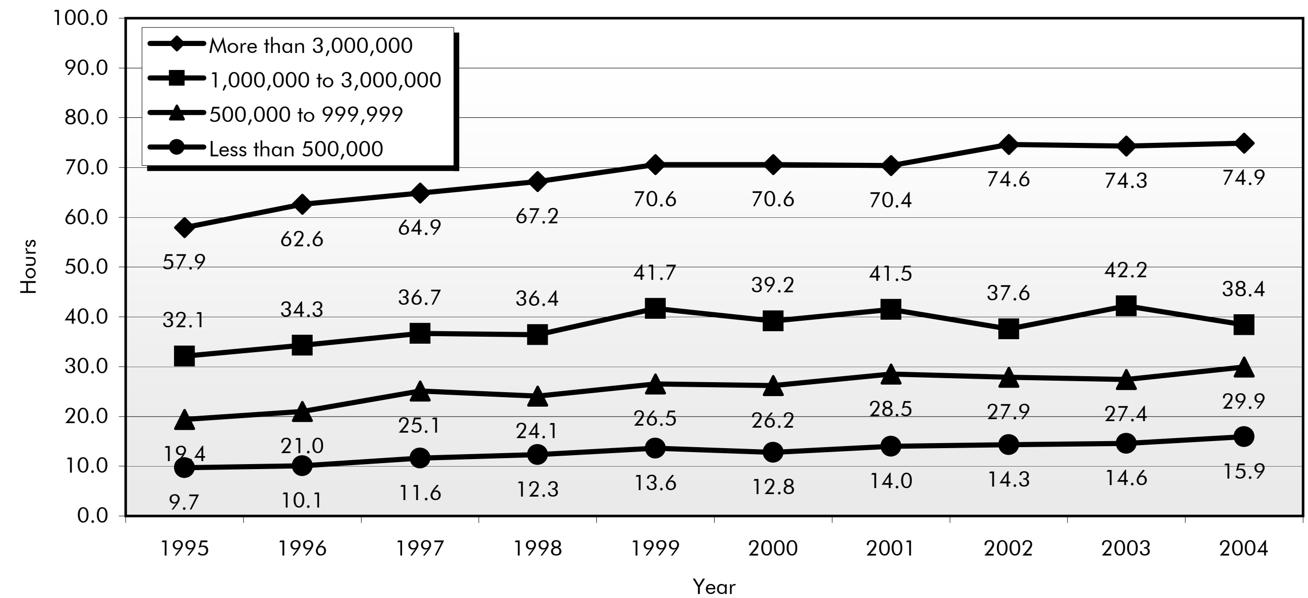
Annual Delay per Peak Period Traveler for All Urbanized Areas, 1995-2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-9

Annual Delay per Peak Period Traveler by Urbanized Area Size, 1995 –2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

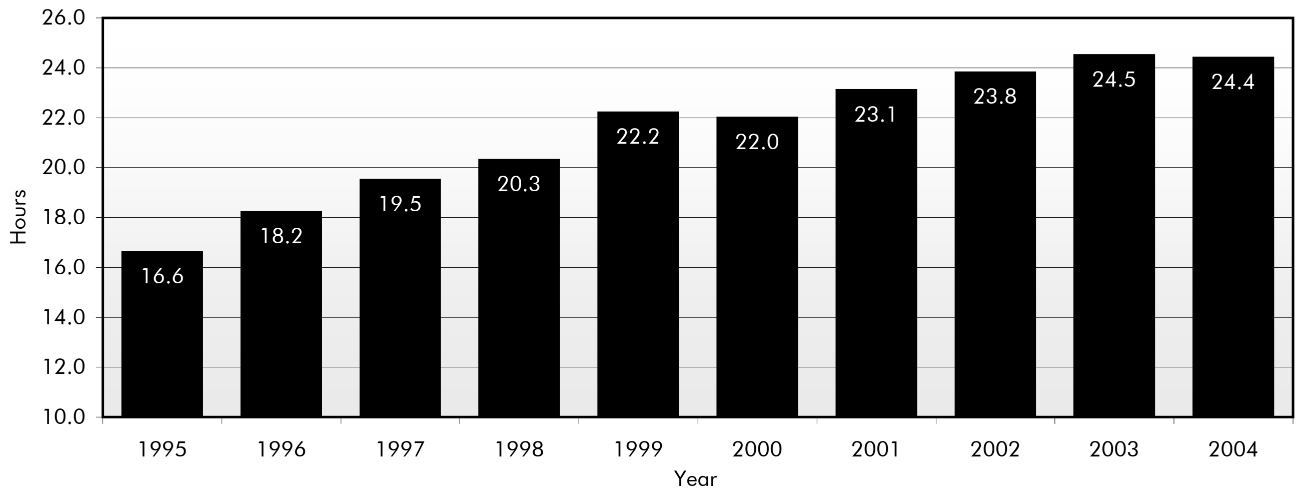
While there have been fluctuations in individual years (such as the decline for peak period travelers in the Large population category from 2003 to 2004), the longer term trend since 1995 has been an increase in this metric. Since 1995, travelers in Very Large (population > 3 million) communities have experienced the greatest increase in delay, with the amount of time lost due to traveling during congested periods increasing steadily from 57.9 hours in 1995 to 74.9 hours in 2004—an increase of 17 hours. The next largest increase has occurred in Medium (population 500,000 to 999,999) urbanized areas where travelers have contended with an increase from 19.4 hours in 1995 to 29.9 hours of annual delay in 2004. Travelers in communities in Small (population <500,000) urbanized areas experienced an increase from 9.7 hours in 1995 to 15.9 hours of annual delay in 2004, while travelers in the Large (population 1 million to 3 million) urbanized areas experienced the smallest increase, from 32.1 hours in 1995 to 38.4 hours in 2004.

Annual Delay per Capita

Annual Delay per Capita (hours) is another measure of the **severity, extent, and duration** of congestion, relating to the average hours of travel delay experienced by a resident of an urbanized area because of recurring congestion and incidents, such as vehicle breakdowns and crashes. Note that this measure reflects the average delay experienced by all residents of a given area, not just those who drive in the peak period. *Exhibit 4-10* shows that, in 2004, the average resident lost 24.4 hours because of congestion. This is an increase of 0.6 hour over the amount of annual delay since 2002, an increase of approximately 2.5 percent. Since 1995, the average for all urbanized areas combined has increased from 16.6 hours of delay per year to 24.4 hours of delay per year, or approximately 47 percent.

Exhibit 4-10

Average Annual Delay per Capita for All Urbanized Areas, 1995 –2004

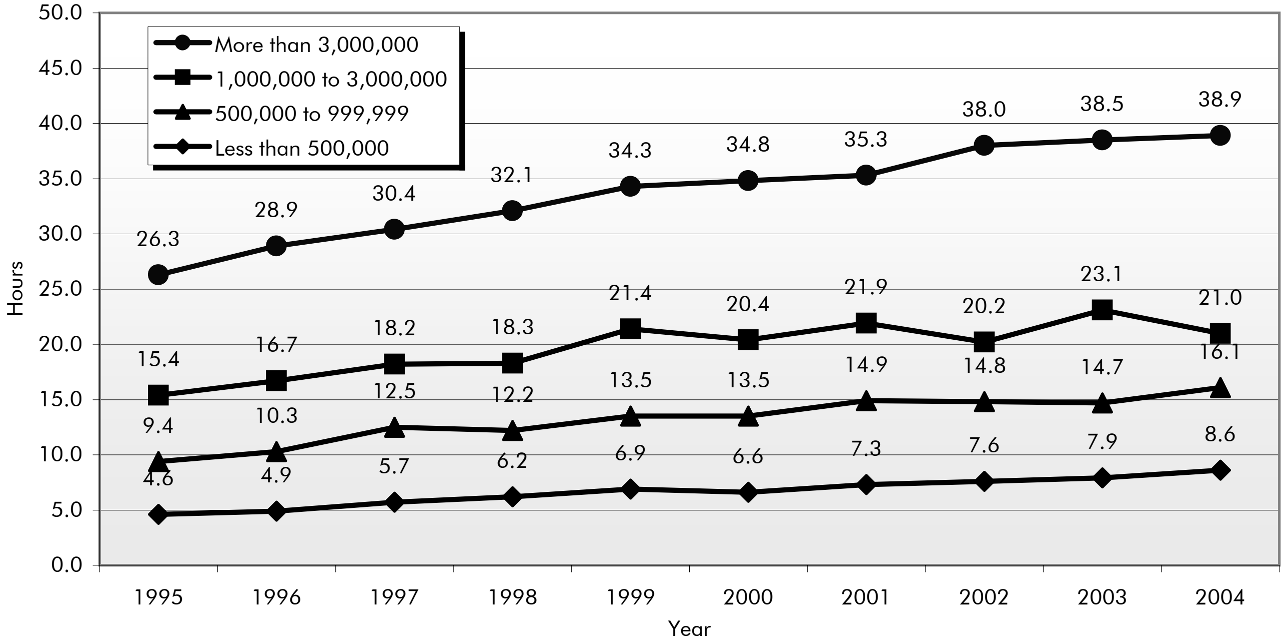


Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

Exhibit 4-11 shows that cities over 3 million in population have experienced an increase of 0.9 hour in the Annual Delay per Capita between 2002 and 2004. The average value for these cities was 38.9 hours per driver per year in 2004. Cities with populations between 500,000 and 999,999 experienced the greatest increase in Annual Delay per Capita, from 14.8 hours in 2002 to 16.1 hours in 2004, an increase of 1.3 hours of delay per capita over the 2-year period. Cities with populations of less than 500,000 experienced an increase in delay per capita since 2002—from 7.6 hours to 8.6 hours, an increase of 1 hour in delay.

Exhibit 4-11

Average Annual Hours of Delay per Capita by Urbanized Area Size, 1995-2004



Source: Texas Transportation Institute, for FHWA Performance Plan Congestion/Mobility Measures.

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, or 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. If travel time increases or reliability decreases, businesses will need to increase average inventory levels to compensate, increasing storage costs. Congestion, then, imposes a real economic cost for businesses and these costs will ultimately impact consumer prices. [See Chapter 14 for additional details on the impacts of congestion on freight transportation.]

The TTI's *2005 Urban Mobility Report* estimates that, in the 85 urban areas studied in 2003, drivers experienced in excess of 3.7 billion hours of delay and wasted approximately 2.3 billion gallons of fuel in the year 2003. The total congestion cost for these areas, including wasted fuel and time, was estimated to be approximately $63.1 billion. Over 60 percent of that cost, or approximately $38 billion, was experienced in the 10 metropolitan areas with the most congestion. The estimated wasted fuel in the same top 10 metropolitan areas was approximately 58.6 percent, or over 1.3 billion gallons of fuel. When expanded to include the top 20 areas with the most congestion, the total annual cost is estimated at over $50.2 billion and the total estimated wasted fuel is approximately 1.8 billion gallons for 2003, or 79.7 percent and 79.1 percent, respectively, of the total wasted dollars and gallons of fuel for the top 85 urban areas studied.

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 indicate that the demand for travel is growing faster than the supply of highways. *Exhibit 4-12* shows that the volume of travel per lane mile has increased from 1995 to 2004 on every functional highway system for which data are collected.

The largest magnitude increase occurred on the Interstate System in urbanized areas, where the DVMT per lane mile increased by 1,958 between 1995 and 2004. The largest percentage increase occurred on the Interstate System in rural areas, where the DVMT per lane mile increased by 21.5 percent, from 4,652 to 5,711 between 1995 and 2004.

Note that the declines in DVMT per lane mile between 2002 and 2004 for many functional classes are partially driven by boundary changes resulting from the 2000 decennial census, as many States adjusted their HPMS data during this time period to reflect the new boundaries. As the rural areas on the fringe of small urban or urbanized areas (which would tend to have higher DVMT per lane-mile values within the rural category) were reclassified as small urban or urbanized, this would tend to bring down the average rural DVMT values. The small urban averages would be affected both by the addition of areas formerly classified as rural and the subtraction of areas reclassified as urbanized. The urbanized area averages would also be affected by the reclassification of formerly small urban or rural areas as urbanized.

Exhibit 4-12

Daily Vehicle-Miles Traveled (DVMT) per Lane-mile by Population Area and Functional Class, 1995–2004

Functional System	1995	1997	1999	2000	2002	2004
Rural Areas (under 5,000 in population)						
Interstate	4,652	4,952	5,322	5,455	5,711	5,707
Other Principal Arterial	2,414	2,522	2,651	2,685	2,756	2,642
Minor Arterial	1,485	1,557	1,622	1,640	1,683	1,632
Major Collector	610	634	652	659	676	649
Small Urban Areas (5,000–49,999 in population)						
Interstate	6,524	6,842	7,457	7,545	7,955	7,925
Other Freeway and Expressway	5,025	5,339	5,639	5,841	6,106	5,888
Other Principal Arterial	3,925	4,032	4,173	4,204	4,258	4,092
Minor Arterial	2,424	2,488	2,595	2,601	2,673	2,529
Collector	1,199	1,224	1,254	1,253	1,306	1,214
Urbanized Areas (50,000 or more in population)						
Interstate	13,826	14,465	15,093	15,333	15,689	15,783
Other Freeway and Expressway	10,894	11,304	12,021	12,286	12,730	12,630
Other Principal Arterial	5,986	6,214	6,252	6,284	6,408	6,326
Minor Arterial	3,753	3,893	4,160	4,210	4,345	4,307
Collector	1,994	2,100	2,157	2,192	2,276	2,275

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 1 hour with the theoretical service flow (SF), or the theoretical maximum number of vehicles that could utilize the lane in an hour. *Exhibit 4-13* shows the percentage of peak-hour travel meeting or exceeding a V/SF of 0.80 as well as that exceeding 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, 63.5 percent had peak-hour travel with a V/SF ratio of 0.80 or higher, while 38.4 percent had peak-hour travel with a V/SF ratio of 0.95 or higher.

Exhibit 4-13

Percent of Peak-hour Travel Exceeding V/SF Thresholds, 1995-2004

	1995		1997		2000		2002		2004	
Functional System	**V/SF ≥ 0.80**	**V/SF > 0.95**	**V/SF ≥ 0.80**	**V/SF > 0.95**	**V/SF ≥ 0.80**	**V/SF > 0.95**	**V/SF ≥ 0.80**	**V/SF > 0.95**	**V/SF ≥ 0.80**	**V/SF > 0.95**
Rural										
Interstate	9.9%	2.4%	11.0%	3.6%	10.4%	3.3%	15.9%	4.8%	15.1%	5.6%
Principal Arterial	6.8%	3.2%	7.0%	3.2%	7.4%	3.8%	6.9%	3.8%	6.3%	2.4%
Minor Arterial	4.4%	2.5%	4.2%	1.9%	4.6%	2.2%	4.8%	2.2%	4.0%	2.1%
Major Collector	2.8%	1.6%	2.4%	1.2%	2.3%	1.0%	2.3%	1.4%	1.8%	0.9%
Small Urban										
Interstate	15.2%	5.5%	13.2%	4.7%	7.7%	3.2%	13.2%	5.5%	17.8%	3.2%
Other Freeway & Expressway	12.7%	4.6%	11.3%	6.6%	12.5%	6.3%	17.9%	8.9%	17.6%	8.7%
Other Principal Arterial	12.1%	6.8%	11.6%	6.4%	13.2%	6.0%	9.0%	3.8%	8.5%	4.1%
Minor Arterial	14.0%	7.0%	13.1%	6.6%	14.3%	8.0%	12.3%	6.3%	10.7%	4.8%
Collector	9.7%	6.4%	9.7%	5.6%	9.9%	5.7%	8.4%	4.9%	7.1%	3.8%
Urbanized										
Interstate	53.4%	28.7%	55.0%	30.0%	50.0%	26.0%	64.3%	40.2%	63.5%	38.4%
Other Freeway & Expressway	46.8%	26.0%	47.5%	26.4%	46.4%	28.3%	56.7%	35.4%	55.3%	31.9%
Other Principal Arterial	33.1%	22.2%	29.6%	18.1%	29.3%	16.4%	22.3%	10.2%	21.5%	9.4%
Minor Arterial	26.7%	16.8%	25.2%	14.1%	26.4%	14.5%	18.6%	9.3%	17.1%	9.3%
Collector	24.4%	15.7%	21.0%	13.4%	20.3%	13.7%	18.2%	9.3%	15.5%	9.6%

Source: Highway Performance Monitoring System.

For most functional classes, the percent of peak-hour travel exceeding the 0.80 and 0.95 V/SF thresholds declined from 2002 to 2004. This is partially the result of the census boundary issues discussed in the preceding section. However, this is also an indication that this measure of the **severity** of congestion at the peak hour is missing some critical components of the Nation's congestion problems related to increases in the duration and extent of congestion.

Emerging Operational Performance Measures

Measurement of congestion is still a difficult problem. Substantial research has supported the use of delay as the definitive measure of congestion. 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, there currently is no direct measure of delay that can be collected both consistently and inexpensively.

Reliability is another important characteristic of any transportation system, one that industry in particular requires for efficient production. If a given trip requires 1 hour on one day and 1.5 hours on another day, 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

Travel time reliability measures are relatively new, but a few have proven effective at the localized level. Such measures typically compare high-delay days with average-delay days. The simplest method typically applied identifies days that exceed the 90th or 95th percentile in terms of travel times. This approach estimates how bad delay will be on specific routes during the worst one or two travel days each month.

The Buffer Index measures the percentage of extra time travelers must add to their average travel time in order to allow for congestion and be able to arrive at a location on time, about 95 percent of the time. The Planning Time Index represents the total travel time that is necessary to ensure on-time arrival, including both the average travel time and the additional travel time included in the Buffer Index. The Planning Time Index is especially useful because it can be directly compared to the Travel Time Index presented earlier in this chapter on similar numeric scales. While data are not currently available to support these measures at the national level, data have been collected on these indicators for a number of locations and will be applied to additional cities as equipment is deployed and data are accumulated.

The importance of reliability is underscored by a recently completed study of temporary losses of capacity for the FHWA by Oak Ridge National Laboratory. Temporary capacity losses due to work zones, crashes, breakdowns, adverse weather, suboptimal signal timing, toll facilities, and railroad crossings caused over 3.5 billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999. For journeys on regularly congested highways during peak commuting periods, temporary capacity losses added 6 hours of delay for every 1,000 miles of travel. Americans suffer 2.5 hours of delay per 1,000 miles of travel from temporary capacity loss for journeys on roads that do not experience recurring congestion.

Bottlenecks

A February 2004 report prepared by Cambridge Systematics for the American Highway Users Alliance, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks 1999–2004*, listed 233 locations in urban areas that it classified as bottlenecks. Traffic congestion occurs in these areas because of 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 24 worst bottleneck locations. Improvements to these locations may prevent an estimated 449,606 crashes, including 1,787 fatalities and 220,760 injuries. Major reductions in pollutants also were cited as a benefit, including 101,320 tons of carbon monoxide and 10,449 tons of volatile organic compounds. Peak period user delay for the 233 locations may be reduced by an estimated 74.5 percent, which translates to approximately 32 minutes each day per commuter.

An October 2005 report prepared by Cambridge Systematics for the FHWA, *An Initial Assessment of Freight Bottlenecks on Highways*, examines bottlenecks from the freight perspective. See Chapter 14 for additional information on this report and other freight operational performance measures.

Leading Indicators

The FHWA tracks the implementation of various operations strategies as leading indicators of potential future congestion trends. These include the deployment of ITS (see the ITS section in Chapter 2), as well as the deployment of regional ITS Architecture and the deployment of "511" travel information systems. The FHWA has also developed self-assessment tools for States and regions to measure their progress in work zone management, incident management, and congestion partnerships. FHWA's monitoring of the deployment of operations strategies is discussed in more detail in Chapter 15.

Measuring Performance Using ITS Technologies

The deployment of ITS technologies provides opportunities for improved measurement of performance. For example, speed 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. Travel time can also be measured through communications systems used in vehicles, such as monitoring truck movements on intercity and urban sections of the Interstate System as described in Chapter 14. Methods for compiling ITS data, removing spurious observations, and producing useful statistics are still under development.

The Real Time System Management Information Program authorized in section 1201 of the Safe, Accountable, Flexible and Efficient Transportation Equity Act: Legacy for Users (SAFETEA-LU) should provide additional momentum towards the establishment of the types of information systems that could significant improve our ability to measure highway congestion and operational performance. This program is discussed in more detail in Chapter 15.

Transit Operational Performance

Transit operational performance can be measured and evaluated on the basis of a number of different factors such as the speed at which a passenger travels on transit, vehicle occupancy rate and vehicle utilization, as well as service frequency and seating availability. These measures, however, do not necessarily all lead towards a single standard of higher operational performance. For example, while higher average operating speeds are good for passengers, they may indicate that transit systems are not carrying sufficient passengers, and therefore have shorter dwell times. Conversely, while higher vehicle utilization indicates more intensive vehicle use, it may also indicate that passengers are experiencing crowded conditions. For this reason, speed, occupancy, and capacity utilization are analyzed only on the basis of the direction of their change; the optimal levels of these measures are unknown.

Average Operating (Passenger-Carrying) Speeds

Average vehicle operating speed is an approximate measure of the speed experienced by transit riders; it is not a measure of the pure operating speed of transit vehicles between stops. Rather, average operating speed is a measure of the speed passengers experience from the time they enter a transit vehicle to the time they exit the same transit vehicle, including dwell times at stops. It does not include the time passengers spend waiting or transferring. Average vehicle operating speed is calculated for each mode by dividing annual vehicle revenue miles by annual vehicle revenue hours for each agency in each mode, weighted by the passenger miles traveled (PMT) for each agency within the mode, as reported to the National Transit Database. In cases where an agency provides both directly operated service and purchased transportation service within a mode, the speeds for each of these services are calculated and weighted separately. The results of these average speed calculations are presented in *Exhibit 4-14*.

Exhibit 4-14

Average Transit Passenger-Carrying Speed, 2004

(Miles per Hour)	2004
Heavy Rail	21.0
Commuter Rail	32.2
Light Rail	17.7
Other Rail [1]	7.9
Motorbus	13.6
Demand Response	15.3
Vanpool	39.1
Other Nonrail [2]	8.3

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail.

[2] Aerial tramway, jitney, público, and trolleybus.

Source: National Transit Database.

The average speed of a transit mode is strongly affected by the number of stops it makes. Motorbus service, which typically makes frequent stops, has a relatively low average speed of 13.6 miles per hour. In contrast, commuter rail has high sustained speeds between infrequent stops, and a high average speed of 32.2 miles per hour. Vanpools also travel at high speeds, usually with only a few stops at each end of the route, and an average speed of 39.1 mph. Also, in many cases, modes using exclusive guideways offer more rapid travel time than modes that do not. Heavy rail, which travels exclusively on fixed guideways, has an average speed of 21.0 mph, while light rail, which often shares guideway, has an average speed of 17.7 mph.

Exhibit 4-15 provides average speed for each year from 1995 to 2004 for all rail modes, all nonrail modes, and all modes combined, as well as the overall average speed for these groups over the entire 1995–2004 time period. As speed numbers fluctuate from year to year, the relation of a given year's average speed to the long-term average provides a better indication of overall trends than comparison to an individual year. These average speeds are based on the average speed of each agency-mode weighted by the number of PMT on that agency-mode. Average transit operating speed as experienced by all transit passengers from 1995 to 2004 was 20.1 miles per hour. The average speed on nonrail modes was 14.0 miles per hour in 2004, which is slightly above the long-term average of 13.8 miles per hour, and indicating an overall trend of increasing speed on nonrail modes. The average speed on rail modes, however, at 25.0 miles per hour in 2004, was below the long-term average of 25.6 miles per hour, and indicating an overall trend of declining average speed on rail modes.

Exhibit 4-15

Passenger-Mile Weighted Average Operating Speed by Transit Mode, 1995–2004

(Miles per Hour)	Rail	Nonrail	Total
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
2001	25.2	13.7	19.9
2002	25.3	13.7	19.9
2003	25.4	13.9	20.1
2004	25.0	14.0	20.1
Average	**25.6**	**13.8**	**20.1**

Source: National Transit Database.

Vehicle Use

Vehicle Occupancy

Exhibit 4-16 shows vehicle occupancy by mode for selected years from 1995 to 2004. Vehicle occupancy is calculated by dividing PMT by vehicle revenue miles (VRM) and shows the average number of people carried in a transit vehicle. In 2004, heavy rail carried an average of 23 persons per vehicle and light rail an average of 24 persons per vehicle. Commuter rail had an average occupancy of 36 persons per vehicle, motorbus had an average of 10 persons per vehicle, vanpool had an average of 6 persons per vehicle, ferryboat had an average of 120 persons per vehicle, and demand response had an average of 1 person per vehicle.

Exhibit 4-16

Unadjusted Vehicle Occupancy: Passengers per Transit Vehicle, 1995–2004

	1995	1997	1999	2000	2002	2004
Rail						
Heavy Rail	20	22	23	24	23	23
Commuter Rail	38	35	36	38	37	36
Light Rail	25	26	25	26	24	24
Other Rail [1]	11	9	9	8	8	10
Nonrail						
Motorbus	11	11	11	11	10	10
Demand Response	1	2	1	1	1	1
Ferryboat	125	126	119	120	112	120
Trolleybus	14	14	14	14	14	13
Vanpool	8	8	7	7	6	6
Other Nonrail [2]	8	8	6	7	8	6

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail.

[2] Aerial tramway, jitney, and público.

Source: National Transit Database.

Exhibit 4-17 provides adjusted vehicle occupancy, or the average number of persons carried per capacity-equivalent vehicle, with the average carrying capacity of motorbus vehicles as a base. Adjusted vehicle occupancy is calculated by dividing PMT by capacity-equivalent VRMs. This measure takes into account differences in seating and standing capacities. Note that modes where standing is not possible or not allowed tend to have higher adjusted vehicle occupancies than modes where standing is possible and allowed. Commuter rail and vanpool, used primarily for commuting, have high levels of adjusted occupancy. Standing is generally not feasible in vanpool vehicles and is frequently not allowed on commuter rail vehicles. [As discussed in Chapter 2, capacity-equivalent VRMs have been revised to reflect the actual carrying capacities that existed in each year. Prior reports had used the same factor for each mode for all years. For this reason, except for motorbus, which is the base, adjusted vehicle occupancy in this report may differ slightly from the values in the 2004 C&P report.]

Exhibit 4-17

Adjusted Vehicle Occupancy: Passengers per Capacity-Equivalent Transit Vehicle, 1995–2004

	1995	1997	1999	2000	2002	2004
Rail						
Heavy Rail	9	10	10	10	9	9
Commuter Rail	17	15	15	16	15	14
Light Rail	11	11	10	11	10	9
Other Rail [1]	6	5	5	6	6	8
Nonrail						
Motorbus	11	11	11	11	10	10
Demand Response	9	9	8	8	6	7
Ferryboat	11	10	10	10	9	11
Trolleybus	11	10	10	10	10	9
Vanpool	42	41	37	36	31	31
Other Nonrail [2]	32	32	24	28	30	23
Total	**11**	**11**	**11**	**11**	**11**	**10**

[1] Alaska railroad, automated guideway, cable car, inclined plane, and monorail.

[2] Aerial tramway, jitney, and público.

Source: National Transit Database.

Vehicle Utilization

Exhibit 4-18 shows vehicle utilization as measured by PMT per capacity-equivalent vehicle (CEV) operated in maximum scheduled service. PMT per CEV is a measure of service effectiveness, measuring vehicle utilization by taking account of differences in vehicle carrying capacities. PMT per CEV, or capacity utilization, is calculated by dividing the total number of PMT on each mode by the total number of vehicles operated in maximum service in each mode, adjusted by the average capacity of the Nation's motorbus fleet. A high number of PMT per CEV indicates high passenger use; a low number of PMT per CEV indicates low passenger use. For example, in 2004 there were 1,615 thousand PMT per heavy rail vehicle, over four times the 373 thousand PMT per motorbus vehicle. However, since heavy rail vehicles have, on average, two and a half times the capacity of a motorbus, heavy rail provides 652 thousand PMT per CEV, or roughly 75 percent more than motorbus, considerably less than on an unadjusted basis. [Note again that, due to revisions to the capacity-equivalent factors, vehicle utilization in this report may differ from the values in the 2004 C&P report, except for motorbus, which is the base.] Commuter rail has consistently had the highest level of utilization, reflecting longer average trip lengths with seating capacity only. As shown in Exhibit 4-18, between 1995 and 2004, most modes reached their highest level of utilization in 2000 or 2001. All modes, except ferryboat, were at a lower level of capacity utilization in 2004 than the long-term average utilization from 1995 to 2004.

Q&A

What is service effectiveness and how can it be measured?

Service effectiveness measures the extent to which transit agencies are providing service that is demanded and used by consumers. This is primarily measured as "vehicle utilization"—the PMT per capacity-equivalent vehicle mile. Other measures of service effectiveness include unlinked passenger trips per vehicle revenue mile (VRM), unlinked passenger trips per vehicle revenue hour, annual passenger miles per actual annual VRM, and passenger miles traveled per scheduled vehicle mile.

Exhibit 4-18

Transit Vehicle Utilization:
Annual Passenger Miles per Capacity-Equivalent Vehicle by Mode, 1995 –2004

(Thousands of Passenger Miles)

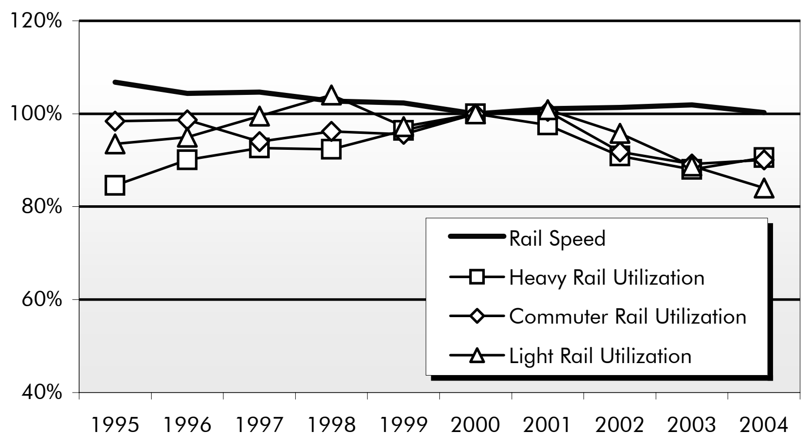
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
Heavy Rail	609	649	667	665	694	720	703	655	634	652	**665**
Commuter Rail	825	827	788	806	801	838	843	769	748	755	**800**
Light Rail	520	529	554	579	541	557	561	533	494	468	**534**
Motorbus	391	392	401	393	397	393	397	389	383	373	**391**
Demand Response	199	190	242	207	204	207	185	168	172	181	**195**
Vanpool	598	683	609	621	618	592	501	498	535	502	**576**
Ferryboat	304	307	298	298	294	305	284	297	350	328	**306**
Trolleybus	301	292	266	252	257	264	288	246	236	237	**264**

Source: National Transit Database.

Changes in the capacity utilization of rail vehicles have influenced these vehicles' operating speeds through changes in dwell times. As vehicles become more crowded, they take longer to unload and load, increasing wait times at stations, and hence, passengers' total travel time. *Exhibit 4-19* illustrates this relationship between capacity utilization and average speed by comparing an index of rail speed with indexes of the capacity utilization of commuter rail, heavy rail, and light rail vehicles between 1995 and 2004, with 2000 as the base year. As the capacity utilization of these rail vehicles increased between 1995 and 2000 (2001 in the case of commuter and light rail), average rail speed decreased. As the capacity utilization of these rail modes all declined from 2001 to 2003, average rail speed increased. Finally, the capacity utilization of heavy rail and commuter rail increased from 2003 to 2004, outweighing the continued decline in the capacity utilization of light rail, and leading to an overall decrease in average rail speed in 2004.

Exhibit 4-19

Index of Rail Speed and Capacity Utilization of Rail Vehicles (2000=100%)



Source: National Transit Database.

Revenue Miles per Active Vehicle (Service Use)

Vehicle service use, the average distance traveled per vehicle in service, can be measured by VRMs per vehicle in active service. Revenue miles per active vehicle measures transit system performance. *Exhibit 4-20* provides vehicle service use by mode for selected years from 1995 to 2004. Heavy rail, generally offering long hours of frequent service, had the highest vehicle use over this period, increasing from 51 thousand miles per vehicle in 1995 to 57 thousand miles per vehicle in 2004. Vehicle service use for light rail increased from 34 thousand miles per vehicle in 1995 to 40 thousand miles per vehicle in 2004, vehicle service use for demand response increased from 16 thousand miles per vehicle in 1995 to 20 thousand miles per vehicle in 2004, and vehicle service use for vanpool increased from 11 thousand miles per vehicle in 1995 to 14 thousand miles per vehicle in 2004. Vehicle service use

Exhibit 4-20

Vehicle Service Utilization:
Vehicle Revenue Miles per Vehicle by Mode, 1995–2004

	(Thousands of Vehicle Revenue Miles)						Average Annual Rate of Change	
	1995	1997	1999	2000	2002	2004	2004/ 1995	2004/ 2002
Heavy Rail	51	54	54	56	55	57	1.3%	1.6%
Commuter Rail	40	41	41	42	44	41	0.3%	-3.3%
Light Rail	34	32	32	33	41	40	1.9%	-1.5%
Motorbus	29	29	29	28	30	30	0.3%	0.6%
Demand Response	16	19	19	18	21	20	2.3%	-2.3%
Vanpool	11	13	13	13	14	14	2.5%	1.9%
Ferryboat	23	24	24	24	24	25	0.9%	0.9%
Trolleybus	19	18	18	19	20	21	1.0%	2.0%

Source: National Transit Database.

by motorbus, ferryboat, and trolleybus increased more slowly. The number of service miles provided per commuter rail vehicle in active service reached a high of 44 thousand in 2002, compared with 40 thousand in 1995 and 41 thousand in 2004.

Frequency and Reliability of Services

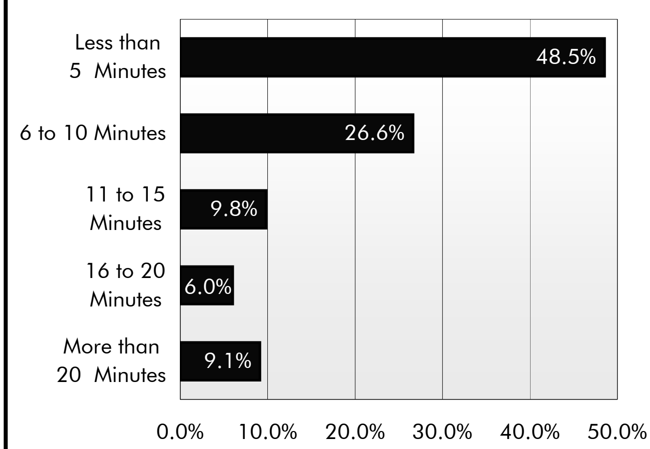
The frequency of transit service varies considerably according to location and time of day. Transit service is more frequent in urban areas and during rush hours, in locations and during times when the demand for transit is highest. Studies have found that transit passengers consider the time spent waiting 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. Further, the less frequently scheduled service is offered, the more important reliability becomes to users.

Exhibit 4-21 shows findings on waiting times from the 2001 National Household Travel Survey (NHTS) by the Federal Highway Administration (FHWA), the most recent nationwide survey of this information. As indicated in the 2004 C&P Report, the NHTS found that 49 percent of all passengers who ride transit wait 5 minutes or less and 75 percent wait 10 minutes or less. Nine percent of all passengers wait more than 20 minutes. A number of factors influence passenger wait-times, including the frequency of service, the reliability of service, and passengers' awareness of timetables. These factors are also interrelated. For example, passengers may intentionally arrive earlier for service that is infrequent, compared with equally reliable services that are more frequent. Overall, waiting times of 5 minutes or less are clearly associated with good service that is either frequent, reliably provided according to a schedule, or both. Waiting times of 5 to 10 minutes are most likely consistent with adequate levels of service that are both reasonably frequent and generally reliable. Waiting times of 20 minutes or more indicate that service is likely both infrequent and unreliable.

Waiting times are also correlated with incomes. Passengers from households with annual incomes of $30,000 or more are much more likely to report a waiting time of 5 minutes or less than passengers from households with incomes of less than $30,000. Additionally, passengers from households with more than $65,000 in annual income report almost never waiting more than 15 minutes for transit *(Exhibit 4-22).* This disparity is in large part due to the fact that high income riders tend to be "choice" riders who primarily ride transit on modes, routes, and at times of day when the service is frequent and reliable—and who generally substitute the use of personal automobiles for trips when these conditions aren't met. In contrast, passengers with lower incomes are more likely to use transit for basic mobility and have more limited alternative means of travel, therefore using transit even when the service is not as frequent or reliable as they may prefer.

Exhibit 4-21

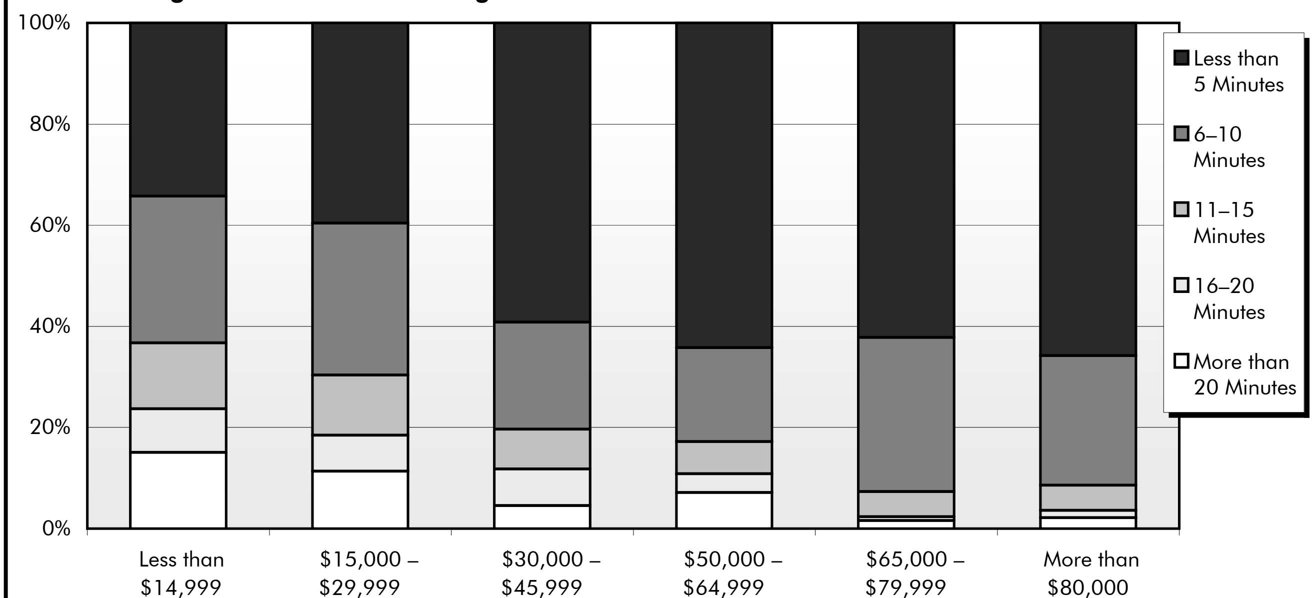
Distribution of Passengers by Waiting Times



Source: National Household Travel Survey, FHWA, April 2001.

Exhibit 4-22

Passenger Wait-Times According to Household Income



Source: National Household Travel Survey, FHWA, 2001.

Seating Conditions

Transit travel conditions are often crowded. Information on crowding was not collected by the 2001 NHTS. The 1995 Nationwide Personal Transportation Survey (NPTS), which was the FHWA nationwide personal travel survey preceding the NHTS and which is the most recent source of data available, found that 27.3 percent of the people sampled were unable to find a seat upon boarding a transit vehicle and that 31.3 percent were unable to find seats during rush hours.