Transportation Statistics Annual Report 1999

Bureau of Transportation Statistics

U.S. Department of Transportation

Transportation Statistics Annual Report
1999

Bureau of
Transportation
Statistics

BTS99-03

U.S. Department of Transportation

Recommended citation

U.S. Department of Transportation
Bureau of Transportation Statistics
Transportation Statistics Annual Report 1999
BTS99-03
Washington, DC: 1999

To obtain copies of this report and other BTS products contact:

Customer Service
Bureau of Transportation Statistics
U.S. Department of Transportation
400 7th Street SW, Room 3430
Washington, DC 20590

phone	202.366.DATA
fax	202.366.3640
email (product orders)	orders@bts.gov
statistics by phone	800.853.1351
statistics by email	statistics@bts.gov
internet	www.bts.gov

Photographs

Summary: Lock & Dam 14, Le Claire, IA, by C. Arney for the U.S. Army Corps of Engineers.

Ch. 1: Alaska Oil Pipeline by B. Heims for the U.S. Army Corps of Engineers.

Ch. 2, 3, & 6: Gate Information and Luggage at Reagan National Airport, Washington, DC, and MARC train in Baltimore City, MD, by M. Fenn for the Bureau of Transportation Statistics.

Ch. 4: Maine Avenue Waterfront, Washington, DC, by S. Giesecke for the Bureau of Transportation Statistics.

Ch. 5: Dredging, New York District, U.S. Army Corps of Engineers.

Acknowledgments

U.S. Department of Transportation

Rodney E. Slater
Secretary

Mortimer L. Downey
Deputy Secretary

Bureau of Transportation Statistics

Ashish K. Sen
Director

Richard R. Kowalewski
Deputy Director

Rolf R. Schmitt
Associate Director for Transportation Studies

Susan J. Lapham
Acting Associate Director for Statistical Programs and Services

Project Manager
Wendell Fletcher

Assistant Project Manager
Joanne Sedor

Editor
Marsha Fenn

Major Contributors
Felix Ammah-Tagoe
Audrey Buyrn
John Cikota
Alan Crane
Bingsong Fang
John Fuller
Robert Gibson
Lee Giesbrecht
David Greene
Xiaoli Han
Peter Kuhn
Anna Lynn LaCombe
Susan Lapham
William Mallett
Peter Montague
Alexander Newcomer
Kirsten Oldenburg
Joel Palley
Lisa Randall
Michael Rossetti
Mark Safford
Paul Schimek
Rolf Schmitt
Basav Sen

Other Contributors
Carol Brandt
Eugene Brown
Russell Capelle
Lillian Chapman
Stacy Davis
Selena Giesecke
Emilia Govan
Madeline Gross
Thomas Hoffman
Gary Krauss
Michael Myers
Alan Pisarski
Tonia Rifaey
Simon Randrianarivelo
Bruce Spear

Cover Design
OmniDigital, Inc.
Ginny McDonagh

Report Layout and Production
OmniDigital, Inc.
Gardner Smith
Linda Rolla

Table of Contents

List of Tables

List of Figures

Preface

Congress requires the Bureau of Transportation Statistics to transmit an annual report on transportation statistics to the President and Congress. *Transportation Statistics Annual Report 1999* is the sixth such report prepared in response to this congressional mandate, laid out in 49 U.S.C. 111 (j). The report discusses the extent and condition of the transportation system; its use, performance, and safety record; transportation's economic contributions and costs; and its energy and environmental impacts. All modes of transportation are covered in the report.

Special features this year include an update of the status of high-speed rail corridors and pedestrian and bicycle safety. In addition, the environmental impacts discussion has been expanded to include transportation infrastructure, equipment manufacturing, vehicle maintenance and disposal, and vehicle emissions.

Summary

The Bureau of Transportation Statistics (BTS) presents the sixth *Transportation Statistics Annual Report*. Mandated by Congress, the report discusses the U.S. transportation system, including its physical components, economic performance, safety record, and related energy and environmental impacts. It also assesses the state of transportation statistics.

EXTENT AND CONDITION OF THE U.S. TRANSPORTATION SYSTEM

The nation's inventory of transportation infrastructure and vehicles shows a continuing trend of expansion and improvement, although a few exceptions exist. From 1987 to 1997, public road mileage increased by less than 2 percent, and the percentage of paved roadway increased from 56 percent to 61 percent. Surface roughness measurements indicate that the conditions of most roadways are improving. Likewise, the percentage of bridges classified as functionally and/or structurally obsolete decreased noticeably since 1990, dropping from 41 percent to 30 percent.

The nation's highway vehicle fleet consisted of about 212 million vehicles in 1997, nearly 28 million more vehicles than a decade earlier. Of special note has been the dramatic growth in the number of sport utility vehicles and other light trucks. This segment of the fleet increased from 41 million vehicles in 1987 to over 70 million in

1997, accounting for 33 percent of the fleet. Still, passenger cars accounted for over 61 percent of the total highway fleet (nearly 130 million vehicles), despite a 5 million vehicle decrease in the number of automobiles over the past decade. Large trucks and buses show a more moderate increase.

In 1997, there were 9 Class I freight railroads (railroads with at least $256 million in operating revenues) in the United States, 34 regional railroads, and 507 local railroads. The railroad industry operated over 170,000 miles of track, over 70 percent of which was operated by Class I railroads. Since 1980, Class I traffic, measured in ton-miles, increased by 47 percent, while miles of road owned declined by 38 percent due to the sale of track to smaller railroads and abandonment. In the case of passenger rail, the National Railroad Passenger Corporation, better known as Amtrak, operated more than 250 intercity trains per day, along a 22,000 mile network in 44 states with service to 500 communities in fiscal year (FY) 1998.

In 1997, the United States had 18,345 airports, a 20 percent increase compared with 1980. The increase was due to the addition of more than 3,200 general aviation airports. The number of airports served by certificated aircraft decreased from 730 to 660. The condition of runway surfaces improved overall, especially at airports not regularly served by commercial carriers. (Runway surface conditions at commercial carrier airports were generally in better condition than those at airports not served by commercial carriers.)

The number of certificated aircraft in operation grew steadily, increasing to more than 7,600 in 1997 (excluding air taxi aircraft operated in nonscheduled service). This represents a 4 percent increase over 1992, which is the first year for which a comprehensive commercial aircraft inventory is available. More than 190,000 general aviation aircraft were reported active in 1997, 60 percent of which were flown primarily for personal use. In 1997, there were 91 air carriers (both passenger and freight) operating in the United States.

The number of both commercial and recreational boats continued to increase in 1997. The U.S.-flag commercial vessel fleet was over 41,400 in 1997 compared with 38,800 in 1980. Approximately 12.3 million recreational boats were registered in the United States in 1997 compared with 10 million in 1987, representing a 23 percent increase in registered recreational watercraft during that decade.

In 1997, the nation's waterborne commerce was handled by 3,726 public marine terminals. These terminals were about equally divided among deep-draft (ocean and Great Lake) and shallow-draft (inland waterway) facilities. Most inland facilities (86 percent) were used for transporting bulk commodities, while coastal facilities were more evenly divided between bulk commodities and general cargo—about 41 percent and 38 percent, respectively.

Over the next few years, coastal ports may face the challenge of handling the next generation of containerships that have the capacity of 4,500 20-foot equivalent container units (TEUs) or more and drafts of 40 to 46 feet when fully loaded. Only 5 of the top 15 U.S. container ports—Baltimore, Tacoma, Hampton Roads, Long Beach, and Seattle—currently have adequate channel depths, and only those on the west coast have adequate berth depths to accommodate these vessels. In addition, ports may need to expand terminal infrastructure and improve rail and highway connections to facilitate the increased volumes of cargo from these ships. Many ports have already initiated expansion projects to accommodate these ships. How effectively U.S. ports handle this next generation of containerships will have implications for the efficiency of the U.S. transportation system and U.S. trade competitiveness.

Oil and gas pipeline mileage remained relatively constant in the 1990s. Because comprehensive oil and gas pipeline data are not available, an accurate assessment of total mileage does not currently exist. Current efforts to develop geographic information systems on liquid and natural gas networks may narrow this data gap.

In 1997, there were 556 federally assisted transit agencies urbanized areas, operating more than 76,000 vehicles and providing 8 billion passenger trips. Most transit trips and passenger-miles are on buses and demand responsive vehicles, which account for three-quarters of all transit vehicles. Federally assisted mass transit infrastructure increased modestly during the 1992 to 1997 period. Increases in new fixed-guideway mileage (both rail and nonrail) are evident. In particular, exclusive and access-controlled bus lanes covered 60 percent more route-miles in 1997 than in 1992. Fixed-guideway mileage increased by 21 percent from 1992 to 1997, reaching 10,800 directional route-miles. Directional route mileage for buses operating on mixed rights-of-way, however, fluctuated from year to year between 1992 and 1997, with no evident pattern of growth or decline.

The mass transit vehicle fleet grew between 1992 and 1997, primarily due to increases in vehicles used in demand responsive service and vanpools. Over three-quarters of vehicles operated by federally assisted transit agencies provided service in large urban areas with populations in excess of 1 million people. Buses and demand responsive vehicles accounted for the majority of the fleet—57 percent and 18 percent, respectively—and were more widely used than commuter, light, and heavy rail modes.

Nonfederally assisted transit agencies also provide important services, especially in rural areas. However, information about these services is limited.

Information technologies have long been an important element in the transportation system, especially in the railroad, aviation, and marine modes. In recent years, technological advances have expanded information technology use in all modes, including highways, transit, recreational boating, and general aviation. The use of intelligent transportation systems (ITS) increased primarily in congested urban areas. A survey of the nation's top 78 urban areas provides baseline data on highway- and transit-related ITS implementation which, when new survey data are obtained, may permit comparison of ITS changes over time. Other advanced technologies such as Global Positioning Systems are also becoming an integral part of the transportation system, being used in air, marine, and land-based transportation modes.

TRANSPORTATION SYSTEM USE AND PERFORMANCE

Both freight transportation and passenger travel have grown considerably in recent years. The Commodity Flow Survey (CFS), undertaken by BTS and the Census Bureau, presents the broadest picture of domestic commodity flows. According to preliminary CFS data and additional estimates by BTS, between 1993 and 1997, freight shipments increased about 17 percent by value, 14 percent by tons, and 10 percent by ton-miles. Preliminary BTS estimates also show that nearly 14 billion tons of goods and raw materials, valued at over $8 trillion, moved over the U.S. transportation system in 1997, generating nearly 4 trillion ton-miles. These figures translate into 38 million tons of commodities shipped on the nation's transportation system on a typical day in 1997.

Most modes showed an increase in ton-miles. Shipments by air (including those involving truck and air) grew 86 percent in ton-miles, followed by parcel, postal, and courier services (41 percent), and truck (26 percent). Rail ton-miles (including truck and rail) increased by only 7 percent, while ton-miles by water decreased by about 3 percent. Nevertheless, trucking (including for-hire and private, and excluding parcel, postal, and courier services) was the mode used most frequently to move the nation's freight whether measured by value, tons, or ton-miles. Truck shipments accounted for 69 percent of the total value of shipments in 1997 about the same as in 1993. Trucking was followed by parcel, postal, and courier services; rail; pipeline; and air (including truck and air) in 1997.

Although many factors have affected the growth in U.S. freight shipments since 1993, sustained economic growth has been key. Economic growth has been accompanied by expansion of international trade and increases in disposable personal income per capita. Other factors, such as changes in how and where goods are produced, have also contributed to the rise in freight tons and ton-miles over the past few years.

International trade has become an even more integral part of the U.S. economy, as illustrated by the increased value of U.S. merchandise trade. Between 1980 and 1997, the real dollar value of U.S. merchandise trade more than tripled from $496 billion to $1.7 trillion (in chained 1992 dollars). In addition, the ratio of the value of U.S. merchandise trade relative to U.S. Gross Domestic Product (GDP) doubled from about 11 percent in 1980 to 23 percent in 1997. The trade relationship with Canada and Mexico has deepened over this period. In 1997, Canada and Mexico together accounted for 30 percent of all U.S. trade by value, up from 22 percent in 1980. Trade with Asian Pacific countries also grew in importance, so much so that in 1997, 5 Asian countries were among the top 10 U.S. trading partners.

In U.S. international trade, water was the predominant mode in terms of value and tonnage. In 1997, for example, waterborne trade accounted for more than three-quarters of the tonnage and 40 percent of the value of U.S. international trade. However, its share of the value of U.S. international trade declined from 62 percent in 1980. Because of the rise of trade with Asian Pacific countries a relative shift has occurred in freight handling from east coast to west coast ports. Since 1988, foreign trade tonnage moved by water increased by 25 percent while domestic freight tonnage moved by water remained about the same—1.1 billion tons.

Between 1980 and 1997, air freight's share of the value of U.S. international merchandise trade increased from 16 percent to nearly 28 percent. Commodities that move by air tend to be high in value; air's share of U.S. international trade by weight was less than 1 percent in 1997.

Passenger travel has grown rapidly in recent decades. In 1995, people averaged about 4.3 one-way trips per day and about 14,100 miles (39 miles per day) per year, up from 2.9 trips and 9,500 miles (26 miles per day) in 1977. Long-distance travel (trips 100 miles or more from home) also increased over this period from 2.5 roundtrips in 1977 to 3.9 in 1995. Several factors account for this increase in travel, including greater labor force participation, income, and vehicle availability, and reduced travel cost.

People travel primarily by personal-use vehicles (PUVs) for both local daily travel and more infrequent long-distance travel. Cars and other PUVs accounted for about 90 percent of local trips and 80 percent of long-distance trips. Bicycling and walking accounted for 6.5 percent of local trips and transit about 4 percent of local trips. Air transportation was the second most popular means of long-distance travel, accounting for 18 percent of trips, with buses about 2 percent and passenger trains about 0.5 percent of intercity trips.

Vehicle-miles traveled (vmt) by cars, trucks, and buses on public roads increased 68 percent between 1980 and 1997, with urban vmt growth outpacing rural vmt 83 percent to 49 percent. One result of this growth has been greater congestion in the nation's urban areas. According to the Texas Transportation Institute's (TTI) most recent analysis of urban highway congestion in 70 urban areas, the estimated level of congestion declined in only two—Phoenix and Houston—between 1982 and 1996. Congestion in most other urban areas increased, dramatically in some instances. According to TTI, the number of urban areas in the study experiencing unacceptable congestion rose from 10 of the 70 in 1982 to 39 in 1996, with the average roadway congestion index rising about 25 percent from 0.91 to 1.14. An index of 1.00 or greater was selected as the threshold for unacceptable congestion.

In the 1980s and 1990s, air travel also grew dramatically. Domestic and international passenger enplanements at U.S. airports increased from 302 million in 1980 to 575 million in 1997. On-time performance decreased only slightly since the early 1990s. The percentage of passengers denied boarding (i.e., "bumped" from flights because seats were oversold by the airline) on the 10 largest U.S. air carriers has risen appreciably since 1993 from 683,000 (0.15 percent of boardings) to 1.1 million passengers (0.21 percent of boardings) in 1997. While the percentage of mishandled baggage has declined steadily since 1992, the total number of consumer complaints against major air carriers received by the U.S. Department of Transportation (DOT) increased in 1997 for the second year in a row after several years of decline. In 1997, 86 out of every 1 million persons enplaned on a major airline registered a complaint with DOT, the highest rate since 1993.

Transit ridership remained relatively constant between 1987 and 1997 with 7.85 million unlinked trips in 1987 compared with 7.98 million in 1997, while miles traveled increased from about 36 billion to 40 billion. Riders on buses and heavy rail constitute the majority of transit users, but ridership stagnated over this period, while the number of riders on other modes—especially demand responsive service, light rail, and ferries—increased markedly. Ridership on commuter rail increased by a moderate amount. The performance and general quality of transit service in the United States seems to be improving, at least for federally subsidized transit, which accounts for approximately 90 to 95 percent of total transit passenger-miles.

While freight rail traffic increased, passenger rail traffic remained relatively constant. There were 20.2 million Amtrak passengers in FY 1997, about the same as the number in FY 1987.

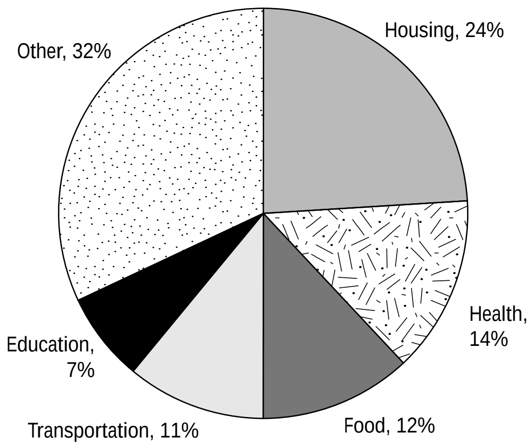
TRANSPORTATION AND THE ECONOMY

Measures of transportation's importance in the growing U.S. economy include the level of transportation-related production and consumption of goods and services, household spending, wages and salaries, and government revenues and expenditures.

In 1997, transportation-related goods and services contributed $905 billion, or about 11 percent, to U.S. GDP. This is the broadest measure of transportation's contribution to GDP. Transportation continued to rank fourth, after housing, health care, and food, in terms of societal demand for goods and services.

A narrower measure of transportation's economic role is the value-added by transportation services, both for-hire and in-house. This measure includes only those services that move peo-

Major Societal Functions in Gross Domestic Product: 1997



SOURCE: See table 3-3 in chapter 3.

ple and goods on the transportation system. In 1997, the for-hire transportation industry, together with warehousing, contributed $255 billion to the U.S. economy.

The contribution of transportation services conducted by nontransportation industries (in-house transportation) to GDP are calculated using the Transportation Satellite Accounts. According to a recent BTS report, *Transportation Satellite Accounts: A New Way of Measuring Transportation Services in America*, in-house transportation services contributed $121 billion in 1992, the most recent year analyzed.

Household expenditures also indicate the importance of transportation in the U.S. economy. In 1996, households spent, on average, $6,400 on transportation, which is about 17 percent of total expenditures. Vehicle purchases were the largest component of these expenditures. In 1996, southern and rural households spent more than 50 percent of their transportation budgets on purchasing new and used vehicles—more than other regions and urban households.

In terms of employment, the for-hire transportation industry's share of total employment changed little from 1990 to 1997, hovering around 3 percent of the total U.S. civilian labor force. The largest portion of for-hire transportation industry employment in 1997 was in the trucking and warehousing group (41 percent), but the group's annual growth rate was not as large as that of other modes such as transit. Also, trucking and warehousing had the largest share of the for-hire transportation industry's total wages and salaries in 1997, but the air transportation industry's share increased more dramatically. Similarly, truck drivers accounted for the largest percentage of transportation occupations in 1997 (67.8 percent), which was a slightly lower share than throughout the 1980s and 1990s. Occupations in the air mode experienced the fastest growth (12.4 percent gain) in 1997.

Based on limited data on transportation occupational wages and salaries, airline pilots and navigators were paid the most in 1997 (although earnings declined from the past year), while bus and taxi drivers were paid the least.

Labor productivity—the relationship between ton-miles or passenger-miles to number of employees or employee-hours—varied by transportation modes. In the railroad industry, labor productivity (measured by an index of passenger-miles, freight ton-miles, revenue, and other factors) went up between 1990 and 1996 by a total of 44.5 percent, which was faster than the petroleum pipeline industry (36.1 percent), the air transportation industry (both passenger and freight—19.5 percent), and the trucking industry (17.7 percent).

All levels of government benefit from revenues received from transportation. Transportation revenue growth fluctuated considerably over the past decade, but increased in constant dollars from $83.5 billion in FY 1994 to $86.7 billion in FY 1995. States generated nearly one-half of total government transportation revenues in 1995, followed by the federal government (32 percent) and local governments (20 percent). Highways generated $66.74 billion (current dollars) or 71 percent in 1995. Fuels taxes are an important source of highway revenue, accounting for 85.8 percent of the Highway Trust Fund and 60 percent of state highway revenues in 1995.

Government also contributed to transportation's role in the economy through public expenditures, including capital investment. All levels of government spent a total of $129.3 billion (current dollars) on all modes of transportation in 1995. State and local governments spent about 69 percent of total government transportation expenditures.

As in past years, more government funds were spent on highways than on all other transportation modes combined. In 1995, highway spending was $79.2 billion, about 61 percent of total government expenditures, while transit received about 20 percent. State and local governments continued to spend more on highways, transit, and pipelines, while the federal government spent more on air, water, and rail. In 1995, highways also continued to receive most (71 percent) of the $60.6 billion capital investment made by governments for infrastructure and equipment, a sum that is nearly half of all government expenditures. In 1996, transportation infrastructure capital stock in highways and streets was worth $1.3 trillion, nearly all owned by state and local governments.

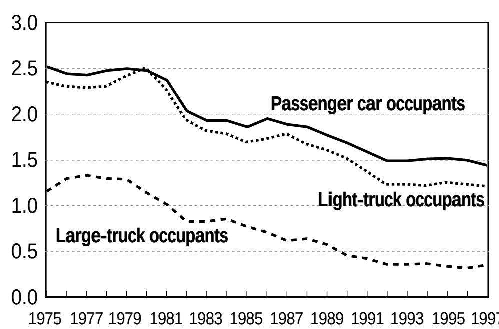
TRANSPORTATION SAFETY

Thanks to technological innovations, educational campaigns, and diligent enforcement efforts, the United States has made tremendous progress in transportation safety, especially in the last three decades. Despite all of these activities, work still remains. More than 44,000 people died in transportation incidents during 1997, equivalent to the population of a large suburban town. The number one goal of the Department of Transportation is to reduce this total in the years ahead.

Data show that the nation's highways and roads still account for 95 percent of all fatalities, although the rate of fatalities per 100 million vehicle-miles traveled has shown clear improvement over the past 25 years. In 1975, there were 3.4 motor vehicle-related fatalities per 100 million vmt, while in 1998 there were 1.6 fatalities per 100 million vmt. The rate shows only modest improvement in the 1990s, however. These figures include occupants of all types of highway vehicles and nonoccupants (e.g., pedestrians) as well. Ironically, media attention tends to focus on the much more infrequent air disasters. Worth noting is that 1998 marked the first year on record in which there were no onboard fatalities involving large, U.S.-flag air carriers.

Transportation, by its very nature, provides enhanced opportunities but also risks to those who travel, including pedestrians and bicyclists. In 1997, more than 5,300 pedestrians were killed in collisions involving motor vehicles. A high percentage of pedestrian fatalities were children, the elderly, people who walk after dark,

Occupant Fatality Rates for Selected Modes
Per 100 million vehicle-miles



SOURCE: See figure 4-1 in chapter 4.

and intoxicated individuals. In 1997, 814 bicyclists or pedalcyclists died and 58,000 were injured in traffic crashes with motor vehicles.

Despite our growing knowledge about transportation safety, there are still many unmet data needs, such as risk exposure measures for water and pipeline transportation. Even for highway exposure, the accuracy of vmt is unclear. To gain a deeper understanding of safety, exposure measures are needed for specific populations such as the elderly, as well as for specific conditions such as adverse weather.

Outcome data also need improvement. Statistics for fatalities, injuries, crashes, and property damages should be in a clear, easy-to-understand formats, distinguishing occupants from nonoccupants, and transportation incidents from nontransportation incidents. Ideally, all modes would have reporting frameworks, including definitions, measures, and explanatory text, that enable quick comparisons across transportation types. With increasing international motorization and globalization, the United States also needs to work with safety officials in other countries to develop statistics that permit valid comparisons across countries. In this manner, a robust stock of information about specific risk factors, causes, and societal impacts of transportation crashes and incidents can be built.

ENERGY

Petroleum provides about 97 percent of the transportation sector's energy requirements. In recent years, the abundance of petroleum supplies and low fuel prices has encouraged consumption and led to increased imports and greater dependence on foreign oil. The volume of imported oil exceeded domestic production in 1997, the first time in U.S. history.

Highway vehicles accounted for about 80 percent of total transportation energy use in 1997. Average fuel economy for the new passenger car fleet has ranged from 27.9 miles per gallon to 28.8 miles per gallon since 1988. Efficiency gains have been offset by the increases in the weight and power of passenger cars and shifts to less fuel-efficient vehicles. In 1997, sales of most light-truck classes gained while most automobile classes declined. Light trucks consume more fuel than cars.

Although technologies are available for raising vehicle efficiency further, there is little consumer demand or regulatory incentive for such improvement. Further, oil prices may remain low for a while, at least until Asian economies recover and their demand for oil increases. All these factors make it likely that petroleum consumption will continue to grow. While there is some interest in alternative and replacement fuels and electric vehicles that could reduce air emissions and oil dependence, those options still involve many uncertainties and limitations.

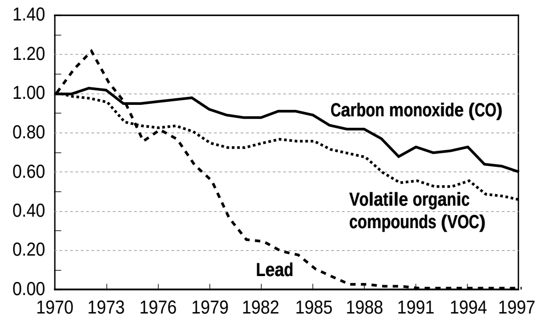
ENVIRONMENT

Serious environmental issues continue to be associated with transportation. The use of petroleum is responsible for most of the environmental problems resulting from transportation, including carbon dioxide emissions that may contribute to global climate change. In 1997, the transportation sector contributed about 26 percent of all U.S. emissions covered by an international agreement, the Kyoto Protocol. If Congress consents to the Protocol, the announced target for the United States will be 7 percent below the 1990 level for six greenhouse gases, averaged over the 2008 to 2012 period. Carbon emissions from automobiles can be limited by improving vehicle efficiency, shifting consumer purchases to favor more efficient cars, using nonfossil fuels, and driving less.

Emissions from mobile sources also continue to be the primary source of air pollutants, as well

National Transportation Emissions Trends Index: 1970–97

1970 = 1.0



NOTE: In estimating criteria and related pollutant emissions for 1997, the Environmental Protection Agency (EPA) made adjustments to prior years. For onroad mobile sources, EPA revised 1996 data. For nonroad mobile sources, EPA revised some estimates back to 1970. The figure reflects those changes and supercedes the similar figure 4-8 in *Transportation Statistics Annual Report 1998.*

SOURCE: See figure 5-8 in chapter 5.

as a significant source of hazardous toxic releases. Despite rapid growth in vehicle activity over the past two decades, emissions of carbon monoxide and volatile organic compounds have declined and lead emissions from gasoline have been eliminated, leading to improved air quality.

Mobile air conditioning systems in many vehicles emit chlorofluorocarbons and other chemicals that contribute to the depletion of the stratospheric ozone layer that protects the earth from harmful ultraviolet rays. Emissions, while declining, are expected to continue for a time because older units that use CFCs as a refrigerant are still in service.

Further, aircraft, particularly during the cruise phase, emit carbon dioxide, nitrogen oxides, and water vapor that have the potential to contribute to global atmospheric problems. Oil and gas pipeline systems also emit criteria and related pollutants that contribute to air pollution. The extent of some of these emissions and their impacts are being studied further.

Other impacts of vehicle travel include the accidents and leaks that result in spills of hazardous materials, such as crude oil and petroleum products. Recent data on oil pollution incidents in U.S. waters show that, despite annual variations, there has been an overall decline since the 1970s.

Noise is an impact of travel that affects many U.S. communities. Various noise standards now apply to different types of vehicles and equipment, and some progress is being made, particularly in addressing aircraft noise. In 1998, there was more than a 4 percent increase over the past year in the number of noise-certified aircraft (Stage 3 fleet mix), thus helping to lessen the noise problem in some communities.

The development of infrastructure for transportation vehicles, including highways, bridges, rail lines and marine ports and terminals, and airports, continues to have impacts on the land and can disrupt or displace people and wildlife. Maintenance and operation of these facilities also generates air and water pollutants, wastes, and noise. One specific problem for ports and navigation channels is the disposal of large volumes of dredged materials—273 million cubic yards from 1993 through 1997—some of it hazardous or toxic.

With the exception of waterway dredging by the U.S. Army Corps of Engineers, there are no trends data on infrastructure impacts. In addition, data on environmental impacts specific to airports must be aggregated or disaggregated from other sources.

Additional environmental impacts in the form of air and water pollutants and hazardous and nonhazardous solid wastes are associated with the manufacture, maintenance, support, and disposal of vehicles. The transportation equipment industry as a category has been a major contributor to onsite and offsite releases of toxic air pollutants.

To control gasoline evaporative emissions during refueling of vehicles, EPA requires the installation of fuel pumps at dispensing facilities to recover emissions, and vapor recovery systems in new light-duty vehicles. Fuel storage tanks buried underground are also a problem due to leaks and spills. As of 1998, progress has been made in closing tanks and conducting cleanups, although additional cleanup still needs to be done.

STATE OF TRANSPORTATION STATISTICS

Although transportation statistics are now more extensive and up-to-date than at any time in the last two decades, major challenges remain in meeting the emerging needs of the information age. The transportation community now requires that statistics be more complete, detailed, timely, and accurate than ever before. Transportation statistics remain incomplete despite major data-collection efforts of the past decade. For example, data have not yet been collected on the domestic movement of commodities traded internationally. The demand for completeness also extends to transportation impacts. These and other data not currently collected could provide valuable insights to decisionmakers at all levels of government.

The demand for detailed information recognizes the importance of geography-specific data in addressing transportation problems, such as congestion, and their effects on people and freight. Timely transportation data are needed to respond to rapidly changing conditions, especially in a global economy.

The Transportation Equity Act for the 21st Century (TEA-21) reaffirmed the data programs begun under the Intermodal Surface Transportation Efficiency Act of 1991. It also added several new areas of study, including global competitiveness, the relationships between highway transportation and international trade, bicycle and pedestrian travel, and an accounting of expenditures and capital stocks related to transportation infrastructure.

TEA-21 requires BTS to maintain two databases: The National Transportation Atlas Database (NTAD) and the Intermodal Transportation Database (ITDB). NTAD provides information on facilities, services on facilities (e.g., railroad trackage rights), flow over facilities, and background data, such as political boundaries, economic activity, and environmental conditions. The ITDB, when fully developed, will describe the basic mobility provided by the transportation system, identify the denominator for safety rates and environmental emissions, illustrate the links between transportation activity and the economy, and provide a framework for integrating critical data on all aspects of transportation. The ITDB will also provide a framework for identifying and filling data gaps in essential information. One of the biggest gaps involves the domestic transportation of international trade.

TEA-21 and a recent report by the National Research Council Committee on National Statistics emphasized the need to improve transportation data quality and comparability. From the BTS perspective, improving transportation data quality and comparability will require the adoption of common definitions, adherence to good statistical practice, the replacement of questionnaires with unobtrusive methods of data collection, and the validation of statistics used in performance measures and other applications. As part of its effort to improve the quality of statistics, BTS is working with the Federal Highway Administration to coordinate the American Travel Survey and the Nationwide Personal Transportation Survey in order to develop better estimates of mid-range travel (30 miles to 99 miles), and improve data comparability and analysis of the continuum of travel from short walking trips to international air travel.

BTS also will continue to work with its partners and customers to ensure that its statistics are relevant for transportation decisionmakers at all levels of government, transportation-related associations, private businesses, and consumers. To further this, BTS cosponsored a national conference on economic data needs and is hosting workshops on transportation safety data needs. In addition, BTS will begin to analyze existing data for the congressionally mandated study of domestic transportation of commodities traded internationally. Furthermore, BTS will continue to participate in the North American Interchange on Transportation Statistics and host working groups on geospatial and maritime data, performance measures, and other topics.

System Extent and Condition

The U.S. transportation system makes possible a high level of personal mobility and freight activity for the nation's 268 million residents and nearly 7 million business establishments. In 1997, they had at their disposal over 230 million motor vehicles, transit vehicles, boats, planes, and railroad cars that circulated over 4 million miles of highways, railroads, and waterways connecting all parts of the United States, the fourth largest nation in land area. The transportation system also includes over 500,000 miles of oil and gas transmission pipelines (enough pipeline to circle the earth nearly 20 times), 18,000 public and private airports (an average of about 6 per county), and transit systems offering half the urban population access to a transit route within one-quarter mile of their home. In addition to traditional infrastructure components, advanced communications and information technologies are emerging as integral parts of transportation systems. These technologies help people and businesses use transportation more efficiently by providing the capability to monitor, analyze, and control infrastructure and vehicles, and by providing real-time information to system users.

In 1997, passenger-miles of travel in the United States totaled approximately 4.6 trillion. Americans averaged 39 miles of local travel per day in 1995, roughly the straight-line distance between Baltimore and Washington, DC. If summed up for the entire year, the local and long-distance travel-miles of the typical American would extend more than halfway around the world. As for freight, preliminary estimates by the Bureau of Transportation Statistics (BTS) show that domestic commodity shipments in 1997 produced 3.9 trillion ton-miles of activity, 10 percent more than in 1993. (The estimate is based on the Commodity Flow Survey conducted in both years by BTS and the Census Bureau, plus additional data on underrepresented movements).

This chapter discusses the physical extent and condition of the nation's transportation system, updating information in previous editions of the *Transportation Statistics Annual Report* (TSAR). Table 1-1 provides a snapshot of the key elements of the transportation system by mode. Where information is available, the chapter reports on the operating condition of transportation vehicles and the infrastructure they use. The topics in this chapter are presented by mode, except for a discussion of intelligent transportation system (ITS) components, because ITS is multimodal in nature. This year's report profiles in more detail the extent and condition of the rail transportation system (prior editions of the TSAR focused on domestic water transportation, urban transit, and commercial aviation). The rail profile includes discussion of the status of high-speed rail projects in the United States and use of information technology by railroads to improve safety. Trends in passenger travel, freight movement, and transportation system performance are discussed in chapter 2.

HIGHWAY

In the United States, public roads—an extensive network that ranges from unpaved farm roads to 16-lane freeways—carry over 90 percent of all passenger trips and over half the freight tonnage. The number of miles of public roads has increased year by year, but by small amounts in relation to the overall size of the system (see figure 1-1 on page 21). Between 1987 and 1997, about 55,000 miles of public roads were added to the system, increasing total miles to 3.94 million—less than a 2.0 percent increase over 10 years. The size of the highway system in urban areas grew more, by about 15 percent since 1987, although much of the growth was due to changes in classification rather than construction of new mileage (USDOT FHWA 1997, table HM-20; USDOT FHWA Annual editions, table HM-20). The growth in urban mileage is due primarily to expanding urban boundaries and additional areas being defined as urban, and not to highway construction. Even though public road mileage is relatively static, the number of lane-miles of highways has risen as roads are expanded from two lanes to four or more. There were nearly 61,000 new lane-miles added in 1997 alone, bringing the total to around 8.24 million (USDOT FHWA 1998a, table HM-60).

Paved roadways constituted about 61 percent of all highway mileage in 1997, up from 56 percent in 1987. Nearly all of the public roads in urban areas are paved. However, about half the miles of rural public roads are unpaved, accounting for 98 percent of total unpaved public road miles—much the same ratio as in 1987 (USDOT FHWA Annual editions, table HM-51). The quality of roads is more difficult to evaluate than their extent. Furthermore, long-term trends in the condition of the nation's roads are particularly hard to assess because the Federal Highway Administration (FHWA) has been in the process of changing to a different assessment methodology. In 1993, FHWA began using a road quality measure called the International Roughness Index (IRI) to evaluate part of the highway system: the so-called higher functional-class roadways, consisting of urban and rural Interstates, freeways, expressways and other principal arterials, and rural principal and minor arterials. The IRI shows moderate improvement in pavement conditions on these highways in both urban and rural areas between 1994 and 1997. The per-

Table 1-1
Major Elements of the Transportation System: 1997

Mode	Major elements	Components
Highways[1]	Public roads and streets; automobiles, vans, trucks, motorcycles, taxis, and buses operated by transportation companies, other businesses, governments, and households; garages, truck terminals, and other facilities for motor vehicles	*Public roads*[2] 46,068 miles of Interstate highways 112,855 miles of other National Highway System (NHS) roads 3,785,674 miles of non-NHS roads *Vehicles and use* 130 million cars, driven 1.5 trillion miles 70 million light trucks, driven 0.9 trillion miles 7.1 million commercial trucks with 6 tires or more, driven 0.2 trillion miles 697,548 buses, driven 6.8 billion miles 3.8 million motorcycles, driven 10.1 billion miles
Air	Airways and airports; airplanes, helicopters, and other flying craft for carrying passengers and cargo	*Airports* 5,357 public-use airports 12,988 private-use airports *Airports serving large certificated carriers*[3] 29 large hubs (75 airports), 431 million enplaned passengers 32 medium hubs (57 airports), 92 million enplaned passengers 58 small hubs (75 airports), 37 million enplaned passengers 603 nonhubs (840 airports), 15 million enplaned passengers
		Aircraft 7,616 certificated air carrier aircraft,[4] 4.9 billion domestic miles flown[5] 192,000 active general aviation aircraft,[6] 3.9 billion statute-miles flown *Passenger and freight companies*[5] 91 carriers 549 million domestic revenue passenger enplanements 13.6 billion domestic revenue ton-miles of freight shipments *Certificated air carriers (domestic and international)* Majors: 13 carriers, 598,000 employess, 527 million revenue passenger enplanements Nationals: 31 carriers, 49,000 employees, 68 million revenue passenger enplanements Regionals: 47 carriers, 12,000 employess, approximately 10 million revenue passenger enplanements

(continued on following page)

1 U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: 1998), tables HM-20 and HM-14.
2 Does not include Puerto Rico.
3 U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Airport Activity Statistics of Certificated Air Carriers,12 Months Ending December 31, 1997* (Washington, DC: 1998).
4 U.S. Department of Transportation, Federal Aviation Administration, personal communication. Note: This total excludes aircraft used as on-demand air taxis.
5 U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Air Carrier Statistics Monthly* (Washington, DC: 1998). Note: These data are for large certificated carriers.
6 U.S. Department of Transportation, Federal Aviation Administration, *General Aviation and Air Taxi Activity Survey, Calendar Year 1997*, FAA-APO-99-4 (Washington, DC: 1999).

Table 1-1
Major Elements of the Transportation System: 1997 ***(continued)***

Mode	Major elements	Components
Rail[7]	Freight railroads and Amtrak	*Miles of road operated* 121,670 miles by major (Class I) railroads 21,466 miles by regional railroads 28,149 by local railroads 22,000 miles by Amtrak (FY 1998) *Equipment* 1.3 million freight cars 19,684 freight locomotives in service *Freight railroad firms* Class I: 9 systems, 177,981 employees, 1.3 trillion ton-miles of freight carried Regional: 34 companies, 10,995 employees Local: 507 companies, 11,741 employees *Passenger (Amtrak, FY 1998)* 24,000 employees, 1,962 passenger cars 345 locomotives, 21.1 million passengers carried
Transit[8]	Commuter trains, heavy-rail (rapid rail) and light-rail (streetcar) transit systems, local transit buses, vans and other demand responsive vehicles, and ferry boats	*Vehicles* 54,946 buses, 17.5 billion passenger-miles 11,290 heavy and light rail, 13.1 billion passenger-miles 5,425 commuter rail, 8.0 billion passenger-miles 87 ferries, 254 million passenger-miles 19,820 demand responsive, 0.5 billion passenger-miles 6,813 other vehicles, 0.8 billion passenger-miles Employment in urban transit: 326,000
Water	Navigable rivers, canals, the Great Lakes, St. Lawrence Seaway, Intracoastal Waterway, and ocean shipping channels; ports; commercial ships and barges, fishing vessels, and recreational boating	*U.S.-flag fleet* Great Lakes: 737 vessels,[9] 62 billion ton-miles (domestic commerce)[10] Inland: 33,668 vessels,[9] 294 billion ton-miles (domestic commerce)[10] Ocean: 7,014 vessels,[9] 350 billion ton-miles (domestic commerce)[10] Recreational boats: 12.3 million[11] Cruise ships: 122 serving North American ports, 5.4 million passengers[12] *Ports[13]* Great Lakes: 340 terminals, 483 berths Inland: 1,812 terminals Ocean: 1,574 terminals, 2,675 berths

(continued on following page)

7 Unless otherwise noted, all freight rail data from Association of American Railroads, *Railroad Facts: 1997* (Washington, DC: 1998); all Amtrak information from National Railroad Passenger Corp., *Amtrak Annual Report 1997* (Washington, DC: 1998), statistical appendix.
8 U.S. Department of Transportation, Federal Transit Administration, National Transit Database 1997.
9 U.S. Army Corps of Engineers, Water Resources Support Center, *1997 Vessel Characteristics Database* (Fort Belvoir, VA: 1999).
10 U.S. Army Corps of Engineers, Water Resources Support Center, *Waterborne Commerce of the United States 1997* (Fort Belvoir, VA: 1999). Domestic ton-miles include commerce among the 48 contiguous states, Alaska, Hawaii, Puerto Rico, the Virgin Islands, Guam, American Samoa, Wake Island, and the U.S. Trust Territories. Domestic total does not include cargo carried on general ferries, coal and petroleum products loaded from shore facilities directly into bunkers of vessels for fuel, and insignificant amounts of government materials (less than 100 tons) moved on government-owned equipment in support of U.S. Army Corps of Engineers projects. Fish are also excluded from internal (inland) domestic traffic.
11 U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: 1998).
12 Ship: U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Analysis, personal communication, 1999; Passengers: *Cruise Industry News 1998 Annual.* Edited by O. Mathisen. New York, NY: Oivind and Angela Mathisen.
13 U.S. Department of Transportation, Maritime Administration, *A Report to Congress on the Status of the Public Ports of the United States: 1996–1997* (Washington, DC: 1998).

Table 1-1
Major Elements of the Transportation System: 1997 ***(continued)***

Mode	Major elements	Components
Pipeline	Crude oil, petroleum product, and natural gas lines	*Oil (1996)*[14] Crude lines: 114,000 miles, 338 billion ton-miles transported Product lines: 86,500 miles, 281 billion ton-miles transported, 160 companies regulated by FERC, 14,500 employess Gas American Gas Association estimates[15] Transmission: 256, 000 miles of pipe Distribution: 955,300 miles of pipe, 198 companies, 155,000 employees

[14] Eno Foundation, Inc., *Transportation in America, 1998* (Washington, DC: 1999).
[15] American Gas Association, *Gas Facts* (Washington, DC: 1998).

KEY: FERC = Federal Energy Regulatory Commission; FY = fiscal year.

SOURCE: Unless otherwise noted, U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at www.bts.gov.

centage of these roadways in fair or better condition increased, although in 1997 conditions on urban roadways classified as other principal arterials decreased slightly.

An older index, the Present Serviceability Rating (PSR), continues to be used to assess conditions for other highway functional classes (rural major collectors, urban minor arterials, and urban collectors) and to provide historical data for all classes prior to 1993. In 1997, 561,000 miles of highway were reported in these categories, whereas the number of miles assessed by the IRI was 316,000. The overall condition of urban minor arterials (as measured using the PSR) worsened a bit from 1994 to 1997 (see table 1-2), and the condition of urban collectors improved very little. The percentage of rural major collectors in fair or better condition improved from 71.5 percent in 1994 to 79.9 percent in 1997. However, the reported number of miles of rural major collector dropped 10.4 percent between 1994 and 1997, making it unclear whether conditions actually improved (USDOT FHWA Annual editions, tables HM-63 and HM-64; USDOT BTS 1998, table 1-38).

The condition of U.S. bridges has improved noticeably since 1990 (see table 1-3). Of the 583,000 bridges in operation in 1997, about 30 percent were either structurally deficient or functionally obsolete compared with over 41 percent in 1990. In general, bridges on roads in higher functional classes, such as Interstates and other principal arterials, are more likely to be structurally sound than are those on lower functional classes, such as collectors and local roads. Except for bridges on local roads, a higher percentage of rural bridges are structurally and functionally sound compared with their urban counterparts (USDOT FHWA 1998b).

The nation's highway vehicle fleet consisted of about 212 million vehicles in 1997, nearly 28 million more vehicles than a decade earlier. The composition of vehicles in the fleet changed as more people bought pickup or other light trucks, sport utility vehicles (SUVs), and vans (see figure 1-2). These vehicles' share of the fleet increased from 22 percent in 1987 to 33 percent in 1997, when there were over 70 million registered light trucks, SUVs, and vans. The number of registered automobiles fell from its historic high of

Table 1-2
Highway Pavement Conditions: 1994–97

Highway functional class	Year	Poor	Mediocre	Fair	Good	Very good	Total miles reported	Poor or mediocre	Fair or better
URBAN									
Interstate	1994	13.0%	29.9%	24.2%	26.7%	6.2%	12,338	42.9%	57.1%
	1995	10.4%	26.8%	23.8%	27.5%	11.4%	12,307	37.2%	62.7%
	1996	8.6%	28.3%	24.7%	30.7%	7.6%	12,430	36.9%	63.0%
	1997	9.0%	27.0%	24.4%	32.9%	6.7%	12,477	36.0%	64.0%
Other freeways/ expressways	1994	5.3%	12.7%	58.1%	20.9%	2.9%	7,618	18.0%	81.9%
	1995	4.8%	9.8%	54.7%	20.4%	10.3%	7,804	14.6%	85.4%
	1996	3.4%	8.7%	54.7%	26.3%	6.8%	8,410	12.1%	87.8%
	1997	12.0%	34.2%	24.3%	25.2%	4.2%	8,480	12.0%	88.0%
Other principal arterials	1994	12.5%	16.3%	50.8%	16.6%	3.8%	38,598	28.7%	71.2%
	1995	12.4%	14.7%	47.2%	15.9%	9.7%	41,444	27.1%	72.8%
	1996	11.8%	14.1%	48.9%	17.5%	7.7%	44,498	25.9%	74.1%
	1997	26.7%	33.0%	16.5%	17.8%	6.0%	45,009	26.7%	73.3%
Minor arterials	1994	6.7%	12.3%	38.1%	20.5%	22.1%	87,852	19.0%	80.7%
	1995	6.7%	13.6%	36.9%	20.4%	22.1%	88,510	20.3%	79.4%
	1996	6.9%	13.0%	37.9%	20.7%	21.1%	89,020	19.9%	79.7%
	1997	7.2%	13.0%	37.9%	21.4%	20.6%	88,484	20.2%	79.8%
Collectors	1994	9.8%	16.2%	40.0%	17.0%	16.0%	86,098	26.0%	73.0%
	1995	9.7%	16.8%	39.0%	17.2%	16.6%	87,331	26.5%	72.8%
	1996	9.7%	16.6%	39.2%	18.2%	15.4%	87,790	26.3%	72.8%
	1997	10.6%	16.0%	39.0%	18.4%	15.9%	86,666	26.6%	73.4%
Urban subtotal	1994	9.1%	15.4%	40.8%	18.9%	15.3%	232,504	24.4%	75.1%
	1995	8.9%	15.5%	39.4%	18.8%	17.0%	237,396	24.5%	75.2%
	1996	8.8%	15.1%	40.3%	19.9%	15.4%	242,148	23.9%	75.6%
	1997	9.3%	15.0%	40.5%	20.4%	14.9%	241,116	24.3%	75.8%

(continued on following page)

135 million in 1989, but the nearly 130 million automobiles in use in 1997 still accounted for about 61 percent of the highway vehicle fleet (USDOT FHWA 1997).

The total number of larger single-unit trucks (large trucks on a single frame with at least 2 axles and 6 tires), combination trucks (power units—trucks or truck tractors—and one or more trailing units), and buses increased over the decade. Registrations of 2-axle single-unit trucks with 6 tires or more grew from 4.2 million in 1987 to 5.3 million in 1997, and combination truck registrations increased from 1.5 million to 1.8 million. Bus registrations grew from 602,000 to 698,000 during this period.

Motorcycle registrations declined, dropping from 4.9 million to 3.8 million over the same decade—a 22 percent decrease (USDOT FHWA 1997).

According to the 1995 Nationwide Personal Transportation Survey, nearly 92 percent of all households in the United States owned at least

Table 1-2

Highway Pavement Conditions: 1994–97 ***(continued)***

Highway functional class	Year	Poor	Mediocre	Fair	Good	Very good	Total miles reported	Poor or mediocre	Fair or better
RURAL									
Interstates	1994	6.5%	26.5%	23.9%	33.2%	9.9%	31,502	33.0%	67.0%
	1995	6.2%	20.7%	22.3%	36.9%	13.9%	31,254	26.9%	73.1%
	1996	3.9%	19.1%	21.7%	38.8%	16.6%	31,312	23.3%	76.6%
	1997	3.6%	19.1%	20.7%	41.0%	15.7%	31,431	22.7%	77.3%
Other principal arterials	1994	2.4%	8.2%	57.4%	26.6%	5.4%	89,506	10.6%	89.4%
	1995	4.4%	7.6%	51.1%	27.9%	9.0%	89,265	12.0%	88.0%
	1996	1.4%	5.8%	49.1%	34.4%	9.3%	92,103	7.4%	92.6%
	1997	1.6%	4.9%	47.7%	37.2%	8.6%	92,170	6.5%	93.5%
Minor arterials	1994	3.5%	10.5%	57.9%	23.6%	4.5%	124,877	14.0%	86.0%
	1995	3.7%	9.0%	54.7%	23.9%	8.7%	121,443	12.7%	87.3%
	1996	2.3%	8.2%	50.7%	31.0%	7.7%	126,381	10.6%	89.4%
	1997	2.3%	6.7%	50.4%	33.6%	7.0%	126,525	9.0%	91.0%
Major collectors	1994	6.5%	11.3%	33.5%	16.1%	21.9%	431,111	17.8%	71.5%
	1995	6.5%	11.4%	30.8%	17.4%	23.7%	431,712	17.9%	71.9%
	1996	6.7%	10.3%	34.4%	20.0%	18.4%	432,117	19.8%	70.1%
	1997	7.8%	12.3%	37.6%	23.0%	19.3%	386,122	20.1%	79.9%
Rural subtotal	1994	5.4%	11.4%	40.7%	19.7%	16.0%	676,996	16.9%	76.3%
	1995	5.7%	10.4%	38.1%	20.1%	18.8%	643,749	16.1%	77.0%
	1996	5.0%	9.7%	38.8%	24.8%	14.8%	681,913	14.7%	78.4%
	1997	5.6%	10.4%	40.8%	28.1%	15.1%	636,248	16.0%	84.0%
URBAN AND RURAL									
	1994	6.3%	12.4%	40.7%	19.5%	15.8%	909,500	18.8%	76.0%
	1995	6.6%	11.8%	38.4%	19.8%	18.3%	881,145	18.4%	76.5%
	1996	6.0%	11.2%	39.2%	23.5%	15.2%	924,061	17.2%	79.2%
	1997	6.6%	11.7%	40.7%	26.0%	15.0%	877,364	18.3%	81.7%

NOTES: Numbers may not total due to rounding. Condition for rural and urban Interstates and other principal arterials, urban other freeways and expressways, and rural minor arterials based on International Roughness Index data from the Federal Highway Administration. Condition for urban minor arterials and collectors and rural major collectors based on Present Serviceability Rating data from the Federal Highway Administration.

KEY: **Poor** = needs immediate improvement. **Mediocre** = needs improvement in the near future to preserve usability. **Fair** = will likely need improvement in the near future, but depends on traffic use. **Good** = in good condition; will not require improvement in the near future. **Very good** = new or almost new pavement; will not require improvement for some time.

SOURCES: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual editions), tables HM-63 and HM-64. U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming).

Table 1-3
Highway Bridge Conditions: 1990 and 1997

	1990				1997			
Functional category	Percentage structurally deficient	Percentage functionally obsolete	Percentage in good condition	Total bridges	Percentage structurally deficient	Percentage functionally obsolete	Percentage in good condition	Total bridges
RURAL								
Principal arterials—Interstates	5.2	20.9	73.9	29,076	4.5	12.2	83.3	28,073
Principal arterials—Other	8.4	14.9	76.7	32,169	7.0	10.7	82.3	34,813
Minor arterials	14.1	14.5	71.3	40,927	10.4	11.8	77.9	38,401
Major collectors	19.5	13.3	67.2	103,979	13.4	10.4	76.2	95,751
Minor collectors	23.2	16.0	60.8	48,797	17.0	10.9	72.1	47,390
Local roads	38.1	15.2	46.7	208,487	26.1	11.3	62.6	210,678
Total rural	**26.1**	**15.1**	**58.8**	**463,435**	**18.4**	**11.1**	**70.5**	**455,106**
URBAN								
Principal arterials—Interstates	9.9	30.2	60.0	24,435	7.4	19.4	73.2	27,142
Principal arterials—other freeways/expressways	9.2	32.0	58.8	11,890	7.0	20.1	72.9	15,170
Other principal arterials	15.9	27.0	57.1	21,403	11.9	21.7	66.4	23,297
Major arterials	17.4	29.0	53.7	18,580	13.4	25.3	61.3	23,300
Collectors	20.2	29.0	50.8	11,876	15.2	23.4	61.4	14,939
Local roads	21.0	21.7	57.3	20,586	15.1	17.6	67.3	24,780
Total urban	**15.5**	**27.8**	**56.7**	**108,770**	**11.6**	**21.0**	**67.3**	**127,628**
URBAN AND RURAL	24.1	17.5	58.4	572,205	16.9	13.3	69.8	582,734

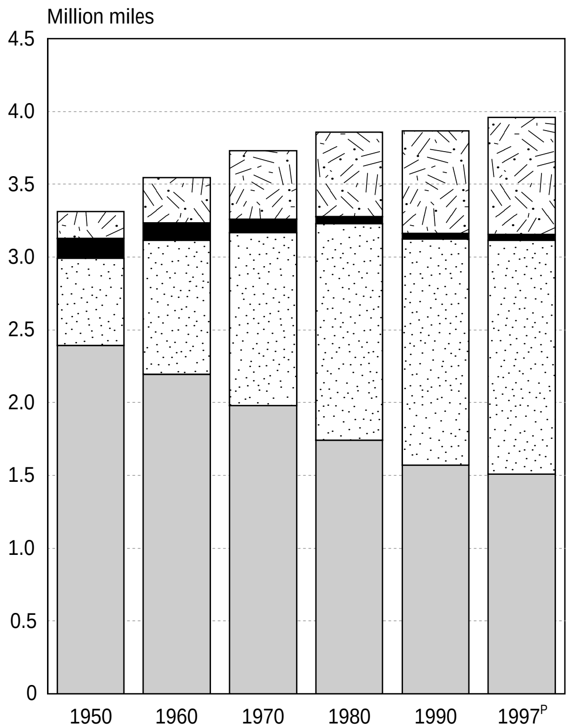
SOURCE: U.S. Department of Transportation, Federal Highway Administration, National Bridge Inventory Database, 1998.

one vehicle in that year, with an average of about 1.8 vehicles per household. Households without at least one vehicle fell from about 11.5 million (15 percent of all households) in 1977 to about 8 million (8 percent of households) in 1995. Nearly one-fifth of low-income households (those earning less than $25,000 per year) had no vehicle in 1995 (ORNL 1999, 7, 9, 28, 29).

The cars and trucks driven in the United States are older now, on average, than a decade or so ago. The median age of an automobile in 1997 was 8.1 years, compared with 6.9 years in 1987 and 5.6 years in 1977. Median truck age increased to 7.8 years in 1997, compared with 7.6 in 1987 and 5.7 in 1977.[1] (Polk 1999; USDOT BTS 1998, table 1-37). Although it is the only national indicator available, age is not necessarily a good indicator of vehicle condition, as the median age of vehicles is affected by many factors, including changes in vehicle quality, vehicle costs, and overall economic conditions.

[1] Median truck age is based on the ages of all trucks, including light-duty trucks.

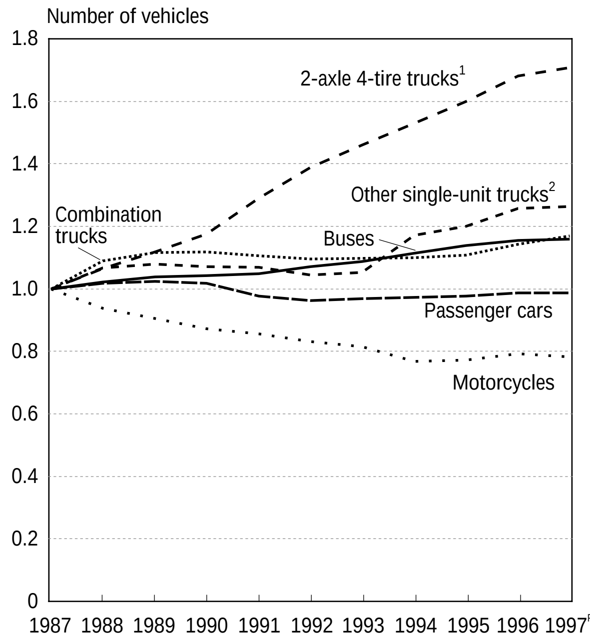
Figure 1-1
Urban and Rural Roadway Mileage by Surface Type: 1950–97



KEY: P = preliminary.

SOURCES: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual editions), table HM.
______. *Highway Statistics Summary to 1995* (Washington, DC: 1997), table HM-212.

Figure 1-2
Registered Highway Vehicle Trends: 1987–97
Index: 1987 = 1.0



[1] Includes vans, light trucks, and sport utility vehicles.
[2] Includes all single-unit trucks with at least 2 axles and 6 tires.

KEY: P = preliminary.

SOURCES: 1987–95: U.S. Department of Transportation, Federal Highway Administration. *Highway Statistics Summary to 1995* (Washington, DC: 1997), table MV-201 and VM201a.
1996–1997: _____. *Highway Statistics 1997* (Washington, DC: 1999), table VM-1.

RAIL

In 1997, there were nine Class I freight railroads (railroads with operating revenues of $256.4 million or more) in the United States. These railroads accounted for 71 percent of the industry's 171,285 miles operated, 89 percent of its approximately 201,000 employees, and 91 percent of its $35.3 billion in freight revenue. There were 34 regional railroads (those with operating revenues between $40 million and $256.4 million and/or operating at least 350 miles of road). The regional railroads operated 21,466 miles, had about 11,000 employees, and earned $1.6 billion in freight revenue. There were 507 local railroads (falling below the regional railroad threshold, and including switching and terminal railroads) operating over 28,149 miles of road. They had slightly under 12,000 employees and earned $1.4 billion in freight revenue (AAR 1998, 3).

These freight railroads maintain their tracks, rights-of-way, and fleets of railcars and locomotives. Over the years, through mergers and rationalization of their physical plants, many little-used lines were abandoned or sold to smaller railroads. Since 1980, the Class I railroads increased their traffic (measured in ton-miles) by 47 percent, while their network (miles of road owned) declined by 38 percent (AAR 1998, 6, 44). Traffic density increased as traffic was concentrated over a smaller network. Because of this increased density, some railroads expanded capacity in their highest density corridors by double-tracking, such as was done by CSX in Ohio in the last few years. In some cases, railroads have even tripled or quadrupled their track on stretches of rail line where traffic is very heavy.

As for passenger rail, the National Railroad Passenger Corporation, more widely known as Amtrak, has operated a national passenger system since May 1971. Amtrak was created by the Rail Passenger Service Act of 1971 ". . . to operate a national rail passenger system which ties together existing and emergent regional rail passenger service and other intermodal passenger service." During fiscal year (FY) 1998 (October 1, 1997 to September 30, 1998), Amtrak operated more than 250 intercity trains per day along a 22,000 route-mile railroad network in 44 states with service to more than 500 communities. In FY 1998, Amtrak carried 21.1 million intercity passengers, generating a total of 5.3 billion passenger-miles (up from FY 1996 and FY1997, but still below other years in the 1990s) and 54 million commuters carried under contract with transit authorities (NRPC 1998, 47–50). Amtrak also relies on an extensive feeder bus network to carry rail passengers to and from off-line locations.

Over the past several years, Amtrak has ordered and taken delivery of about 200 bi-level Superliners (designed to replace aging Heritage equipment) and 50 Viewliners servicing the Midwest and the East Coast). The Viewliners are the first single-level sleeping cars manufactured in the United States in 40 years. Amtrak also replaced their aging F-40 locomotives with 150 nearly new locomotives.

High-speed passenger rail service continues to build momentum, albeit slowly. Box 1-1 discusses its status in the United States.

AIR

Air transportation is the fastest growing transportation mode. Domestic passenger-miles of air travel more than doubled since 1980, while ton-miles of freight carried by air increased threefold.[2] Airway system mileage increased from 341,000 miles in 1980 to 394,000 in 1995; no estimates are available for 1996 and 1997. In 1997, the United States had 18,345 airports of all sizes and descriptions, about 20 percent more than in 1980. The increase over the period is explained by the addition of over 3,200 general aviation airports, which totaled 17,685 in 1997. Certificated airports (those serving scheduled air carrier operations with aircraft seating more than 30 passengers), on the other hand, decreased from 730 in 1980 to 660 in 1997.[3] This decline probably reflects the influence of the hub-and-spoke systems used by most major airlines since airline deregulation in the late 1970s (USDOT BTS 1998, table 1-2).

Airport runway quality improved from 1986 to 1997. The percentage of public-use airports with paved runways increased slightly, as did the percentage with lighted runways (USDOT BTS 1998, table 1-2). Runway pavement quality also improved at the subset of airports listed in the Federal Aviation Administration's National Plan of Integrated Airport Systems (NPIAS). The NPIAS's classification of airports includes those with commercial service, all reliever airports, and selected general aviation airports. Runways in poor to fair condition dropped from 39 percent in 1986 to 28 percent in 1997, while those in good condition rose from 61 percent to 72 per-

[2] Travel and freight estimates apply to large U.S. air carriers that file Form 41 with BTS's Office of Airline Information, rather than the entire certificated fleet.

[3] The number of certificated airports differs from that for airports serving large certificated carriers shown in table 1-1.

Box 1-1

High-Speed Rail Corridor Status

In recent years, high-speed rail (HSR) service for intercity passengers has experienced renewed interest. Several parts of the country have produced HSR plans and some corridors are undertaking development activities (see map). Section 1010 of the Intermodal Surface Transportation Efficiency Act of 1991 authorized funding for elimination of grade-crossing hazards in designated HSR corridors. The provision was continued in Section 104(c) of the Transportation Equity Act for the 21st Century (TEA-21) of 1998.

Northeast and Empire Corridors

The Northeast Corridor (NEC) handles approximately half of Amtrak's intercity passengers. Amtrak plans high-speed passenger service along the entire NEC between Washington, DC, and Boston. Its goal is to reduce travel times to 3 hours between New York City and Boston and 2½ hours between Washington, DC, and New York City. When an overhead electric power supply system, known as a catenary, between New Haven, Connecticut, and Boston is completed in 2000, all 456 miles of the NEC will be electrified. Other infrastructure investments needed to meet the trip-time goals include additional tracks to separate high-speed intercity trains from slower commuter operations, straightening curves within the boundaries of existing rights-of-way, and modernization of train control systems. Amtrak plans to place 20 high-speed (up to 150 miles per hour—mph) all-electric trainsets in service along the NEC by the end of 2000.

TEA-21 designated the "Empire Corridor" from New York to Albany and on to Buffalo as a high-speed corridor under Section 1103(c). In late 1998, Amtrak officials and New York's Governor announced a 5-year, $185 million plan to upgrade the New York City/Albany/Buffalo line and rebuild trains used on the route. Travel times for the 141-mile New York City-Albany trip could be reduced to under 2 hours. A second track will be built between Albany and Schenectady, and the track between Albany and Buffalo will be upgraded, cutting as much as 1 hour off the 7½-hour trip between New York City and Buffalo.

California Corridor

California has spent or committed nearly $800 million to upgrade the San Francisco-Oakland-Sacramento-Los Angeles-San Diego Corridor, near which 90 percent of the state's population lives. This HSR corridor contains approximately 600 at-grade crossings. The state has received $5.7 million in federal funds to close redundant crossings and upgrade the corridor's other public and private crossings. Amtrak plans to acquire eight trainsets to be used in Amtrak's San Diegan service from San Diego to Los Angeles, Santa Barbara, and San Luis Obispo.

California's High Speed Rail Authority is preparing a state plan for HSR for the Governor and the legislature. Its predecessor, the California Intercity High-Speed Rail Commission, had recommended two options for a 676-mile statewide HSR network. One would cost $23.3 billion, the other (a magnetic levitation system) $31.6 billion—public works projects on a scale with California's freeway system. In February 1999, the Authority decided on a less ambitious HSR plan. It proposed a very high-speed (186 mph) grade-separated service only from Los Angeles to San Francisco. San Diego, Sacramento, and other system routes would be served by a high-speed feeder network operating at 100 mph.

Pacific Northwest Corridor (Cascadia)

The Pacific Northwest Corridor extends from Eugene, Oregon, to Vancouver, British Columbia. Washington State's Department of Transportation and Amtrak have purchased four high-speed trainsets, which are now operating in the corridor.

Chicago Hub Network

• *Midwest Regional Rail Initiative.* In August 1998, nine midwestern states released an HSR corridor study. The study found that, by upgrading routes now in place and using diesel multiple unit power, speeds of up to 110 mph could be achieved at a cost of about $3.5 billion to upgrade the tracks and signals and to purchase equipment. The plan would take about six years to implement. The plan has a positive benefit to cost and operating ratio. The states are seeking funding to continue work on HSR.

• *Detroit-Chicago Segment.* Michigan is demonstrating an advanced communications-based train control system on an 80-mile section of the Detroit-Chicago corridor. The system ensures safe distances between trains operating at speeds of up to 100 mph. (See box 1-3 later in the chapter for details.)

• *St. Louis-Chicago Segment.* Six miles of Union Pacific track are being rehabilitated to provide a less congested

(continued on following page)

Box 1-1

High-Speed Rail Corridor Status *(continued)*

alternative route across the Mississippi River into St. Louis. Amtrak trains would be rerouted to achieve more direct access to the St. Louis terminal and to reduce mixing of freight and passenger traffic. The current travel time would be reduced by more than 20 minutes and on-time performance would be improved.

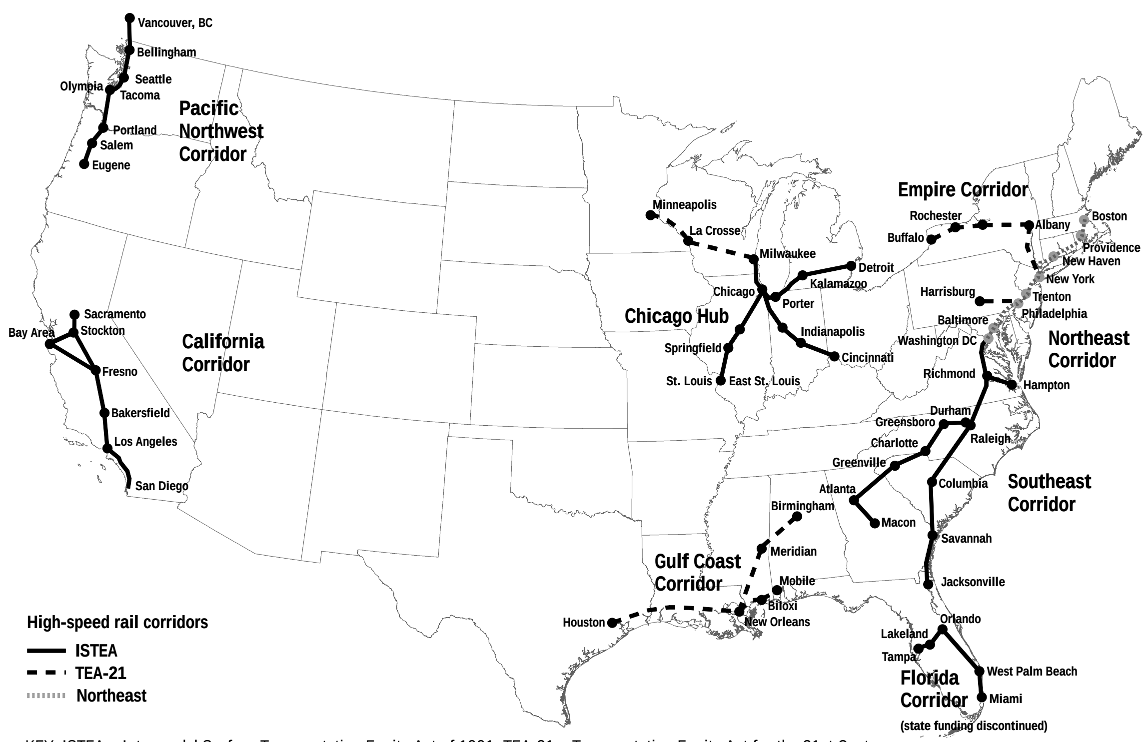
Southeast Corridor

In late 1998, the Southeast Corridor partnership between North Carolina and Virginia was expanded to include South Carolina, Georgia, and Florida. The intention of the new partnership is to develop an HSR corridor connecting Charlotte, Raleigh, and Richmond with the high-speed Northeast Corridor (beginning in Washington, DC), as well as major travel markets of the Southeast. It could cost $1.1 billion to upgrade the entire corridor from Charlotte to Washington.

Another candidate for HSR service is the Richmond to Tidewater area of Virginia. The Virginia Major Investment Study recommends that the rail corridor be double-tracked with track and signal improvements to allow train speeds up to 110 mph, with 8 roundtrips per day, and 3 new train stations. These improvements could cost $256 million and would be part of a larger package of transportation corridor improvements (including a third highway lane and interchange and other highway improvements) that would cost an estimated $1.34 billion).

SOURCE: U.S. Department of Transportation, Federal Railroad Administration.

Designated High-Speed Rail Corridors



KEY: ISTEA = Intermodal Surface Transportation Equity Act of 1991; TEA-21 = Transportation Equity Act for the 21st Century.

SOURCE: U.S. Department of Transportation, Federal Railroad Administration, 1999.

cent. Airport runway conditions at commercial service airports, a subset of the NPIAS, have remained nearly static, though, with 79 percent in good condition in 1997. The remaining 21 percent of commercial airport runways were classified as poor or fair (USDOT BTS 1998, table 1-36). Still, overall commercial airport runways remain in better condition than NPIAS airports.

The number of aircraft operated by certificated air carriers increased from 7,320 in 1992 to 7,616 in 1997[4] (USDOT FAA 1999b). Totals for the entire certificated fleet are not available for years prior to 1992, though growth is evident for the portion of the fleet for which pre-1992 data are available.

The general aviation fleet consisted of over 192,000 active aircraft in 1997, the third consecutive year of increase. A decline in the fleet occurred between 1989 and 1994—from 205,000 aircraft to 172,000 aircraft. General aviation aircraft are flown for a variety of purposes. The most popular is personal use (60 percent), followed by business (14 percent), instruction (8 percent), and corporate activities (5 percent), with smaller portions of the fleet used for air tours, sightseeing, air taxi, and other applications. Most active general aviation aircraft (52 percent of those whose ages are known) are 25 years old or less, 40 percent are between 26 and 50 years old, and 8 percent are over 50 years old (USDOT FAA 1999a; USDOT FAA 1998).

WATER

U.S. water ports handled approximately 2.3 billion tons of foreign and domestic waterborne commerce in 1997 (USACE 1997). International shipments increased by one-third between 1980 and 1997, while domestic shipments—coastwise, inland, and on the Great Lakes—increased very little. About 27 percent of the world merchant fleet called at U.S. ports in 1997, representing 44 percent of the world's dead-weight-tonnage capacity (USDOT BTS MARAD USCG Forthcoming).

The port and waterway system plays an important role in recreation and tourism. Of the 223 large cruise ships in the world fleet, about half (109) call regularly at U.S. ports. In addition, recreational boating is a major activity. Approximately 12.3 million recreational boats were numbered (registered) in the United States in 1997, compared with 10 million in 1987 and 8 million in 1977. Numbered recreational boats increased by 441,000 in 1997, the most growth in a single year since 1988. An unknown number of other boats are not registered (USDOT BTS MARAD USCG Forthcoming).

In the United States, 25,000 miles of commercially navigable waterways serve 41 states, including all states east of the Mississippi River (USACE 1999a). Hundreds of locks facilitate travel along these waterways. The U.S. Army Corps of Engineers owned or operated 276 lock chambers at 230 sites in 1997, with lifts ranging from 5 to 49 feet on the Mississippi River and up to 110 feet at the John Daly Lock on the Columbia River (USACE 1999b, 1999c). In January 1999, 135 of the 276 chambers had exceeded their 50-year design lives. The oldest operating locks in the United States, Kentucky River Locks 1 and 2, were built in 1839 (USACE 1999c).

U.S. ports, or marine terminals, function as intermodal freight connections between water vessels and highway and rail networks. In 1997, the nation's marine terminals were nearly equally divided in number among deep-draft (ocean and Great Lake) and shallow-draft (inland waterway) facilities with 1,914 located along the coasts (including Alaska, Hawaii, Puerto Rico,

[4] Air carrier aircraft are aircraft carrying passengers or cargo for-hire under 14 CFR 121 and 14 CFR 135, except for on-demand air taxis.

and the U.S. Virgin Islands) and Great Lakes and 1,812 located along inland waterways (USDOT MARAD 1998). Nearly 90 percent of inland facilities were privately owned in 1997 compared with about two-thirds of coastal facilities.

In 1997, 86 percent of the inland ports were used primarily for the transfer of bulk commodities such as grain, coal, and petroleum; only 14 percent of these ports were general cargo or multipurpose terminals. At coastal terminals, general cargo accounted for 37.5 percent of the berths (including the Great Lakes) and a similar share (41.2 percent) was used for bulk commodities. About 2.8 percent of coastal berths served passenger vessels, 11.2 percent served barges, 4.2 percent were used for mooring or other purposes, and 3 percent were inactive (USDOT MARAD 1998).

Over the next few years, coastal ports will be faced with the challenge of handling the next generation of containerships. Each "megaship" has a capacity of 4,500 20-foot equivalent container units (TEUs) or more, and drafts of 40 to 46 feet when fully loaded. The first of these vessels was delivered in 1996, and containership operators around the world may take delivery of 35 more through 1999. To physically accommodate megaships at U.S. ports, channel and berth depths must be at least 50 feet. However, only 5 of the top 15 U.S. container ports—Baltimore, Tacoma, Hampton Roads, Long Beach, and Seattle—have adequate channel depths, and only those on the west coast have adequate berth depths. In addition, ports may need to expand terminal infrastructure, such as cranes, storage yards, and information systems, to facilitate the increased volumes of cargo from these ships. Also, landside modes and facilities connecting with water terminals will face higher volumes of rail and truck traffic. Many ports have initiated expansion projects to accommodate these ships. How effectively U.S. ports handle this next generation of containerships will have implications for the efficiency of the U.S. transportation system and U.S. trade competitiveness (USDOT MARAD 1998, 49–51).

The U.S.-flag commercial vessel fleet increased to 41,419 in 1997, compared with 38,788 in 1980 (USACE NDC 1999; USACE WRSC 1998). Barges accounted for the overwhelming share—nearly 80 percent of the entire fleet—both in terms of number of vessels and cargo capacity. Tugboat and towboats accounted for around 12.5 percent of the fleet, and other self-propelled vessels such as dry cargo ships, cruise ships, tankers, and offshore support vessels accounted for the remainder.

Self-propelled vessels, such as tankers, containerships, and dry bulk carriers, have larger cargo capacity than barges (see table 1-4). Tankers have the most capacity—51,000 short tons on average (the largest tankers have a capacity of over 262,000 short tons). The average carry of liquid and dry cargo barges was 1,700 short tons.

Cruise ships, gambling/casino boats, and vessels reported as employed in sightseeing, excursions, and other such activities numbered 1,206 in 1997. These vessels had an average capacity of 298 passengers. There were 5,713 tugboats/pushboats available to operate or operating during 1997. Of these, about 32 percent had 500 to 1,000 horsepower and were, on average, 26 years old, and 17 percent were under 500 horsepower and averaged 34 years of age.[5]

The average commercial vessel (including cargo, passenger, and other vessels) in 1997 was about 27 years old. Containerships were, in general, newer than the rest of the fleet, averaging about 16 years, while dry bulk carriers were the oldest, averaging 28 years. Passenger vessels

[5] Average capacity calculation excludes two vessels for which passenger capacity data were not available; average cargo capacity calculation excludes 52 vessels for which cargo capacity data were not available.

Table 1-4
U.S.-Flag Waterborne Cargo-Carrying Vessel Fleet Profile: 1997

	ICST codes	Vessels	Total cargo capacity (short tons)	Average cargo capacity[1] (short tons)	Average age[2]
Self-propelled[3]		**2,209**	**13,973,152**	**6,326**	**22**
Dry cargo		692	6,191,012	8,947	23
Containership	310	82	2,632,171	32,100	16
Dry bulk carrier	229	72	2,529,358	35,130	28
General cargo	333,334,335	350	943,899	2,697	27
Specialized	321,325,329	188	85,584	455	19
Offshore support	422	1,370	306,120	223	26
Tanker	114,120,139,199	147	7,476,020	50,857	23
Non-self-propelled		**33,011**	**54,974,961**	**1,665**	**20**
Dry cargo barge	341-344,349	29,040	43,809,931	1,509	17
Tank barge	141-144,149	3,971	11,264,868	2,837	23

[1] Average is calculated from only those vessels with known capacity and not the total number of vessels.
[2] Age is based on the year the vessel was built or rebuilt. Average is calculated from only those vessels with known year built or rebuilt.
[3] Does not include passenger vessels and towboats.

KEY: ICST = International Classification of Ships by Type.

NOTE: Includes vessels operating or available to operate in 1997.
Excludes, for example, fishing and excursion vessels, general ferries and dredges used in construction work.

SOURCE: U.S. Army Corps of Engineers, Navigation Data Center, Waterborne Commerce Statistics Center, Vessel Characteristics Database (New Orleans, LA: 1999).

averaged about 21 years old. Ferries in operation in the United States averaged about 23 years old.

BTS and two other Department of Transportation agencies, the Maritime Administration and the U.S. Coast Guard, will issue a comprehensive report on water transportation in late 1999 (see box 1-2).

OIL AND GAS PIPELINES

An extensive system of pipelines is in place for transmission of petroleum, petroleum products, and natural gas throughout the country. The extent of the network and the amount of pipeline activity are unclear due to differences in national estimates and gaps in publicly available data. Table 1-1 shows Eno Foundation estimates for oil pipelines and American Gas Association estimates for natural gas pipelines.[6]

[6] Two federal agencies estimate oil and natural gas pipeline mileage: the Federal Energy Regulatory Commission (FERC) and the Office of Pipeline Safety (OPS) in the U.S. Department of Transportation's Research and Special Projects Administration. Their mileage estimates differ, largely due to jurisdictional differences. FERC collects data for pipelines involved in interstate commerce or those with continuous flow, including gathering lines. Operators with an annual revenue of less than $350,000 are excluded. OPS, on the other hand, collects data for all pipelines except gathering lines of 6 inches or less in diameter, pipelines owned by companies with fewer than 30 miles of pipe nationwide, and gas lines less than 1 mile in length. These criteria are illustrative and are not complete. Additional criteria determine whether a pipeline is under FERC and/or OPS jurisdiction.

Box 1-2

Report on Maritime Trade and Water Transportation

In late 1999, three Department of Transportation administrations, the Bureau of Transportation Statistics (BTS), the Maritime Administration (MARAD), and the U.S. Coast Guard (USCG) will issue a report, *Maritime Trade & Transportation 1999,* which presents information about maritime transportation in the United States and around the world. It covers waterborne trade and transportation services between 1993 and 1997, reviews trends in U.S. shipbuilding, explores safety and environmental issues associated with maritime activities and recreational boating, discusses national security issues and navigation technology, and presents data needs. The report also examines capacity trends for three categories of vessels in deep-sea trade: 1) containerships and other general cargo vessels, 2) dry bulk carriers, and 3) tankers.

The capacity of the world's containership fleet increased dramatically between 1993 and 1997, growing 15 percent per year. The growth was partly due to newly deployed large containerships (those able to handle 4,000 or more 20-foot equivalent container units) in east/west trade (e.g., between the United States and Japan), which led to the redeployment of smaller vessels for north/south intra-regional trade. Dry bulk fleet capacity grew 4.2 percent per year, while growth in tanker fleet capacity was 0.6 percent per year. A growing proportion of the world fleet is owned by parties whose nationality differs from that of the country in which the vessel is registered. In 1993, 50 percent of the world merchant fleet were in such open registries, while in 1997, open registries accounted for 57 percent of the merchant fleet. A very different picture of the world fleet appears if flag registry is compared with country of ownership. Panama, Liberia, Greece, the Bahamas, and Malta are the top five countries by registry, measured in total dead-weight tonnage, with the United States ranked 11th. Tankers accounted for a majority of the U.S.-owned capacity. When ownership is the criterion, Japan, Greece, the United States, Norway, and the United Kingdom are the top five. However, for containerships, Germany ranks highest by far in ownership, with twice the dead-weight tonnage of the next two countries (Japan and Taiwan), each with over 5,000 dead-weight tons. Japan led in tanker and dry bulk capacity.

In the area of U.S. domestic waterborne trade, Alaskan crude oil shipments decreased in the 1990s resulting in an overall decline in domestic deep-sea shipping, even though other categories of shipments grew. Vessels on inland waterways carried 655 million metric tons in 1997. Great Lakes shipping reached 111 million metric tons in 1997.

Japan and South Korea are the world's largest merchant shipbuilders, each holding about one-third of the market, followed by China, which is a distant third. The United States ranks 14th, with about 1 percent of the market by gross tonnage. Other components of the shipbuilding market include military construction, and ship repair and related industries. The major U.S. shipbuilding and repair base comprises 92 facilities, including 19 shipbuilding facilities, 33 dry-dock repair facilities, and 40 topside repair facilities. Although the U.S. shipbuilding industry is large, it traditionally focused on military orders, which are lower today than in the 1980s. Thus, the global market has become an important strategic opportunity for the U.S. shipbuilding industry.

TRANSIT[7]

In 1997, 556 federally assisted transit agencies provided service in urbanized areas of the United States. About 98,000 vehicles were available for maximum service[8] in that year. Of these, over 76,000 vehicles operated in maximum service, carrying nearly 8 billion passenger trips. Federal law requires these transit agencies to report their financial and operational activities to the Federal Transit Administration (FTA). Agencies operating 9 or fewer vehicles—there were 66 such agencies in 1997—are not required to submit detailed data.[9] There are other transit operations that may not be required to report data to FTA (e.g., private subscription bus services and some rural operators); these are not included in the discussion that follows.

Over three-quarters of the 76,000 transit vehicles were operated in urbanized areas with a population of 1 million or more, while only about 9 percent operated in areas with a population of less than 200,000. Fixed-route buses, demand responsive service, and heavy rail were the most prevalent transit modes. Bus accounted for 58 percent of passenger trips and 44 percent of passenger-miles. Heavy rail accounted for 30 percent of passenger trips by transit and 30 percent of passenger-miles. Buses and demand responsive vehicles are common in cities of all sizes, but fixed-rail modes are found almost exclusively in large urban areas with a population of more than 1 million.

The total number of vehicles operated in maximum service increased by a modest 12 percent between 1992 and 1997, with most of this increase due to growing numbers of demand responsive vehicles and vehicles used in vanpool service. Buses accounted for over 57 percent of reported transit vehicles operated in maximum service, and demand responsive vehicles accounted for 18 percent. Heavy-, commuter-, and light-rail vehicles accounted for 11, 6, and 1 percent of the reported fleet, respectively. Vehicles used in other modes such as vanpools, trolleys, and ferry boats accounted for approximately 7 percent of the fleet.

Federally assisted public transit agencies in urbanized areas operated and maintained over 10,800 directional route-miles of fixed guideway in 1997, compared with 8,900 in 1992—a 21 percent increase in just 5 years. Included in this total is bus exclusive and access-controlled rights-of-way, which increased 60 percent—from 790 miles to 1,266 miles—during this period (see figure 1-3).

In addition to service provided along fixed guideways maintained by transit agencies, buses provided service over 154,489 directional route-miles of public highway in 1997. Directional route-miles of bus service on mixed right-of-way public highways shows little or no real growth over this period.

Heavy-, light-, and commuter-rail services also expanded directional route mileage, increasing by 8.9, 17.0, and 20.0 percent, respectively. The increase in light rail is due, in large part, to the opening of new service in Denver (10.6 route-miles) and St. Louis (34 route-miles) in 1994 and new service in Dallas, which began in 1996 (23 route-miles) and expanded by an additional 17.8 route-miles in 1996/97. Ferryboat, trolley bus, and other transit modes also increased route mileage during this period.

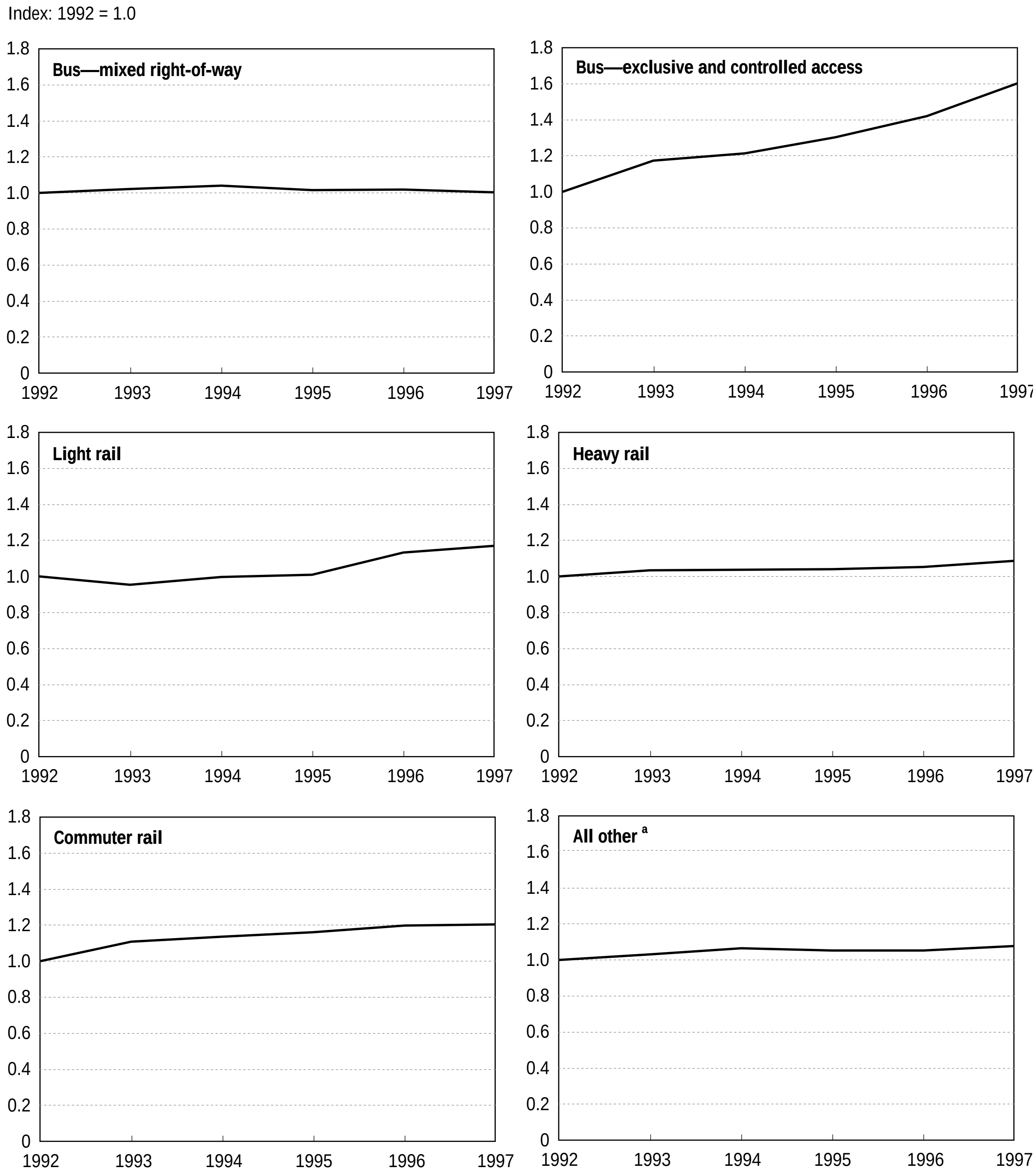
---

[7] Except where noted, this section is based on data from the Federal Transit Administration (USDOT FTA 1999).

[8] *Vehicles operated in maximum service* is defined as the number of vehicles used during the peak day, week, and season of the year, excluding atypical days and one-time special events. *Vehicles available for maximum service* refers to the total number of vehicles held by a transit agency, except emergency contingency vehicles and those awaiting sale.

[9] In addition, data from 14 agencies were deleted from the National Transit Database due to quality and completeness issues.

Figure 1-3
Trends in Directional Route-Miles Serviced by Mass Transit: 1992–97



[a] Includes ferry boats, trolley buses, and modes not included in the other categories. It does not, however, include demand responsive vehicles, since these vehicles do not operate on a fixed route.

SOURCES: U.S. Department of Transportation, Federal Highway Administration, *1996 National Transit Summaries and Trends* (Washington, DC: 1998), p. 25.
_____. *1997 National Transit Summaries and Trends* (Washington, DC: 1999), p. 25.
_____. 1992–97 National Transit Databases.

There were approximately 5,000 other transit agencies in existence in 1997. About 4,000 of these were federally assisted with 1,000 serving rural areas (Section 18 operators) and 3,500 providing service to people with special needs (Section 16 operators) (APTA 1999).

The average age of transit vehicles overall was stable between 1992 and 1997, largely because buses, the most numerous vehicle type, showed little change. The average age of buses in 1997 was 8.1 years, compared with 8.3 in 1992. Demand responsive vehicles averaged 3.4 years, the same as in 1992 although the average increased to 3.7 in 1993/94. The average age of light-rail vehicles was 15.9 years in 1997, compared with 17.1 years in 1992. Commuter rail and heavy rail, on average, have the oldest vehicles, and during this period show the most increase in average age. The average age of commuter-rail vehicles rose by 2.1 years to 20.6, and heavy rail increased from 17.8 to 21.1 years.

INFORMATION TECHNOLOGY USE IN TRANSPORTATION

Railroading, aviation, and marine navigation have actively used information technologies (IT) to enhance the capabilities of the transportation system, as evidenced by the rapid diffusion of transportation applications for such innovations as the telegraph in the 19th century, and radio and radar in the first half of the 20th century. (Box 1-3 discusses innovative applications for IT in the railroad industry.) Advances in telecommunications and computer hardware and software allow all modes of transportation access to IT applications, including highways and transit, which previously used information and communications technologies less intensively than other modes.

Intelligent transportation systems (ITS), which comprise a broad range of technologies, help to improve the efficiency and effectiveness of transportation. Electronic surveillance, communications, and traffic analysis and control technologies provide information and guidance to transportation system users and help transportation agencies monitor, route, control, and disseminate information.

ITS for highway and transit is in the early stages of implementation. Particular goals include improving safety, reducing travel time, and easing delay and congestion. Tracking of deployment is complicated by the variety of technologies and approaches that could be classified as ITS. However, implementation is expanding, especially in larger urban areas troubled by traffic congestion. A federal survey of ITS in 78 of the largest cities in the United States was conducted between the summer of 1997 and the summer of 1998. Data were collected on deployment of nine components of ITS infrastructure for highways, transit, and highway-rail grade crossings within the boundaries of the metropolitan planning organizations (MPOs) for these large metropolitan areas (see figure 1-4). Several technologies or approaches could be utilized in a single component.

Global Positioning Systems (GPS) are in use in numerous transportation modes (even walking), although to what extent is uncertain. For the MPOs surveyed above, 23 percent showed some deployment of automatic vehicle location devices in fixed-route or light-rail transit vehicles. In 1996, the U.S. Coast Guard brought its Differential GPS online. Reference stations located every 200 miles along the coast and major rivers allow ships with the proper GPS receiving equipment to identify their positions within 5 to 10 meters, compared with 100 meters for other positioning systems. This is an important navigational aid, as some channels are less than 100 meters wide.

GPS is used for both commercial and general aviation. About 70 percent of corporate and

Box 1-3

Railroad Applications for Information Technology

In an era of growing rail traffic and increased interest in high-speed rail passenger service, several ongoing projects suggest the importance of information technologies (IT) for railroad safety. IT is at the heart of many train control concepts, aimed at reducing the probability of collisions between trains while increasing track capacity and asset use. At least 13 projects are at various stages of implementation in the United States and Canada, a few of which are described below.

The states of Oregon and Washington, in partnership with the Federal Railroad Administration (FRA) and Burlington Northern Santa Fe and Union Pacific railroads, are testing new Positive Train Separation technology. The system, which uses global positioning satellites and land-based transponders, is being tested for reliability and the ability to safely provide more capacity on the existing rail infrastructure. When operational, the system may enable passenger trains to operate faster than the current 79 mph speed limit. A communications system being developed as part of the project would carry control signals between trains and railroad dispatch centers. Testing of the prototype has verified the reliability of digital communications links, automatic location systems based on the Differential Global Positioning System (DGPS), and the performance of an adaptive braking system governed by an onboard computer to determine safe braking distances.

Michigan's Department of Transportation (MDOT) is installing and demonstrating an advanced communications-based train control system on an 80-mile segment of the Amtrak-owned portion of the Detroit-Chicago corridor between Kalamazoo, Michigan, and the Indiana state line. MDOT and Amtrak matched the federal funds to upgrade the track so that trains can operate at speeds of up to 110 mph and to make fencing and station improvements. As a first step, a 100 mph test of an Incremental Train Control System (ITCS) was conducted on a 20-mile section. Revenue service could begin in 2000, and will be coordinated with local freight operations on the line.

The ITCS uses digital radio to broadcast status information to the train. An onboard computer combines information from the DGPS, wayside status information, and data from an onboard route database to inform the engineer of safe operating speeds. The onboard computer acts to stop the train if unsafe operation is attempted. The onboard computer also uses the digital radio links to activate highway grade-crossing warning systems at the appropriate time for the approach of the high-speed train, and confirms the readiness of the crossing systems back to the train.

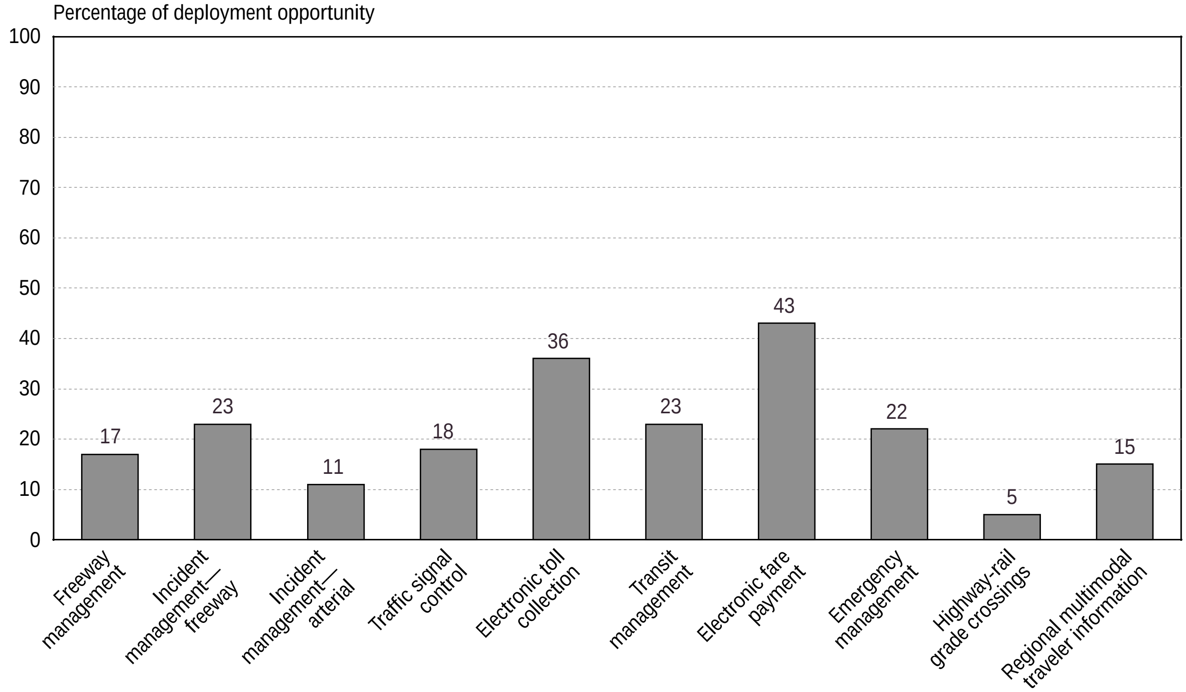
In a portion of the Chicago-St. Louis corridor, the state of Illinois, FRA, and major freight railroads represented by the Association of American Railroads are conducting a joint demonstration of a Positive Train Control system expected to cost about $60 million over four years. The program will address interoperability issues among the various railroads, as well as result in a demonstration system. The demonstration system will use DGPS onboard locomotives, digital radio, and advanced computers to monitor the location of trains in the rail system and oversee operation by locomotive engineers to prevent collisions and overspeed derailments. The system on the Chicago-St. Louis corridor will be controlled from Union Pacific's Harriman Dispatch Center in Omaha.

over half of business-use aircraft have GPS devices, compared with about 40 percent of personal-use aircraft (USDOT FAA Forthcoming, table 7.2).

DATA NEEDS

Information about the extent of the nation's transportation infrastructure and vehicle fleet is fairly complete for most modes. However, publicly available data for gas and liquid pipelines differ among sources, and accurate, national-level estimates of the pipeline inventory are not available on an annual basis. Transit vehicle information from public agencies that do not report to FTA is limited, yet these agencies purchase or support sizable amounts of transit services. Few national data are available about the number of small, rural transit providers and organizations that provide transit as a secondary

Figure 1-4
Indicators of Intelligent Transportation System Infrastructure Deployment: Fiscal Year 1997



NOTE: These percentages describe the amount of deployment relative to total deployment potential (e.g., a city that has 10 miles of its 100 miles of freeway covered by incident detection systems would have a 10% deployment rate). It should be noted that deployment opportunity describes the total deployment potential and does not necessarily represent implementation goals or a specified level of need.

SOURCE: U.S. Department of Transportation, Federal Highway Adminstration, Intelligent Transportation Systems Joint Program Office, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 1997 Results* (Washington, DC: 1998), p. ES-2.

service (e.g., shuttle and dial-a-ride services provided by hotels, airports, universities, and others). Also, as ITS evolves and its implementation becomes more extensive, it will become important to have a comprehensive inventory of this technology across the nation.

Information about the condition of transportation vehicles and infrastructure is spotty and uncertain. Condition data for highways, bridges, and airport runways have a long history, but for other infrastructure as well as for vehicles, vessels, and aircraft, age is one of the few indicators available, and few age data exist. Also, as the quality and expected lifetime of these transportation elements often change, and because other factors affect new vehicle sales, age alone is an inadequate measure.

REFERENCES

American Public Transit Association (APTA). 1999. Available at www.apta.com/stats/index.htm.

Association of American Railroads (AAR). 1998. *Railroad Facts*. Washington, DC.

National Railroad Passenger Corp. (NRPC). 1998. *Amtrak Annual Report*. Washington, DC.

Oak Ridge National Laboratory (ORNL). 1999. *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey*. Oak Ridge, TN.

Penn Well Publishing Co. 1998. *Oil & Gas Journal* 96:35. Tulsa, OK.

R.L. Polk Co. 1999. Personal communication.

U.S. Army Corps of Engineers (USACE). 1997. *Waterborne Commerce of the United States, Calendar Year 1996; Part 5—National Summaries*. New Orleans, LA: U.S. Army Engineer District.

____. 1999a. Internet website. Available at www.wrsc.usace.army.mil/ndoooc/fcdidu3.htm.

____. 1999b. 1997 Lock Characteristics Database. Available at www.wrsc.usace.army mil/ndc/datalck.htm.

____. 1999c. Lock Fact Sheet. Available at www.wrsc.usace.army.mil/ndc/fcdidu3.htm.

U.S. Army Corps of Engineers (USACE), Navigation Data Center (NDC), Waterborne Commerce Statistics Center. 1999. *Vessel Characteristics Data Base*. New Orleans, LA.

U.S. Army Corps of Engineers (USACE), Water Resources Support Center (WRSC). 1998. *Waterborne Transportation Lines of the United States, Calendar Year 1996: Volume 1—National Summaries*. Fort Belvoir, VA.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS). National Transportation Statistics 1998. Available at www.bts.gov.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS), Maritime Administration (MARAD), U.S. Coast Guard (USCG). Forthcoming. *Maritime Trade & Transportation 1999*. Washington, DC.

U.S. Department of Transportation (USDOT), Federal Aviation Administration (FAA). 1998. *FAA Statistical Handbook of Aviation 1996*. Washington, DC.

____. 1999a. *General Aviation and Air Taxi Survey 1997*. Washington, DC.

____. 1999b. Personal communication.

U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA). 1997. *Highway Statistics Summary to 1995*. Washington, DC.

____. 1998a. *Highway Statistics*. Washington, DC.

____1998b. National Bridge Inventory Database.

____. Annual editions. *Highway Statistics*. Washington, DC.

U.S. Department of Transportation (USDOT), Federal Transit Administration (FTA). 1999. *1997 National Transit Summaries and Trends*. Washington, DC.

U.S. Department of Transportation (USDOT), Maritime Administration (MARAD). 1999. *A Report to Congress on the Status of the Public Ports of the United States 1996–1997*. Washington, DC.

Transportation System Use and Performance

In 1997, the U.S. transportation system supported 4.6 trillion miles of passenger travel and about 4 trillion ton-miles of goods movement. This chapter describes how the system is used and how it performs.

PASSENGER TRAVEL

Passenger travel in the United States, measured by local and long-distance trips, has increased during the past two decades (see table 2-1). The U.S. Department of Transportation's (DOT's) Nationwide Personal Transportation Survey (NPTS), which looked at local travel primarily, shows an 82 percent rise in the number of daily person-miles of travel from 1977 to 1995, and a 79 percent rise in the number of daily trips.[1] In 1977, the average number of daily trips a person made totaled 2.9, compared with 4.3 in 1995. In the NPTS, a trip is movement from one address to another by any mode. Average trip distance was about 9 miles in both survey years. Because people took more trips in 1995, individuals averaged about 14,100 miles on

[1]The NPTS was first conducted in 1969, and then again in 1977, 1983, 1990, and 1995. Numerous methodological improvements in the NPTS and a changing response profile between 1977 and 1995 make trend analysis somewhat risky, but travel behavior for these two points in time are adequately (if not perfectly) reflected in the survey data. Data used are from the travel-day file, which includes trips of all lengths made by respondents on a single day. About 95 percent of these trips were 30 miles or less.

Table 2-1

Population and Passenger Travel in the United States: 1977 and 1995

	1977	1995	Percentage change 1977–95
Resident population (thousands)	219,760	262,761	20
Annual local person trips (travel day) (millions)[1]	211,778	378,930	79
Annual long-distance person trips, domestic (millions)	521	1,001	92
Local person trips per capita, one way (per day)[1]	2.9	4.3	47
Long-distance trips per capita, roundtrip (per year)	2.5	3.9	56
Local person-miles (millions)[1]	1,879,215	3,411,122	82
Long-distance person-miles (millions)	382,466	826,804	116
Local person-miles per capita[1] (annually)	9,470	14,115	49
Long-distance person-miles per capita, domestic (annually)	1,796	3,129	74
Local mean trip length (miles)	8.9	9.0	1
Long-distance mean trip length, domestic (miles)	733	826	13

[1]Persons over 5 years of age.

NOTES: Data used for local travel are from the travel-day file and include trips of all lengths made by respondents on a single day. About 95 percent of these trips were 30 miles or less. Per capita calculations are based on population estimates within each survey, and not from Census Bureau estimates reported here.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997.

U.S. Department of Commerce, Census Bureau, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

_____. *Statistical Abstract of the United States 1998* (Washington, DC: 1998).

U.S. Department of Transportation, Federal Highway Administration, Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey, draft, 1999.

local travel or 39 miles daily, compared with 9,500 miles in 1977, or 26 miles a day (USDOT FHWA 1999a).

Long-distance roundtrips nearly doubled between 1977 and 1995, as shown in the Bureau of Transportation Statistics' American Travel Survey (ATS) and the Bureau of the Census' earlier National Travel Survey.[2] Domestic long-distance travel rose from 1,800 miles annually per person in 1977 to 3,100 in 1995, up 74 percent. The average number and length of long-distance trips taken per person increased from 2.5 (733 miles) in 1977 to 3.9 (826 miles) in 1995. Totaling long-distance and daily travel shows that American's averaged about 17,200 miles in 1995, up 53 percent from 11,300 miles in 1977. About 75 to 80 percent of this travel is local (trips under 100 miles one way), but long-distance travel grew more quickly. It must be noted, however, if NPTS travel-day data are added to ATS data, a small amount of double counting occurs because NPTS data include some trips of 100 miles or more. Moreover, neither survey adequately captures trips between 30 and 99 miles, resulting in an undercounting of total travel and an overrepresentation of long-distance travel in the total.

Several factors account for the growth in travel, most importantly greater vehicle availability

[2]The methodology of the 1995 ATS was similar to the 1977 National Travel Survey. In both surveys, long distance was defined as trips 100 miles or more one way.

and reduced travel cost. People could afford to buy more vehicles and travel services in 1995 than in 1977, especially since the cost of the most widely used kinds of transportation—cars and planes—fell in real terms. The inflation-adjusted cost of owning and operating an automobile declined from 47¢ per mile in 1975 to 39¢ per mile in 1995. The average airfare declined from $100 in 1975 to $70 in 1995 (both measured in constant 1982–1984 dollars) (USDOT BTS 1998a), while trip lengths increased. Furthermore, both intercity bus and train fares increased slightly more than inflation over this period, which affected lower income persons who use buses more often than other people.

Other factors influence travel growth in a less obvious manner. With a U.S. resident population nearly 20 percent higher in 1995 than in 1977, comparable travel growth might be expected if no other factors changed. Some growth can be attributed to greater labor force participation; the labor force rose 36 percent during this period as baby boomers (those born between 1946 and 1964) took jobs and more women joined the workforce. In addition, the number of households rose 34 percent, resulting in more trips to buy groceries and other households items. Notably, disposable personal income per capita rose 34 percent in real terms (measured in chained 1992 dollars), from $14,100 in 1977 to $18,900 in 1995, giving people a greater ability to pay for transportation (USDOC 1998, 456).

Although household size declined by 7 percent between 1977 and 1995, the number of vehicles per household increased from 1.59 to 1.78 (USDOT FHWA 1997a). Households with two vehicles rose by 54 percent, from 26 million households in 1977 to 40 million in 1995, and households without vehicles declined from 11.5 million in 1977 to 8 million in 1995. The number of licensed drivers increased by nearly 50 million from 128 million in 1977 to 177 million in 1995, and the proportion of the population 16 years and older licensed to drive rose from 81 percent to 89 percent.

Travel Mode

Most passenger trips (nearly 90 percent of daily trips and 92 percent of miles traveled) are made in automobiles or other private motorized vehicles (see table 2-2). The share for other modes was considerably smaller—bicycling and walking accounted for 6.5 percent of local trips and 0.5 percent of miles, and transit's share was about 4 percent of trips and 3 percent of miles. The NPTS shows that local private vehicle trips grew more rapidly than overall local trips (111 percent compared with 79 percent). In 1995, the average household made 6.4 local private vehicle trips, up from 4.0 in 1977. Households averaged 57 local miles daily in private vehicles in 1995, 24 more miles than in 1977.

Table 2-2
Daily and Long-Distance Trips by Mode: 1995

Daily trips	Percent
Personal-use vehicle	89.5
Transit	3.6
Bicycle/walking	6.5
Rail	0.01
Other	0.3

NOTE: Transit includes commuter rail.

Long-distance trips	Percent
Personal-use vehicle	79.2
Airplane	18.0
Bus	2.1
Rail	0.5
Other	0.2

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997.

U.S. Department of Transportation, Federal Highway Administration, Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey, draft, 1999.

Table 2-2 also shows a ranking of modes used for long-distance travel. Although travel by bus ranks a distant third and rail maintains an even smaller share, between 1977 and 1995, long-distance person-trips by bus increased by 43 percent and those by train increased by 23 percent. The per capita number of bus trips increased by 20 percent, while those by train remained constant.

Trip Purpose

Data from the ATS and the NPTS can illustrate not only how people travel, but why. Family and personal business made up the greatest share of local trips (55 percent). Long-distance trips to visit friends and relatives held a 33 percent share, while business-related trips (including commuting and business travel) accounted for about the same proportion—just over 20 percent—of both local and long-distance trips.

Between 1977 and 1995, the most growth in *daily travel* per person took place in trips for family and personal business, which more than doubled, and trips for social and recreational purposes, which increased 51 percent. Trips to or from work per person grew by 33 percent, while school or church-related trips grew only 9 percent (USDOT FHWA 1999b). Over the same period, *long-distance trips* for personal business, business, and leisure experienced the most growth. Trips to visit friends and relatives also grew, albeit more slowly than other types of trips; thus, the share declined from 37 percent of all long-distance trips to 33 percent (USDOT BTS 1997; USDOC 1979).

Trip Chaining

People often link local trips together in what is know as trip chaining (e.g., dropping a child off at school before traveling to work). In an analysis of trip chaining involving home-to-work and work-to-home trips using 1995 NPTS data, one report found that people are more likely to stop on their way home from work than on their way to work, and that women are more likely to trip chain than men (McGuckin and Murakami 1999). About 33 percent of women linked trips on their way to work compared with 19 percent of men, while 61 percent of women and 46 percent of men linked trips on their way home from work.

Trip chaining is thought to be increasing because of rising incomes, the entry of women into the workforce, and the increasing use of automobiles (McGuckin and Murakami, 1999). Many household-sustaining goods and services are now often bought rather than provided in the home (e.g., child care and meals), because more time is spent at work and less time is available for family-oriented needs. As a result, people are making extra trips, and these trips are very often chained with the work commute to save time. In addition, the ability to link trips is enhanced by the flexibility provided by the automobile. Linking nonwork-related trips with the work commute has been posited as one reason for increased congestion problems at rush hour (Strathman and Dueker 1995).

Commuting

Time spent traveling to work has increased 36 percent since 1983 (the most recent year for which commute data are available). Commuters spent, on average, 21 minutes traveling to work in 1995, an increase of 13 percent over this period. The average work trip rose from 8.5 miles in 1983 to 11.6 miles in 1995. Research on trip chaining suggests that commute time and distance are underestimated, because only the last leg of a trip chain to work is measured. No data are available from the 1995 NPTS, but 1990 NPTS data show that when trip chaining is taken into account time and distance to work are about 5 percent higher than otherwise estimated (Strathman and Dueker 1995).

Average commute speeds rose from 28 miles per hour (mph) in 1983 to 34 mph in 1995 (a 20 percent increase). Average speed, of course, varied, from 40 mph in rural areas to 24 mph in urban areas. Longer but faster commuting trips are partly a reflection of continued decentralization of metropolitan areas and a switch from slower modes of transportation such as carpools to the faster single-occupant vehicle trips. In 1995, most people traveled to work by personal-use vehicle (PUV), with 1 out of 10 carpooling. Carpooling has declined from about 15 percent in 1977. In 1995, about 5 percent reached work by transit and another 4 percent by other means (e.g., walking and biking). These proportions have been reasonably stable since 1977.

Mobility Patterns

Among different segments of the population, wide variations exist in the number of trips taken and the miles traveled. Figures 2-1 and 2-2 illustrate these variations by income, sex, age, and race/ethnicity.

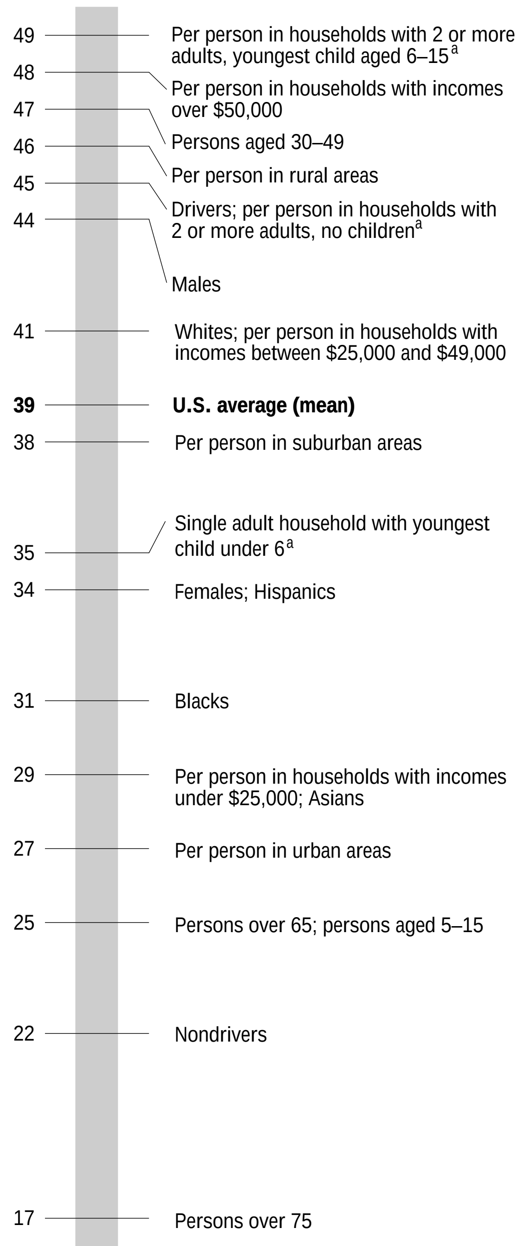
► Females and Males

The NPTS shows that males travel greater distances overall—both local and long-distance—than females. Although both groups averaged 4.3 local trips a day, men traveled 10 miles more than women—44 miles compared with 34 miles. The difference was the result of longer trips by males, not the type of transportation used (which was about the same for both sexes). The average distance of a PUV trip by males was 10.7 miles compared with 8.4 miles by females, and the average transit trip was 9.4 miles for males and 8.2 miles for females.

By trip purpose, table 2-3 shows that the only category where females made a greater propor-

Figure 2-1

Person-Miles Traveled per Day: 1995

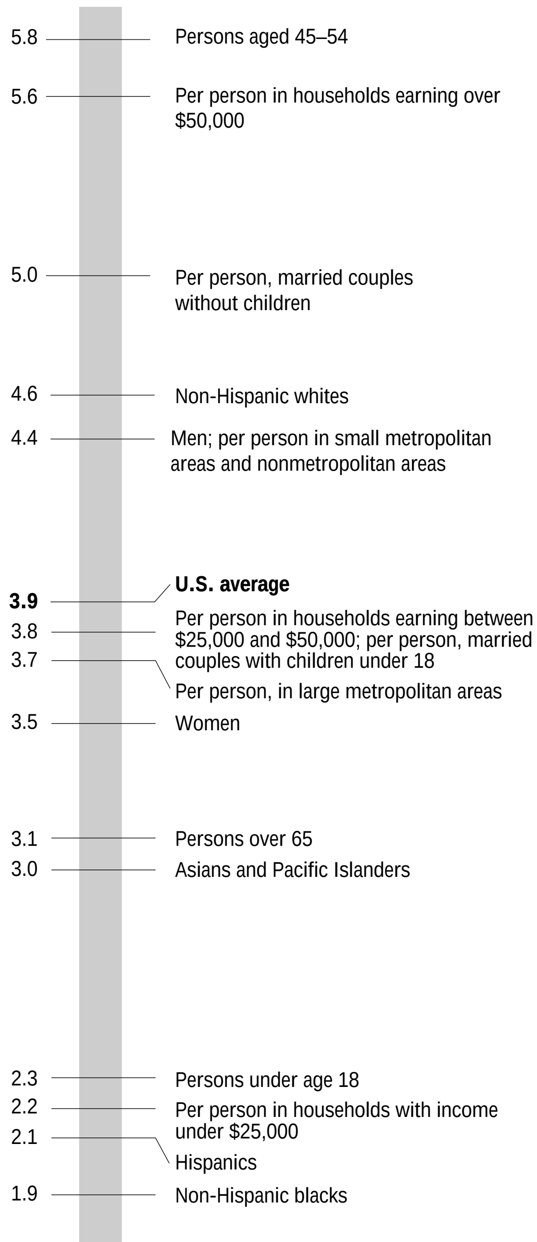


[a] Per adult 20 years or older

NOTE: Some numbers may not differ statistically.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Nationwide Personal Transportation Survey, Our Nation's Travel* (Washington, DC: 1997).

Figure 2-2
Long-Distance Trips per Person: 1995[a]



[a] These numbers differ from those presented in figure 6-9 in *Transportation Statistics Annual Report 1998* and reflect demographic data released in 1999.

NOTE: Some numbers may not differ statistically.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997.

Table 2-3
Person Trips per Day by Purpose and Sex: 1995 (travel day)

	Male	Female
Per capita person trips per day	4.3	4.3
Purpose:		
To or from work	21%	15%
Work-related business	4%	2%
Family and personal business	41%	50%
School/church	9%	9%
Social and recreational	26%	24%

SOURCE: U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey data (travel day), available at www-cta.ornl.gov/npts/1995/Doc/index.shtml, as of Aug. 9, 1999.

tion of trips was for family and personal business—50 percent vs. 41 percent.

Females traveling long-distance in 1995 took, on average, 3.5 roundtrips and males 4.4 roundtrips. The average trip distance was about the same for men and women in 1995 at about 800 miles. About three-quarters of the difference in the number of long-distance trips can be explained by greater business travel by men, with most of the rest resulting from more outdoor recreational travel among men. The modal choice of males and females for long-distance trips was very similar. Both made about 80 percent of their trips by PUV, while women made a slightly higher percentage of their trips by charter or tour bus and men made a slightly higher percentage by air. There were no discernable differences between men and women in the use of intercity bus, train, ship, boat, or ferry (Mallett 1999).

► Income

People in households with higher incomes travel more. In households earning less than $5,000 annually, the NPTS shows the lowest local trip rate, 3.2 trips per person per day in 1995. The number of trips rose to about 4.0 for people in households earning between $15,000 and $20,000, and plateaued at an average of 4.6 trips for people in households earning $30,000 or more. Somewhat similarly, miles traveled also rose with income. People in households earning less than $25,000 a year traveled 29 miles a day. In the $25,000 to $50,000 a year category, people traveled 41 miles a day, and those in households earning more than $50,000 annually traveled 48 miles a day. People in very high income households, those earning $100,000 or more annually, made 4.8 local trips and traveled 53 miles a day.

The difference among income groups appears to be greater for long-distance travel than for daily travel. People in households earning $50,000 or more made 5.6 long-distance trips in 1995 totaling 4,900 miles annually on domestic trips. This compares with 3.8 trips and 2,700 annual miles by people in households earning between $25,000 and $50,000, and 2.2 trips and 1,500 miles by people earning below $25,000.

► Race / Ethnicity

The differences in daily travel among racial and ethnic groups are more readily apparent for miles traveled than for tripmaking. Whites traveled farther, averaging 41 miles a day locally (4.4 trips), compared with 34 miles (4.2 trips) for Hispanics, 31 miles (3.9 trips) for blacks, and 31 miles (3.9 trips) for Asians. Long-distance trip taking in 1995 shows a wider variation with non-Hispanic whites taking more than twice the number of long-distance trips as non-Hispanic blacks (4.6 person-trips per capita versus 1.9) and Hispanics (2.1 trips per capita). Asians and Pacific Islanders made 3.0 person trips per capita on average.

► Age

As might be expected, children and the elderly travel the least. In 1995, children aged 5 to 15 traveled 25 miles a day. Travel distance increased with age to a plateau of 47 miles on average for people between 30 and 49, and then decreased to the same level as child travel—25 miles a day for people over 65. Again, with trips per day, children between 5 and 15 and people over age 65 averaged fewer trips per day (3.7 and 3.4, respectively) with those between 35 and 44 taking the most trips a day (4.9). People over 85 travel the least, taking 1.5 trips a day.

While individuals averaged nearly 4 long-distance trips each in 1995, the highest propensity to travel was found among 45-to 54-year-olds (5.8 trips per capita), followed by those aged 55 to 64 and 35 to 44. As in the local trip category, the youngest (under 18) and oldest members of the population traveled the least. There is, however, much variation among the older population, which encompasses people from age 65 to over 100. People over 65 took on average 3.1 trips in 1995, fewer than all other age groups except those under 18 and about half the number of trips of those in the 45 to 54 age bracket. Those aged 65 to 69 made on average 4.4 trips per year, while people over 85 years old averaged only 1.2 trips annually.

► Geography

The 1995 NPTS provides data on the type of area respondents lived in including urban, suburban, rural, second city, and small town.[3]

[3] The NPTS includes an urban to rural classification based on population density per square mile (centiles) and the density of surrounding areas. According to the NPTS: "To establish this classification, the United States was divided into a grid to reduce the impact of variation in size (land area) of census tracks and block groups. Density was converted into centiles, that is, the raw numbers (persons per square mile) were translated into a scale from 0 to 99. 'Rural' (centiles 19 and less) and 'small town' (centiles 20 to 39) definitions are based solely on the density. Population centers were defined if a route through the eight neighboring cells could be constructed in which the density of successive cells was decreasing or equal. Population centers with centiles greater than 79 were designated 'urban.' Other centers were classified as 'second cities,' places that are near an urban center but with a density greater than the typical suburb. Finally, 'suburban' areas of the population centers were defined, using both the cell density and the cell's density relative to the population center's density" (USDOT FHWA 1997b). The geographical breakdown in the ATS is limited to large metropolitan areas (population of 250,000 or more) and small metropolitan/nonmetropolitan areas (less than 250,000 people).

People in a second city (places such as Gaithersburg, Maryland, and Huntingdon, New York) made the most trips (4.5 a day), followed by residents of suburbs (4.4), small towns (4.3), rural areas (4.2), and urban areas (4.0). The most miles of travel per day, however, were by rural residents (46 miles) followed by town (42 miles), suburban (38 miles), second city (37 miles), and urban (27 miles).

Data from the ATS allow comparison of the long-distance travel behavior of people who live in large metropolitan areas (population of 250,000 or more) with people in small metropolitan areas (population under 250,000) and nonmetropolitan areas. Individuals in small metropolitan/nonmetropolitan (SM/N) areas averaged 4.4 long-distance trips in 1995 compared with 3.7 for people in large metropolitan areas, suggesting that SM/N area residents take some long-distance trips to reach opportunities that are nearby in large metropolitan areas. Trip distance data show that people in large metropolitan areas travel farther than their SM/N counterparts when taking domestic trips (a mean of 920 miles compared with 650 miles), hence, average annual person-miles on domestic trips for large-metropolitan residents was 3,300 miles and for SM/N residents about 2,800 miles.

International Long-Distance Trips

The 1995 ATS found that U.S. residents made 41 million long-distance trips (100 miles or more one way) to foreign destinations, about 4 percent of all long-distance trips. About 28 percent of these long-distance trips were to Canada, 23 percent to Mexico, and the remaining 49 percent to the rest of the world. It must be remembered, however, that this does not take into account trips across the border that were less than 100 miles one way. Excluding North American travel, Europe was the most popular destination of U.S. residents (18 percent of all international trips), followed by the Caribbean (11 percent), and Asia (8 percent).

DOMESTIC FREIGHT

Business establishments in the United States shipped much more commercial freight on the nation's transportation system in 1997 than in 1993, the two most recent years for which comprehensive freight data are available. Freight shipments increased about 17 percent by value, 14 percent by tons, and 10 percent by ton-miles. Preliminary estimates by the Bureau of Transportation Statistics (BTS) show that nearly 14 billion tons of goods and raw materials, valued at nearly $8 trillion, moved over the U.S. transportation system in 1997, generating nearly 4 trillion ton-miles.[4] About 38 million tons of commodities worth nearly $22 billion moved on the nation's transportation system per day in 1997.

Growth in Freight Movement

This section discusses domestic freight movement using preliminary results from the 1997 Commodity Flow Survey (CFS) conducted by BTS and the Census Bureau, plus additional data. Where possible, it also discusses changes in freight movement since 1993 using data from the 1993 CFS. (See box 2-1 for a discussion of the CFS, including what the survey covers, what it excludes, and the supplementary data included in the estimates this section presents.)

Millions of American businesses rely on the U.S. transportation network to ship their products to other businesses, to consumers, and markets here and abroad. Per capita daily freight

[4] These BTS estimates are based on preliminary information from the 1997 Commodity Flow Survey (CFS), which is designed to cover shipments within the United States by domestic establishments, plus additional estimates of shipments such as imports by air and water transportation not fully captured by the CFS.

Box 2-1

The Commodity Flow Survey and Supplementary Freight Data

Most of the national estimates of freight movement presented in this report are based on preliminary results from the 1997 Commodity Flow Survey (CFS), conducted by the Bureau of Transportation Statistics (BTS) and the Census Bureau, and additional estimates of freight shipments that are not fully measured in the CFS. Conducted for the first time in 1993 and again in 1997, the CFS is the nation's primary and most comprehensive data source on domestic freight movement. It surveys a sample of shipments by domestic establishments engaged in manufacturing, mining, wholesale trade, retail trade, and some selected services. The CFS collects information about what modes these establishments used to ship their products and materials, the types of commodities they shipped, and the value, weight, distance, origin, and destination of the shipments. The survey collects information on freight moved by each mode of transportation, and on freight moved by intermodal combinations (e.g., truck and train).

Although the CFS is the most comprehensive source of data on the domestic movement of goods and materials, some industries and commodities and most domestic movement of imports are not included. Thus, BTS has sought to fill in some of the missing pieces, such as crude petroleum pipeline shipments, some waterborne freight, and out-of-scope imports by surface, air, and water, in both the 1997 and 1993 estimates of commodity flows. This supplementary data can be used to compare the magnitude of overall national freight shipments in 1993 and 1997, but not to estimate specific commodities, sizes, or average length of haul.

Even with supplementary data, the existing data do not cover all freight movement on the nation's transportation network. Data on shipments by establishments included in the Standard Industrial Classification under farms, forestry, fishing, governments, construction, transportation, and most retail and service industries, municipal solid waste, and household movers are not available.

The completeness of estimates is due to revisions in the supplementary data to reflect refinements in methodology to include previously unavailable import data, and to address changes in the CFS coverage. Most of the 1993 data presented in this report are revised and differ from previous estimates for 1993 published by BTS and the Census Bureau. The Census Bureau revised some 1993 figures to make them directly comparable to the 1997 CFS results and BTS revised its supplementary data to improve its estimates. The revised data are noted where appropriate. The Oak Ridge National Laboratory (ORNL) prepared estimates for BTS of the value, tons, and ton-miles of crude petroleum and petroleum products shipments by pipelines and some waterborne shipments not captured in the CFS. ORNL converted Federal Energy Regulatory Commission (FERC) information on barrels of petroleum and petroleum products transported into tons and ton-miles. Estimates of value, tons, and ton-miles of waterborne shipments not captured in the CFS are based on information from the U.S. Army Corps of Engineers and the Department of Commerce's International Trade Division.

moved for each U.S. resident grew to 280 pounds in 1997 from about 250 pounds in 1993.

Goods and raw materials shipped to factories and wholesale and retail outlets throughout the nation generated almost 4 trillion ton-miles in 1997 compared with 3.6 trillion ton-miles in 1993. Most modes showed an increase in ton-miles (see table 2-4). Shipments by air (including those involving truck and air) grew the most in ton-miles (86 percent), followed by parcel, postal, or courier services (41 percent), and truck (26 percent). Ton-miles by rail (including truck and rail) increased by only 7 percent and ton-miles by water decreased by about 3 percent.

Multimodal transportation (shipments reported as moving by more than one mode) increased substantially between 1993 and 1997 from $726 billion to $955 billion in constant 1997 dollars (USDOC 1995; 1999). Multimodal shipments grew about 32 percent by value, 17 percent by tons, and 20 percent by ton-miles. Of these shipments, those made by parcel, postal, or courier services (which typically move higher value and smaller size shipments) grew the most rapidly,

Table 2-4

Domestic- and Export-Bound Freight Shipments within the United States: 1993 and 1997

Mode	Value (millions of chained 1997 $)			Tons (thousands)			Ton-miles (millions)		
	1993[R]	1997[P]	Change (%)	1993[R]	1997[P]	Change (%)	1993[R]	1997[P]	Change (%)
Parcel, postal, courier services	616,839	865,661	40.3	18,892	24,677	30.6	13,151	18,512	40.8
Truck (for-hire, private, both)	4,822,222	5,518,716	14.4	6,385,915	7,992,437	25.2	869,536	1,094,924	25.9
Rail (includes truck and rail)	361,901	383,222	5.9	1,584,772	1,538,538	–2.9	980,236	1,050,517	7.2
Water[a]	197,370	195,461	–1.0	1,465,966	1,522,756	3.9	827,089	801,614	–3.1
Air (includes truck and air)	152,313	213,405	40.1	3,139	5,047	60.8	4,009	7,449	85.8
Pipeline[a]	340,664	330,176	–3.1	1,870,496	1,881,209	0.6	641,669	690,490	7.6
Other and unknown modes	283,106	447,908	58.2	706,690	753,848	6.7	233,216	266,732	14.4
BTS total (CFS + additional estimates)	**$6,774,414**	**$7,954,549**	**17.4**	**12,035,870**	**13,718,512**	**14.0**	**3,568,906**	**3,930,238**	**10.1**

[a]Preliminary Oak Ridge National Laboratory estimates prepared for the Bureau of Transportation Statistics, 1999.

KEY: P = preliminary; R = revised (includes modal estimates not shown separately).

SOURCES: U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1995).

____. *1997 Commodity Flow Survey: United States Preliminary,* EC97TCF-US(P) (Washington, DC: 1999).

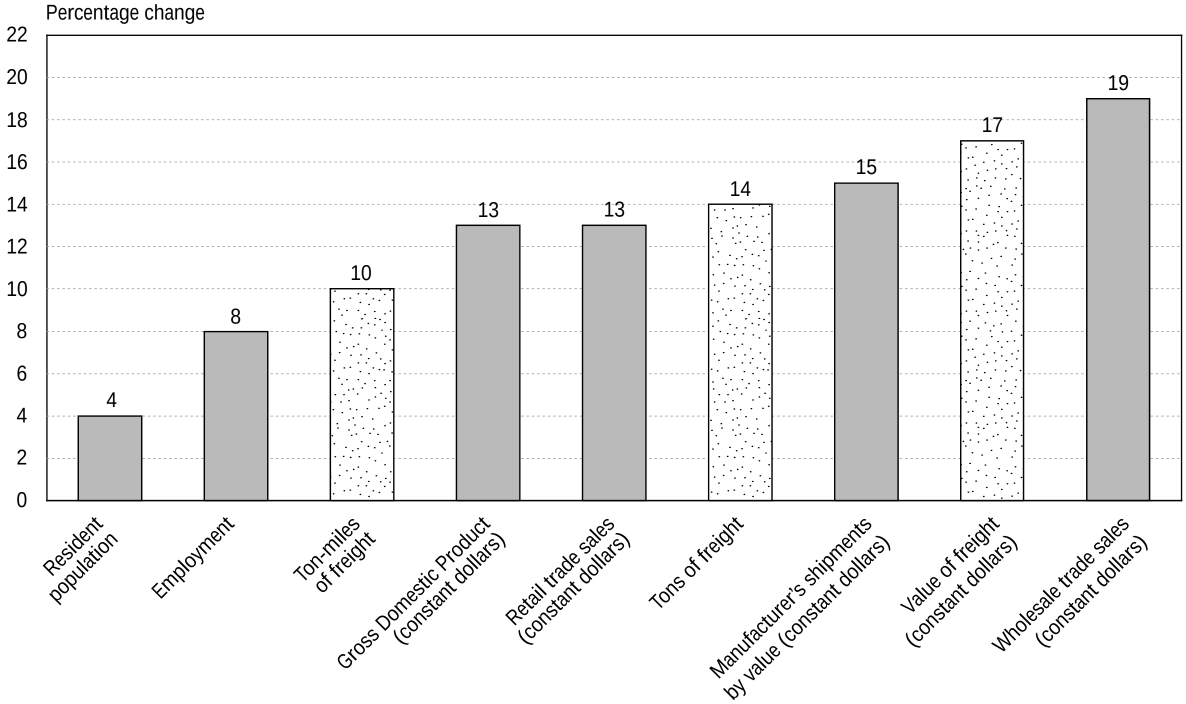
more than 40 percent by value of shipments and 31 percent by tons.

Sustained economic growth is a key factor that has affected the level of U.S. freight shipments since 1993. Expansion in international trade and increases in disposable personal income per capita also affected shipment levels. Between 1993 and 1997, U.S. Gross Domestic Product (GDP) grew about 13 percent in constant dollars compared with the 17 percent increase in the value of freight shipments. Sales by the manufacturing sector and the wholesale and retail trade sectors grew by 15, 19, and 13 percent, respectively, measured in constant dollars (see figure 2-3). Disposable personal income per capita increased from $20,490 to $21,970 in constant 1997 dollars, a 7 percent increase (USDOC 1998, table 722).

Changes in how and where goods are produced and increases in international trade have contributed to the rise in freight tonnage and ton-miles over the past few years. For example, the manufacture, assembly, and sale of a single product may involve several different facilities located hundreds or even thousands of miles apart.

Shifts in the U.S. economy toward more services and high-value, low-weight products are influencing the mix of commodities, even as overall shipments increase. Such shifts affect the average value by unit of weight of commodities shipped (e.g., personal computers have a much higher value per ton than lumber). On average, a ton of goods shipped in 1997 was valued at $580, a slight increase from $563 in 1993 (both in constant 1997 dollars).

Figure 2-3
Freight Shipments and Related Factors of Growth: 1993–97



SOURCES: Freight data based on: U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1993)

________. *1997 Commodity Flow Survey: United States Preliminary,* EC97TCF-US(P) (Washington, DC: 1999).

Preliminary Oak Ridge National Laboratory estimates prepared for the Bureau of Transportation Statistics, 1999.

Other data from U.S. Department of Commerce, Census Bureau, *Statistical Abstract of the United States: 1998* (Washington, DC: 1998).

How Freight Moves

Trucking (for-hire and private) moves more of the nation's freight, whether measured by value, tons, and ton-miles, than other modes (see table 2-5). In 1997, trucks transported $5.5 trillion of freight, a 14 percent increase from $4.8 trillion in 1993 (in constant 1997 dollars). Truck shipments accounted for 69 percent of the total value of shipments in 1997, about the same as in 1993. Measured by value of shipment, trucking was followed by parcel, postal, and courier services; rail; pipeline; and air (including truck and air) in 1997.

While the shipment value per ton increased slightly overall between 1993 and 1997, it decreased for trucking from $755 to $690 per ton (in constant 1997 dollars). The average reflects the wide range of commodities moved by truck—from sand and gravel, coal, and grain to electronic equipment and pharmaceuticals. Interestingly, the average value per ton of rail shipments (as a single mode) increased from $175 in 1993 to $210 in 1997.

Table 2-5
Modal Shares of Freight Shipments within the United States by Domestic Establishments: 1993 and 1997

Mode	Value (percent)		Tons (percent)		Ton miles (percent)	
	1993R	1997P	1993R	1997P	1993R	1997P
Truck (for-hire, private, both)	71.2	69.4	53.1	58.3	24.4	27.9
Rail (includes truck and rail)	5.3	4.8	13.2	11.2	27.5	26.7
Water	2.9	2.5	12.2	11.1	23.2	20.4
Pipeline	5.0	4.2	15.5	13.7	18.0	17.6
Parcel, postal, courier services	9.1	10.9	0.2	0.2	0.4	0.5
Air (includes truck and air)	2.2	2.7	0.0	0.0	0.1	0.2
Other and unknown modes	4.2	5.6	5.9	5.5	6.5	6.8
Total (domestic plus export shipments)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

KEY: P = preliminary; R = revised.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, based on U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1995).

____. *1997 Commodity Flow Survey: United States Preliminary,* EC97TCF-US(P) (Washington, DC: 1999).

Estimates for crude petroleum shipments by pipelines prepared for the Bureau of Transportation Statistics by Oak Ridge National Laboratory.

Local vs. Long-Haul Freight

Freight shipments can be categorized as local (less than 100 miles), intraregional (between 100 and 1,000 miles), and interregional (over 1,000 miles).[5] In 1997, local shipments constituted nearly 67 percent of the weight (7.7 billion tons), 40 percent of the value ($3 trillion), but only 9 percent of the ton-miles (254 billion) of all CFS shipments, about the same proportion of the value, tons, and ton-miles identified by the CFS in 1993, (see table 2-6).

Intraregional shipments in 1997 accounted for 45 percent of the value of goods shipments ($3.4 trillion), 29 percent of the tons (3.3 billion tons), and 62 percent of the ton-miles (1.7 trillion). Interregional shipments accounted for a relatively small proportion of the total CFS tonnage (4.4 percent in 1997), but they have had a large impact on the U.S. transportation system and the tonnage of such shipments has grown rapidly. In 1997, longer haul shipments accounted for 29 percent of the CFS ton-miles, about the same proportion as in 1993. Nevertheless, the tonnage moving such long distances grew about 40 percent, with value increasing nearly 30 percent in real terms.

Shipments of Major Commodities

Table 2-7 presents the relative shares of major commodities shipped by domestic establishments in 1997 as measured by the CFS. The commodities are based on the two-digit Standard Classification of Transported Goods (SCTG) coding system.[6] Because data on freight shipments in 1993 are not currently available in the

[5]Supplementary data are used to estimate total freight shipments in 1993 and 1997, but this supplementary data does not include freight movement for specific commodities, shipment sizes, and average length of haul per ton of shipments. Such changes can only be discussed using CFS data alone.

[6]BTS and the Census Bureau are retabulating the 1993 CFS data from the Standard Transportation Commodity Classification to the SCTG to make the data directly comparable. These data are expected to be available starting in fall 1999.

Table 2-6

U.S. Freight Shipments by Distance Shipped: 1993 and 1997

(Commodity Flow Survey data only)

	Value (constant $ billions)			Tons (millions)			Ton-miles (billions)		
Distance shipped	**1993**	**1997P**	**Change (%)**	**1993**	**1997P**	**Change (%)**	**1993**	**1997P**	**Change (%)**
Less than 100 miles	$2,527	$3,051	20.7	6,490	7,713	18.9	226	254	12.3
100–999 miles	2,981	3,420	14.8	2,833	3,337	17.8	1,492	1,743	16.8
1,000 miles or more	895	1,153	28.8	366	513	40.0	703	812	15.5
Total	**$6,402**	**$7,624**	**19.1**	**9,688**	**11,563**	**19.3**	**2,421**	**2,808**	**16.0**

KEY: P = preliminary.

SOURCES: U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1995).

____. *1997 Commodity Flow Survey: United States Preliminary*, EC97TCF-US(P) (Washington, DC: 1999).

Table 2-7

Major Commodities Shipped in the United States: 1997P

(Commodity Flow Survey data only)

Ranked by value		Ranked by tons		Ranked by ton-miles	
Commodity	**Percent**	**Commodity**	**Percent**	**Commodity**	**Percent**
Electronic and other electrical equipment and components and office equipment	12.1	Gravel and crushed stone	16.0	Coal and coal products	18.5
Motorized and other vehicles (including parts)	7.8	Coal and coal products	10.8	Cereal grains	8.6
Textiles, leather, and articles of textiles or leather	7.2	Gasoline and aviation turbine fuel	7.8	Gasoline and aviation turbine fuel	5.0
Miscellaneous manufactured products	6.8	Nonmetallic mineral products	7.6	Other prepared foodstuffs and fats and oils	4.6
Mixed freight	5.9	Cereal grains	4.8	Base metal in primary or semifinished forms and in finished basic shapes	4.6
Machinery	5.9	Logs and other wood in the rough	4.3	Basic chemicals	4.2
Other prepared foodstuffs and fats and oils	4.6	Fuel oils	3.9	Gravel and crushed stone	3.6
Printed products	4.1	Natural sands	3.9	Wood products	3.6
Plastics and rubber	3.9	Coal and petroleum products, n.e.c.	3.8	Nonmetallic mineral products	3.4
Base metal in primary or semifinished forms and in finished basic shapes	3.8	Other prepared foodstuffs and fats and oils	3.5	Pulp, newsprint, paper, and paperboard	3.3

KEY: n.e.c. = not elsewhere classified; P = preliminary.

NOTE: Data exclude shipments of crude petroleum.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, based on U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1995).

____. *1997 Commodity Flow Survey: United States Preliminary,* EC97TCF-US(P) (Washington, DC: 1999).

SCTG, this discussion of commodities covers shipments in 1997 only. Moreover, it must be remembered that the CFS does not cover several important commodities such as crude petroleum pipeline movements.

Merchandise in the category "electronic, other electrical equipment and components, and office equipment" accounted for the highest dollar value ($925 billion) of CFS shipments in 1997, followed by motorized and other vehicles (including parts); textiles, leather, and articles of textiles and leather; and miscellaneous manufactured products.

As for total tonnage shipped, the top commodity groups were gravel and crushed stone (1.8 billion tons), coal and coal products, gasoline and aviation fuel, and nonmetallic mineral products. Although gravel and crushed stone accounted for 16 percent of total CFS tons, shipments in this category accounted for less than 1 percent of the value and about 4 percent of the ton-miles of all shipments, impacting mostly local transportation.

The transportation of coal generated the most ton-miles (520 billion), followed by cereal grains, gasoline and aviation fuel, and prepared foodstuffs. Coal produced the most ton-miles because, unlike gravel and stone, which move mostly in local areas, coal is often shipped long distances; coal mined in Wyoming and Montana is transported nationwide. In 1997, a ton of coal was shipped 416 miles on average, compared with 55 miles for a ton of gravel and crushed stone.

Shipment Size

In analyzing CFS data, freight shipments were divided into several weight categories: less than 100 pounds, 100 to 999 pounds, 1,000 to 49,999 pounds, and over 50,000 pounds. In 1997, the value of CFS shipments under 100 pounds exceeded $1.1 trillion, 37 percent greater than in 1993 (in real terms) (see table 2-8). Growth in parcel, postal, and courier services and an increase in just-in-time production and distribution systems are partly responsible for this rise in smaller size shipments. Shipments of less than 100 pounds are often high-value, time-sensitive commodities transported by truck and air intermodal combinations, or by truck alone. In 1997, such small-size shipments accounted for 15 percent of the value of CFS shipments, little different from the 13 percent in 1993.

Large-size shipments (over 50,000 pounds) accounted for nearly 66 percent of the CFS ton-miles, 56 percent of tons shipped, but only 12 percent of the value of shipments in 1997. The relative share of large-size shipments fell slightly between 1993 and 1997 in value, tons, and ton-miles.

INTERNATIONAL FREIGHT

The importance of international trade to the U.S. economy can be seen in the increased value of U.S. merchandise trade[7] in recent decades. Between 1980 and 1997, the real-dollar value of U.S. merchandise trade more than tripled, from $496 billion to $1.7 trillion (in chained 1992 dollars). In addition, the ratio of the value of U.S. merchandise trade relative to U.S. GDP doubled from about 11 percent in 1980 to 23 percent in 1997 (USDOC ITA 1998).

During the past two decades, changes can be seen in the geography of trade. Trade with Asian Pacific countries grew greatly. In 1997, five Asian countries were among the top 10 U.S. trading partners, despite a slight downturn in trade in the second half of 1997 related to economic problems in the region (see table 2-9).

[7]Unless otherwise noted, the value of U.S. merchandise imports is based on U.S. general imports, customs value basis. Export value is f.a.s. (free alongside ship) and represents the value of exports at the port of exit, including the transaction price, inland freight, insurance, and other charges. Generally, data for imports that are valued at less than $1,250 and exports that are valued at less than $2,500 are excluded.

Table 2-8

Shipments by Size: 1993 and 1997

(Commodity Flow Survey data only)

	Value (constant $ billions)			Tons (millions)			Ton-miles (billions)		
Shipment size	**1993**	**1997P**	**Change (%)**	**1993**	**1997P**	**Change (%)**	**1993**	**1997P**	**Change (%)**
Less than 100 pounds	852	1,165	36.6	35	41	17.8	12	15	26.4
100–999 pounds	995	1,215	22.1	139	168	20.1	30	41	37.6
1,000–49,999 pounds	3,735	4,360	16.7	3,830	4,877	27.4	728	903	24.1
Over 50,000 pounds	820	885	7.9	5,685	6,477	13.9	1,651	1,849	12.0

KEY: P = preliminary.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, based on U.S. Department of Commerce, Census Bureau, *1993 Commodity Flow Survey: United States,* TC92-CF-52 (Washington, DC: 1995).

____. 1997 *Commodity Flow Survey: United States Preliminary,* EC97TCF-US(P) (Washington, DC: 1999).

Table 2-9

Top 10 U.S. Merchandise Trade Partners by Value: 1980 and 1997 (chained 1997 dollars)

1980					1997				
Rank	**Country**	**Imports**	**Exports**	**Total**	**Rank**	**Country**	**Imports**	**Exports**	**Total**
1	Canada	77,240	65,942	143,182	1	Canada	168,201	151,767	319,968
2	Japan	57,221	38,732	95,954	2	Japan	121,663	65,549	187,212
3	Mexico	23,437	28,216	51,653	3	Mexico	85,938	71,388	157,326
4	West Germany	21,784	20,419	42,203	4	China	62,558	12,862	75,420
5	United Kingdom	18,336	23,649	41,985	5	United Kingdom	32,659	36,425	69,084
6	Saudi Arabia	23,564	10,746	34,310	6	Germany	43,122	24,458	67,580
7	France	9,809	13,945	23,754	7	Taiwan	32,629	20,366	52,995
8	Taiwan	12,769	8,080	20,849	8	South Korea	23,173	25,046	48,219
9	Netherlands	3,564	16,151	19,715	9	Singapore	20,075	17,696	37,771
10	Venezuela	9,913	8,520	18,433	10	France	20,636	15,965	36,601

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, January 1999, based on data from U.S. Department of Commerce, Census Bureau, *Statistical Abstract of the United States* (Washington, DC: Various years).

These five countries accounted for 26 percent of overall U.S. trade in 1997, up from 17 percent in 1980. Canada and Mexico were the first and third largest U.S. trading partners in 1980 and in 1997. While the rankings remained the same, the U.S. trade relationship with these two countries deepened. In 1980, Canada and Mexico together accounted for 22 percent of all U.S. trade by value. By 1997, this had increased to over 30 percent (USDOC 1985; USDOC Census FTD 1997).

Changes over the past two decades also occurred in the commodities traded. Higher value manufactured goods now dominate U.S. trade, accounting for $1.3 trillion or 85 percent of the value of all merchandise trade in 1997. Of these goods, motor vehicles, computers, telecommunications equipment, and aircraft are among the top U.S. import and export commodities by value. While the value of manufactured goods increased as a share of U.S. trade, the share of agricultural commodities declined from 13 percent in 1980 to 6 percent in 1997. Mineral fuels accounted for approximately 6 percent of the value of U.S. trade in 1997, primarily imports of crude petroleum and petroleum products (USDOC ITA 1999).

The relative roles of transportation modes in carrying U.S. international trade have changed in recent decades, especially in terms of value. Due to the way in which data on U.S. trade are collected, it is not possible to fully calculate the role of intermodal or multimodal moves of international freight. Modal shares, therefore, represent single modes in use at a U.S. port of entry or exit. In 1997, water was the predominant mode in both value and tonnage, while air accounted for nearly 28 percent of the value but only a small part of the tonnage (see figure 2-4). Truck and rail accounted for smaller, but still important shares.[8]

Waterborne Trade

While waterborne trade accounted for more than three-quarters of the tonnage of U.S. international trade in 1997, its share of the value of U.S. trade declined from 62 percent in 1980 to 40 percent in 1997[9] (USDOC Census 1994, table 1062; USDOC Census FTD 1997). Among the factors that explain this decline are greater land trade with Canada and Mexico and the demand for faster delivery of high-value commodities, which has increased air trade.

In 1997, maritime ports on the west coast of the United States accounted for 42 percent of the value of U.S. waterborne trade with other countries compared with only 24 percent in 1980. East coast ports' share by value, however, declined from 41 percent to 38 percent over this period (remaining relatively stable in the last 5 years), and the share of value for Gulf ports also dropped from 33 percent to 18 percent (USDOC Census 1997, table 1069; USDOT MARAD 1998). Increased trade with Asian Pacific countries between 1980 and 1997 helps explain this east to west coast shift. The financial crisis impacting several Asian economies, beginning in the second half of 1997,[10] caused a slight decrease in overall merchandise trade by west coast ports. Between 1996 and 1997, the value of total international trade by west coast ports decreased 1.5 percent compared with a 0.4 percent decrease for east coast ports. Because of the appreciation of the U.S. dollar in relation to several Asian currencies, imports through west coast ports increased 3 percent between 1996 and 1997, while exports declined 12 percent.

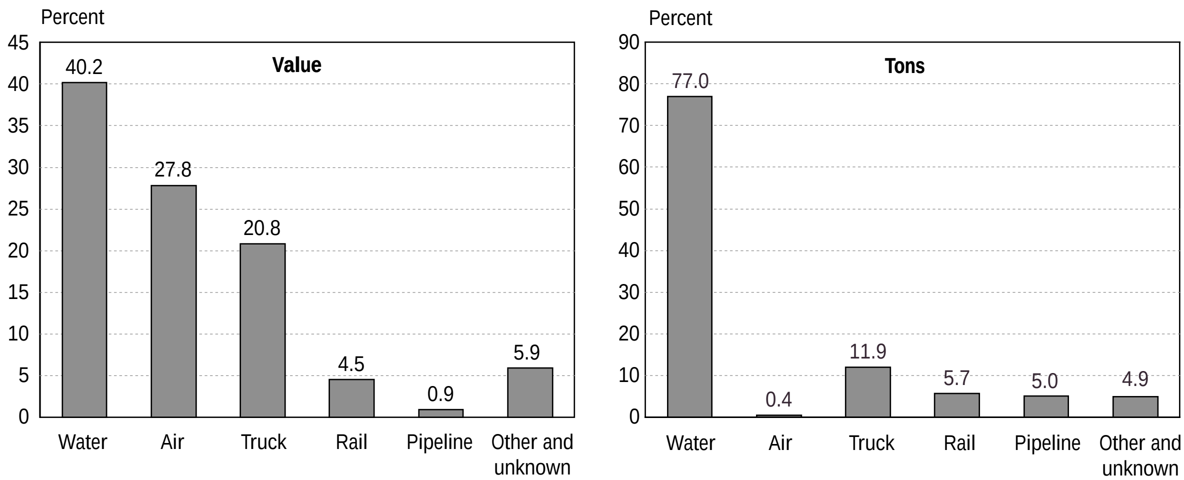
The ports of Long Beach and Los Angeles account for the majority of west coast waterborne trade. Long Beach is also the leading U.S. port both by value and for containerized trade, as measured by the number of 20-foot equivalent units (TEUs) handled. In 1997, $85 billion worth of international trade passed through the

[8] BTS estimated the weight of U.S. land exports. (For water and air, see USDOC Census FTD 1997. Truck, rail, pipeline, and other and unknown are from BTS analyses and Transborder Surface Freight Data.)

[9] Excludes waterborne in-transit shipments. In-transit shipments are merchandise shipped through the United States in transit from one foreign country to another.

[10] The causes of the Asian financial crisis are complex and multifaceted. However, a precipitating event occurred in July 1997 when the government of Thailand abandoned its efforts to maintain a fixed exchange rate for its currency, the baht. The baht quickly depreciated by more than 20 percent. Within a few days, most neighboring countries had also abandoned their fixed exchange rates. Currency crises often have destabilizing effects on international trade. U.S. overall trade with several Asian economies decreased in 1997, while the U.S. trade deficit with several Asian countries increased. (For further information, see USITC 1998.)

Figure 2-4
Modal Shares of U.S. Merchandise Trade by Value and Tons: 1997



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, January 1999, except water and air data from U.S. Department of Commerce, Census Bureau, Foreign Trade Division.

port of Long Beach, and the port handled 2.7 million TEUs (see table 2-10). Other west coast ports such as Los Angeles, Seattle, and Tacoma are also important gateways for U.S. trade with Asia.[11] The port of New York/New Jersey is the east coast leader in both the value of trade ($68 billion) and in the number of containers (1.7 million TEUs) handled in 1997. Charleston and Norfolk are also major east coast container ports. The importance of Gulf ports (e.g., Houston and South Louisiana) in the trade of bulk commodities and crude petroleum can be seen from their listing as the top two U.S. ports by tonnage.

Air Freight

Air freight moves both by all-cargo carriers and carriers that transport passengers. Between 1980 and 1997, air freight's share of the value of U.S. international merchandise trade increased from 16 percent to nearly 28 percent. Commodities that move by air tend to be high in value; air's share of U.S. trade by weight was less than 1 percent in 1997.

Western European and Asian Pacific countries dominate air freight to and from the United States. The top three countries by value of air freight with the United States are Japan, the United Kingdom, and Singapore. New York's John F. Kennedy (JFK) International Airport was the leading gateway for shipments into and out of the United States by all modes, accounting for over $89 billion in 1997. Following JFK were the airports of Chicago, Los Angeles, and San Francisco.[12]

North American Merchandise Trade

U.S. merchandise trade with Canada and Mexico represents 30 percent of all U.S. international trade, with Canada accounting for approximately 20 percent and Mexico 10 percent. U.S. trade with Mexico has grown more quickly than with Canada, and in 1997 Mexico surpassed Japan as the second largest market for U.S. mer-

[11] Many individual west coast ports were also impacted by the Asian financial crisis. The overall value of the port of Long Beach's international trade declined 2 percent between 1996 and 1997. The decline in Long Beach's export trade was more dramatic, 18 percent. The ports of Seattle and Oakland also saw notable decreases in export traffic between 1996 and 1997.

[12] San Francisco includes the San Francisco International Airport and other smaller regional airports. Chicago includes O'Hare, Midway, and other smaller regional airports.

Table 2-10
Top Water Ports for International Trade: 1997

By 20 foot equivalent units (TEUs)

Rank	Port name	TEUs
1	Long Beach, CA	2,673,199
2	Los Angeles, CA	2,084,924
3	New York,NY/NJ	1,738,391
4	Charleston, SC	955,488
5	Seattle, WA	953,304
6	Oakland, CA	843,066
7	Norfolk, VA	769,718
8	Miami, FL	623,658
9	Houston, TX	609,451
10	Tacoma, WA	551,164

By value (billions of current U.S. dollars)

Rank	Port name	Value
1	Long Beach, CA	85.3
2	Los Angeles, CA	73.4
3	New York, NY and NJ	68.0
4	Houston, TX	37.1
5	Seattle, WA	33.6
6	Charleston, SC	27.3
7	Oakland, CA	25.4
8	Norfolk, VA	25.0
9	Tacoma, WA	19.6
10	Baltimore, MD	18.8

By tonnage (millions of U.S. short tons)

Rank	Port name	Tonnage
1	Houston, TX	102.8
2	South Louisiana, LA	76.8
3	Corpus Christi, TX	62.2
4	New York, NY and NJ	56.7
5	New Orleans, LA	52.4
6	Baton Rouge, LA	38.4
7	Long Beach, CA	38.4
8	Texas City, TX	37.4
9	Norfolk, VA	35.4
10	Beaumont, TX	33.6

NOTES: Value data do not include in-transit shipments. Tonnage data, unlike port tonnage data for previous years, do not include in-transit shipments.

SOURCES: TEU data: U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Policy, based on data from the *Journal of Commerce,* Port Import and Export Reporting System (PIERS).
Value data: U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Policy, Annual Waterborne Databanks 1996, 1998.
Tonnage data: U.S. Army Corps of Engineers, Navigation Data Center, special tabulation, December 1998.

chandise exports (although Mexico remained the third largest trading partner overall). Between 1993 and 1997, trade with North American Free Trade Agreement (NAFTA)[13] partners increased 62 percent in current dollars, from $293 billion to $475 billion. During this same period, U.S. trade with Mexico grew most rapidly, almost doubling from $81 billion in 1993 to $157 billion in 1997 (USDOC 1998, table 1323; USDOC Census FTD 1997).

In terms of commodities, motor vehicles and motor vehicle parts and accessories dominate trade between all of the North American countries. Other leading North American trade commodities include consumer electronics, telecommunications equipment, and aircraft equipment and parts. In addition, crude petroleum, natural gas, and petroleum products are important U.S. imports from both Canada and Mexico. Mexico is also a chief source of U.S. imports of clothing and textiles, while paper products, furniture, and wood products are among leading U.S. imports from Canada.

Truck trade represented almost 70 percent of the value and 33 percent of the tonnage of overall NAFTA merchandise trade in 1997.[14] Rail's share was approximately 15 percent both by value and weight. Rail played a greater role in U.S.-Canadian trade than in U.S.-Mexican freight movement. Ten states accounted for approximately two-thirds of the value of North American land trade in 1997.[15] These were Michigan, Texas, California, New York, Ohio, Illinois, Pennsylvania, Indiana, North Carolina, and Tennessee. Many of these states contain major population and manufacturing centers.

[13] The United States, Canada, and Mexico signed the agreement in December 1993 and the treaty entered into force on January 1, 1994.
[14] BTS estimate.
[15] Top origin and destination states are based on U.S. international trade data collected from administrative records. Due to filing requirements and procedures, border state activity may be overrepresented. In addition, trade data do not always reflect physical transportation flows. The location is often misrepresented because trade documents are not always filed where shipments physically cross the border.

On the U.S.-Canadian border, 10 gateways accounted for approximately 83 percent of freight moved by trade, while for U.S.-Mexican trade, the top 10 land gateways account for 93 percent. The three largest gateways for U.S.-Canadian land trade were Detroit, Buffalo-Niagara Falls, and Port Huron (see figure 2-5). On the U.S.-Mexican border, the top gateway was Laredo, followed by El Paso, and Otay Mesa, California. Truck traffic accounted for the majority of the trade at most of these gateways. Port Huron, Michigan, and Eagle Pass, Texas, were important rail gateways. For many of these gateways, the shipment origins and destinations were outside the state in which the gateway is located. For example, nearly four-fifths of the shipments that crossed the border at Laredo had their origins or destinations outside of Texas. Three-quarters of the shipments that crossed the border at Buffalo have their origins or destinations outside of New York (USDOT BTS 1998b).

Although much North American trade takes place between bordering states or provinces such as Ontario and Michigan and Texas and Chihuahua, other trade flows are characterized by longer distances (e.g., truck shipments between California or Texas and Ontario for U.S.-Canadian trade and between Texas and Jalisco and Michigan and the Mexico City metropolitan area for U.S.-Mexican trade). Shipments from maquiladora[16] plants and facilities along the U.S.-Mexican border accounted for some of the shorter flows in U.S.-Mexican trade, while some of the longer flows were between motor vehicle manufacturing and production centers at diverse locations in Mexico, the United States, and Canada.

[16]Maquiladoras are manufacturing or assembly plants located in Mexico that provide parts, components, and additional processing for manufactured products produced by U.S. or multinational companies. Maquiladora plants located near the U.S. border are often wholly owned or are a subsidiary of a U.S. or multinational company.

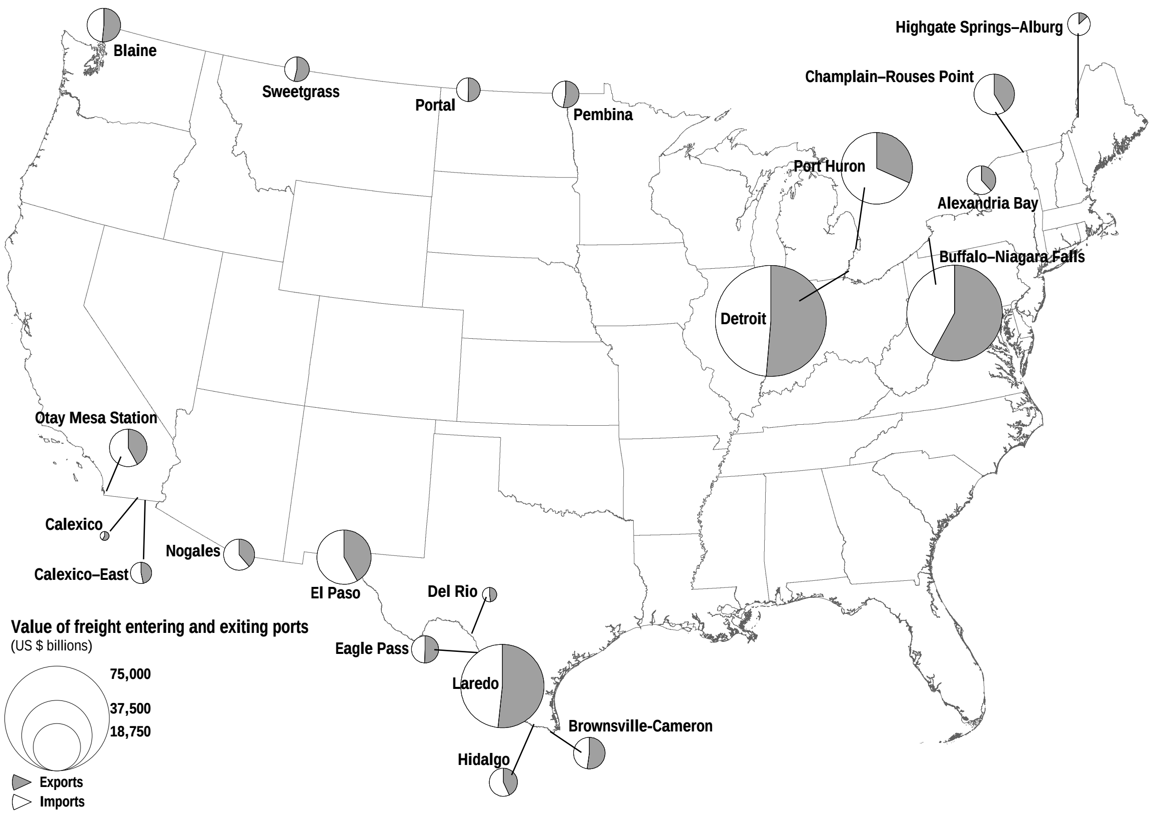
A Multimodal View

Air, land, and water modes are all important in transporting goods in U.S. international trade. Figure 2-6 illustrates the top ports of entry and exit for U.S. international trade shipments by value in 1997. The leading gateway overall in 1997 was JFK International Airport in New York with $89 billion of activity. This was followed by the water port of Long Beach, California, which handled $85 billion worth of shipments, and Detroit, Michigan, a land gateway with $83 billion worth of shipments in 1997. Changes in the mix of commodities traded internationally, geographic shifts in centers of production, global trade patterns, and many other factors will continue to affect these gateways as well as the movement of international trade shipments to, from, and within the United States.

USE AND PERFORMANCE

Many factors affect the performance of the transportation system: accessibility, safety, environmental restraints, input costs, energy efficiency, capacity-to-demand ratios, reliability, travel time and delay, goods damage, and a host of other variables. Safety, energy efficiency, environmental impacts, and economic measures of the system's performance are discussed elsewhere in this report. The following section focuses on trends in the use of the transportation system and how well the transportation system delivers services that people and businesses want, such as speed, reliability, security, convenience, and comfort, when they buy a passenger ticket, forward a shipment, or travel during peak hours. Thus, the discussion of performance that follows highlights such indicators as: 1) on-time performance, congestion, and delay; 2) the security of goods during shipment against damage or loss; 3) productivity; and 4) accessibility of transit services to persons with physical disabilities. In

Figure 2-5
Top Border Land Ports: 1997



NOTES: Data include transshipments between the United States and Mexico. Trade levels reflect the mode of transportation as a shipment entered or exited a U.S. Customs port. Alaska is not shown as its border land ports do not fit the criteria for inclusion in this figure.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data, 1998.

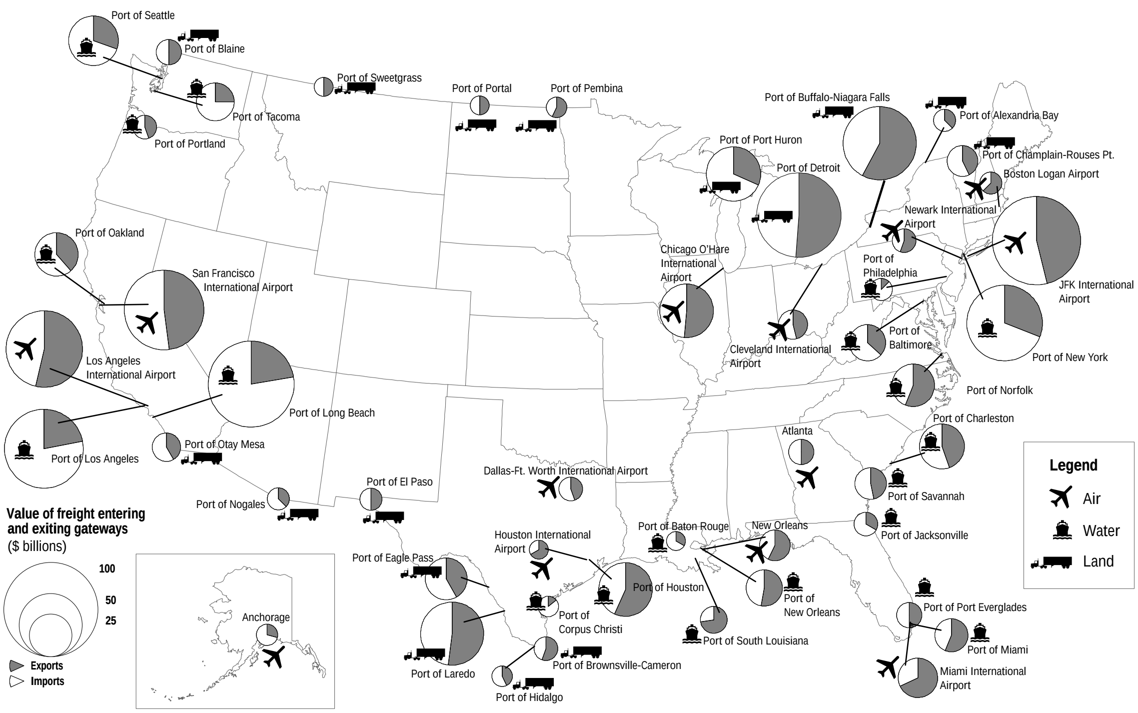
addition, selected operational efficiency indicators will be discussed for some modes.

Highway

Vehicle-miles traveled (vmt) on public roads increased 68 percent between 1980 and 1997, with urban vmt growth outpacing rural vmt—83 percent to 49 percent. Some of the growth in urban areas is due to the expansion of urban boundaries and urban population (USDOT FHWA various years) (see table 2-11). Urban Interstate travel increased the most over these years, about 4.9 percent annually, although other urban arterials still carried the most traffic in 1997.

For the highway user, traffic congestion and delay are measures of highway performance. Unfortunately, direct measures are not now available to determine whether congestion and delay are getting better or worse for the nation as a whole. Two indirect methods are used, however: 1) congestion and delay calculations based on daily volume-to-capacity ratios such as those found in the Federal Highway Administration's (FHWA's) Highway Performance Monitoring System (HPMS); and 2) trip speed estimates based on commuter trip length and travel time data collected from travel surveys.

Figure 2-6
Top Freight Gateways by Shipment Value: 1997



NOTES: Air—Values for some airports may include a low level (generally less than 2 percent of the total value) of small user-fee airports located in the same regional area. In addition, due to the Census Bureau's confidentiality regulations, data for nearby individual courier operations (e.g., DHL, Federal Express, United Parcel Service) are included in the airport totals for New York Kennedy, New Orleans, Los Angeles, Cleveland, Chicago O'Hare, Miami, and Anchorage. Land—Data include transshipments between the United States and Mexico. Trade levels reflect the mode of transportation as a shipment entered or exited a U.S. Customs port. Includes truck, rail, pipeline, and other modes of land transportation.

SOURCES: Air—U.S. Department of Commerce, Census Bureau, Foreign Trade Division, special tabulation. Maritime and Great Lakes—U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Policy, *U.S. Waterborne Exports and General Imports, Annual 1997* (Washington, DC: 1998). Land—U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data, 1998.

Two estimates of congestion using volume-to-capacity ratios are discussed here: the Texas Transportation Institute's (TTI's) studies of urban congestion and FHWA's estimates of volume-to-service-flow (where service flow is a measure of capacity). In addition, results from various Nationwide Personal Transportation Surveys augment these estimates. As shown below, the congestion indicators developed by these indirect methods often produce conflicting views about traffic congestion and/or delay.

TTI's most recent analysis of urban highway congestion shows highway congestion and traffic delay rising in the United States.[17] Of the 70 urban areas included in the TTI study, the estimated level of congestion declined in only 2—Phoenix and Houston—between 1982 and 1996. Congestion in most other urban areas increased, dramatically in some instances. The number of urban areas in the study experiencing unacceptable congestion rose from 10 of the 70 in 1982 to 39 in 1996, with the average roadway congestion index—measured by travel volume per road lane—rising about 25 percent from 0.91 to 1.14. TTI selected an index of 1.00 or greater as the threshold for unacceptable congestion (see figure 2-7).

[17] The primary data source used by TTI is the HPMS.

Table 2-11
Highway Vehicle-Miles Traveled by Functional Class: 1980–97 (millions)

	1980	1997	Percentage change
Urban			
Interstate	161,242	351,371	124.1
Other arterials	484,189	846,596	74.8
Collectors	83,043	130,461	57.1
Local	126,791	222,024	75.1
Total	**855,265**	**1,560,452**	**82.5**
Rural			
Interstate	135,084	240,121	77.8
Other arterials	262,774	391,481	49.0
Collectors	189,468	253,807	34.0
Local	84,704	114,511	35.2
Total	**672,030**	**999,920**	**48.8**
Total	**1,527,295**	**2,560,372**	**67.6**

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Various years).

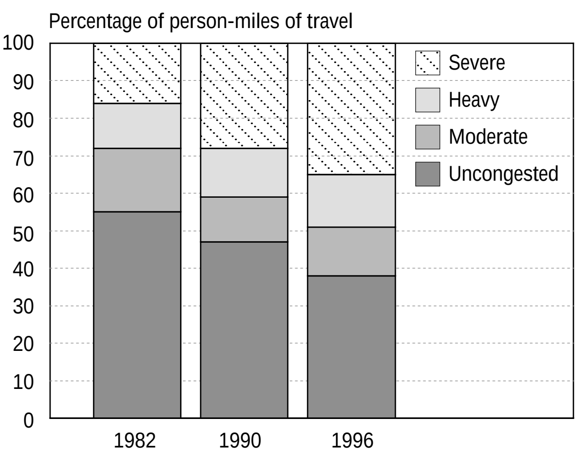
Table 2-12 presents an index of roadway congestion, annual delay, and wasted fuel. In 1996, drivers in the 70 study areas experienced an average of 40 hours of delay each over the course of the year—the equivalent of a full work week. This was 8 percent more delay than in 1990, and 150 percent more than in 1982 when the average was 16 hours. In 1982, peak-hour travel took 13 percent more time than travel in less congested conditions (for the same distance traveled). By 1996, peak period travel required 25 percent more travel time on average, and in some cities it took nearly 50 percent more time than offpeak travel (TTI 1998).

TTI estimated that the total annual costs of congestion in the 70 areas reached $74 billion in 1996, $65 billion due to delay (productivity loss) and $9 billion due to wasted fuel. Costs ranged from $333 per driver in smaller cities to $936 in large cities, averaging about $629 overall. The study estimated that 6.7 billion gallons of fuel was wasted in these areas due to traffic congestion, compared with about 2.7 billion gallons in 1982 (TTI 1998).

FHWA's volume-to-capacity estimates only partly confirm TTI's findings, though changes in the definition of congestion in 1995 make a full comparison difficult. Moreover, FHWA's data only measure recurring congestion, which occurs during normal daily operations because demand exceeds capacity, while TTI's data also measure nonrecurring congestion, which occurs as a result of traffic crashes, breakdowns, or other irregular incidents. FHWA's 1995 through 1997 estimates show slight increases in congestion for principal arterials (i.e., arterials other than Interstates, freeways, and expressways). Urban Interstates, on the other hand, show a reduction in delay over the period. Similarly, urban freeways and expressways show a decrease since 1995. Rural roads show no noticeable increase (USDOT FHWA Various years, table HM-61).

Commuter speeds, as measured by the NPTS in 1983 and 1995, show a 20 percent increase from 28 mph to 34 mph (USDOT FHWA 1997c, 13). At first glance, the NPTS data might seem to contradict the TTI findings. There

Figure 2-7
Congested Person-Miles of Travel in 70 Urban Areas



SOURCE: Texas Transportation Institute, *Urban Roadway Congestion Annual Report: 1998* (College Station, TX: 1998), p. 35.

Table 2-12
Urban Congestion Indicators for 70 Urban Areas: Selected Years

Year	Average roadway congestion index	Annual delay per eligible driver (person-hours)	Wasted fuel per eligible driver (gallons)	Annual fuel wasted per urban area (million gallons)
1982	0.91	16	23	39
1986	1.01	22	32	54
1990	1.07	27	39	68
1992	1.09	30	44	76
1994	1.11	35	51	84
1995	1.12	37	54	91
1996	1.14	40	58	96

SOURCE: Texas Transportation Institute, *Urban Roadway Congestion Annual Report: 1998* (College Station, TX: 1998), pp. 11–21.

are several plausible reasons for different findings, however. First, TTI only includes urban areas, while the NPTS also includes non-urban areas, where congestion is typically less severe or nonexistent. Second, the NPTS data include commuting by all modes, while TTI only includes highway modes of travel. Thus, the NPTS results reflect commuter decisions in the 1980s and 1990s to switch from car pools and transit to single-occupant vehicle trips, which often save time for the individual workers, but increase road congestion. Other reasons commute speeds may have increased are metropolitan decentralization (people have moved to places where speeds are higher) and the widening of the peak period because of work-time flexibility (USDOT FHWA 1997c).

In 1995, the NPTS for the first time included customer satisfaction questions that are helpful in judging how well the transportation system meets people's expectations. Nearly half of respondents said that congestion was no problem at all, with about one-third saying it was a small problem and 20 percent saying it was a large problem. About one-quarter of people in urban and suburban areas reported that congestion was a large problem, whereas 37 percent of suburban residents and 29 percent of urban residents reported it as a small problem. Rural respondents report the least problem with congestion and town and second-city[18] residents fall somewhere in between. A question was also asked about pavement quality on major highways. One-quarter of respondents reported that it is a large problem, and another 39 percent said it is a small problem. About 15 percent of respondents reported that poor walkways or sidewalks were a large problem in their community; another 28 percent reported it as a small problem; the remaining 57 percent reported it was no problem (USDOT FHWA 1999a).

Air

Enplanements (both domestic and international) increased from 302 million in 1980 to 575 million in 1997 (USDOT BTS 1998a). The change in enplanements at major hubs can be seen in figure 2-8. Revenue passenger-miles increased from 268 billion miles in 1980 to 622 billion miles in 1997 (USDOT BTS In press).

Several measures are available to examine the performance of commercial air travel. These include on-time information, speed, and baggage and boarding problems.

[18] For the definition of second cities, see footnote 3.

Figure 2-8
Enplanements at Major Hubs: 1987 and 1997

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Airport Activity Statistics of Certificated Air Carriers: Summary Tables; Twelve Months Ending December 31,1997* (Washington, DC: 1997).

In 1997, 78 percent of major carrier flights arrived on time.[19] Although arrival on-time performance in 1997 was slightly lower than other years during the past decade, it was the first year since 1991 that it improved (USDOT Various years).

Throughout the 1990s, aircraft speed of scheduled large certificated air carrier flights (not including small certificated and commuter airlines) averaged just under 220 mph. Average speed is measured as the ratio of flight length to flight duration. Flight length is measured from airport to airport and does not include any additional mileage due to flight deviations (e.g., going around bad weather or circling because of airport airspace congestion). Flight duration is measured from departure gate to arrival gate. Thus, this metric measures overall trip speed rather than air-over-ground speed.

Both mishandled baggage and complaint rates were lower in 1997 than they were in 1990, although complaints edged up in 1996 and 1997. Mishandled baggage per 1,000 enplanements was 4.96 in 1997, compared with 6.73 in 1990. Approximately 2.3 million claims were filed in 1997 (USDOT BTS 1998, tables 1-44–1-46).

The number of consumer complaints against major air carriers received by the U.S. Department of Transportation increased in 1997 for the second year in a row after several years of decline. In 1997, 86 out of every 1 million persons enplaned on a major airline registered a complaint with DOT, the highest rate since 1993 (USDOT Various issues).

[19] An aircraft departure or arrival is considered on-time if it takes place within 15 minutes of its scheduled time.

The percentage of passengers denied boarding (i.e., “bumped” from flights because seats were oversold by the airline) on the 10 largest U.S. air carriers has risen appreciably since 1993, from 683,000 to 1.1 million passengers in 1997 (from 0.15 percent to 0.21 percent of boardings). Voluntary denials[20] made up 95 percent of all denials in 1997 and is where virtually all the increase has been concentrated (USDOT Various years).

Water

In 1997, 2.3 billion tons of cargo were moved by water, with just over half of it foreign trade. Since 1988, foreign trade tonnage has increased by 25 percent while domestic freight moved by water remained about the same at around 1.1 billion tons. In 1997, 57 percent of domestic tons moved on the inland waterways, 24 percent moved coastwise, and 11 percent moved lakewise (the rest was local and intraterritorial traffic). Lakewise and inland waterway movement increased by 13 percent and 7 percent, respectively, over this period, while coastwise movement declined by 19 percent (USACE 1998).

Port performance is typically measured by annual cargo throughput. In 1997, 150 ports handled more than 1 million tons of cargo, and 31 ports handled over 10 million tons (see figure 2-9).

The U.S. Army Corps of Engineers provides data on lock performance, including average processing time, lock closure, and lock traffic, for each lock chamber of the inland waterway system in its Performance Monitoring System (USACE 1999), but no national summary is currently available.

Transit

Transit ridership, which is concentrated in a few large metropolitan areas (see figure 2-10), remained constant between 1987 and 1997 with unlinked trips going from 7.85 million trips in 1987 to 7.98 million in 1997, while miles traveled increased from about 36 billion to 40 billion. Although bus and heavy-rail ridership stagnated during this period, it still carried the majority of transit users (see table 2-13). Ridership on other modes of transit—especially demand responsive service,[21] light rail, and ferries—markedly increased.

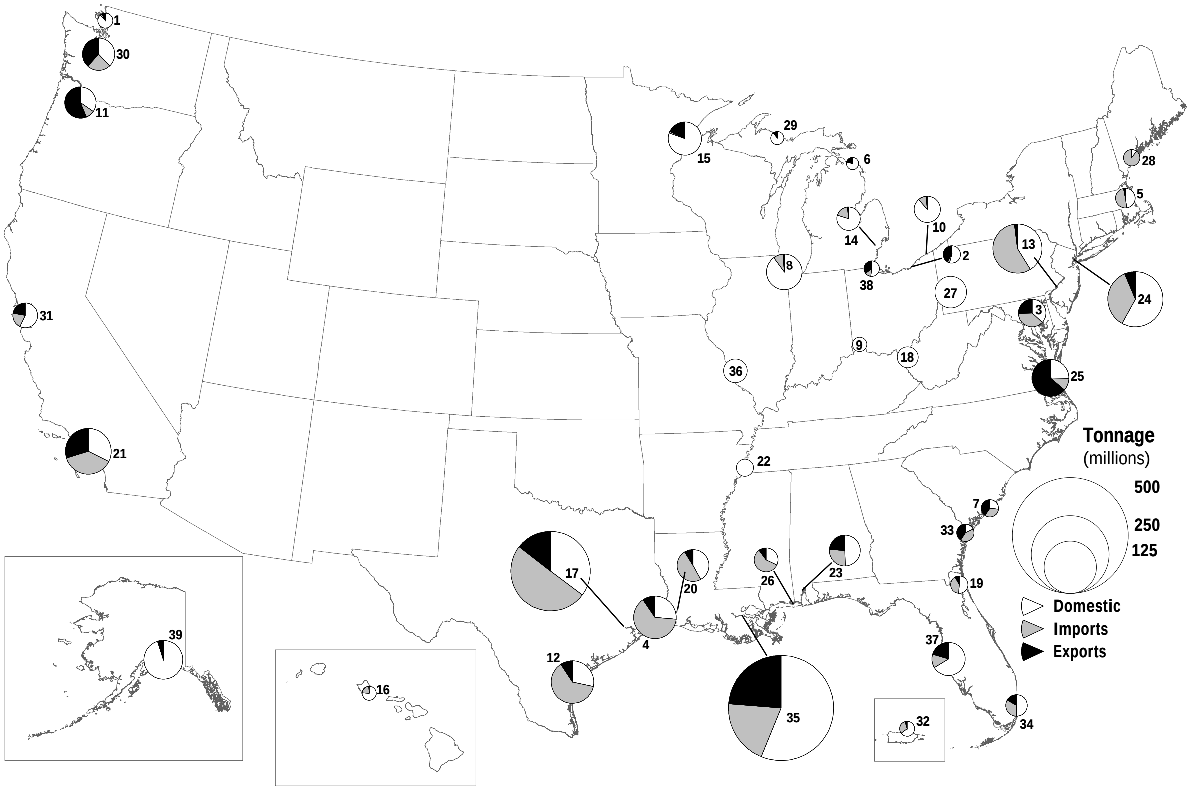
The performance of transit service in the United States seems to be improving, at least for federally subsidized transit for which data are available. Vehicle revenue-miles measure the availability of transit service. From 1987 to 1997, total revenue-miles increased 25 percent from 2.28 billion miles to 2.85 billion miles. Demand responsive transit revenue-miles tripled from 113 million to 350 million. Rail service also increased, with light-rail revenue-miles more than doubling, commuter rail up 35 percent, and heavy rail up 14 percent (see table 2-13). Bus revenue-miles increased only 8 percent but still accounted for 56 percent of all vehicle revenue-miles. In general, increases in vehicle revenue-mileage are due to expansion in the geographic coverage for transit, not increased frequency of existing services (USDOT FTA 1999).

The percentage of transit vehicles providing accessible service under the Americans with Disabilities Act (ADA) varied dramatically by type of transit, but was generally higher in 1997 than in 1993. About 68 percent of buses were ADA accessible in 1997, up from 53 percent in 1993. Only 29 percent of commuter rail vehicles were accessible in 1997, but this was higher than the 18 percent in 1993. A relatively large percentage of heavy-rail vehicles are ADA accessi-

[20] In this type of denial, a customer voluntarily gives up his/her reserved seat on an overbooked flight, usually in return for some form of compensation from the airline.

[21] Demand responsive service includes passenger cars, vans, or buses with fewer than 25 seats operating in response to calls from passengers or their agents rather than on fixed routes. These include paratransit and dial-a-ride services, but exclude jitneys and other fixed-route services.

Figure 2-9
Tonnage Handled by Major Water Ports: 1997

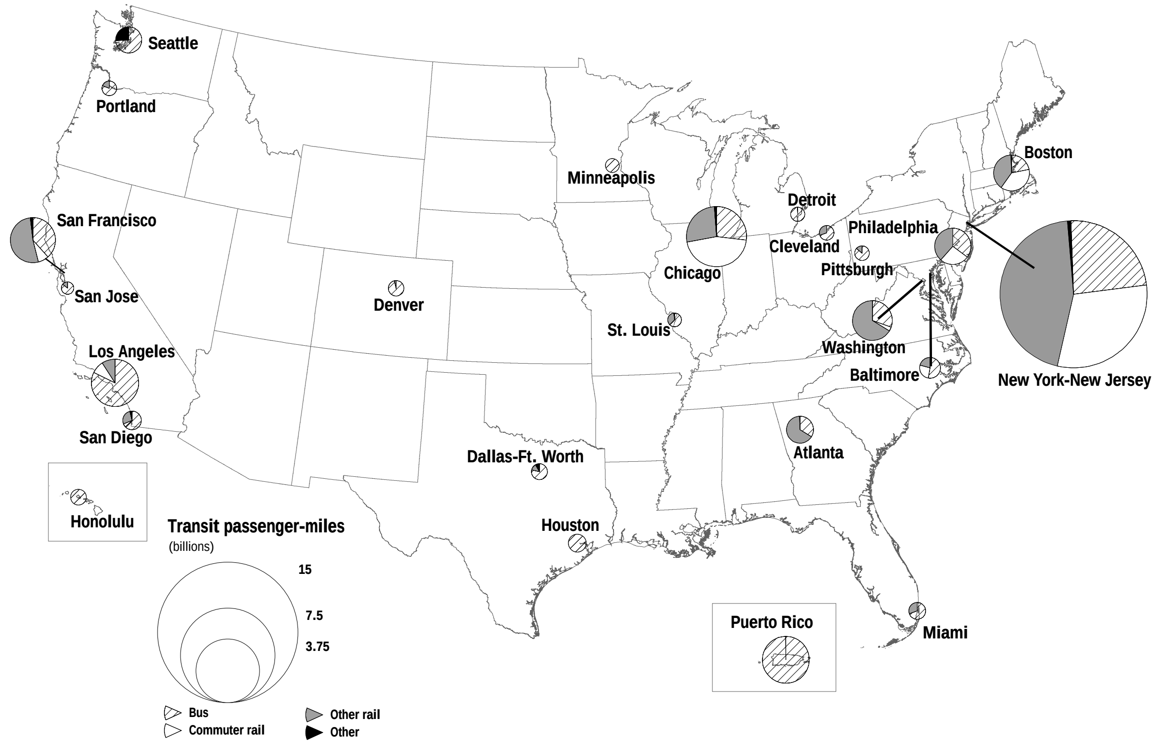


NOTE: Major ports were defined as having one port with over 10 million tons shipped in 1997, and were combined with other ports in the same major waterway or located in the same metropolitan statistical area with at least 1 million tons shipped.

SOURCE: U.S. Army Corps of Engineers, Water Resources Support Center, Navigation Data Center, Alexandria, VA.

1 Anacortes, WA
2 Ashtabula
Ashtabula, OH
Conneaut, OH
3 Baltimore, MD
4 Beaumont-Port Arthur
Beaumont, TX
Port Arthur, TX
5 Boston
Boston, MA
Salem, MA
6 Calcite, MI
7 Charleston, SC
8 Chicago-Gary
Chicago, IL
Gary, IN
Indiana Harbor, IN
Burns Waterway Harbor, IN
Buffington, IN
9 Cincinnati, OH
10 Cleveland-Lorain
Cleveland, OH
Lorain, OH
Fairport Harbor, OH
11 Columbia River
Portland, OR
Vancouver, WA
Longview, WA
Kalama, WA
12 Corpus Christi, TX
13 Delaware River
New Castle, DE
Wilmington, DE
Marcus Hook, DE
Chester, PA
Paulsboro, NJ
Philadelphia, PA
Camden-Gloucester, NJ
14 Detroit
Detroit, MI
St. Clair, MI
Marine City, MI
Monroe, MI
15 Duluth-Superior, MN and WI
16 Honolulu, HI
17 Houston-Galveston
Houston, TX
Galveston, TX
Texas City, TX
Freeport, TX
18 Huntington, IN
19 Jacksonville, FL
20 Lake Charles, LA
21 Los Angeles-Long Beach, CA
22 Memphis, TN
23 Mobile, AL
24 New York-New Jersey
25 Norfolk-Newport News
Norfolk, VA
Newport News, VA
26 Pascagoula, MS
27 Pittsburgh, PA
28 Portland, ME
29 Presque Isle, MI
30 Puget Sound
Seattle, WA
Tacoma, WA
Everett, WA
Olympia, WA
31 San Francisco Bay
San Francisco, CA
Oakland, CA
Richmond, CA
32 San Juan, PR
33 Savannah, GA
34 South Florida
Miami, FL
Port Everglades, FL
35 South Louisiana
Port of South Louisiana
New Orleans, LA
Baton Rouge, LA
Plaquemine, LA
36 St. Louis, MO
37 Tampa, FL
38 Toledo, OH
39 Valdez, AK

Figure 2-10
Largest Transit Markets: 1997



NOTE: Large transit markets are defined as having more than 200 million transit passenger-miles. Alaska has no large transit markets, so it is not shown.
SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, 1997.

ble—78 percent in 1997—but there has been no improvement since 1994 (see figure 2-11).

Transit speeds varied greatly in 1997, from commuter rail at 33.8 mph—the fastest—to bus, which at 12.9 mph was the slowest. Heavy rail was the second fastest with an average speed of 20.7 mph, followed by demand responsive vehicles (14.7 mph), and light rail (15.5) (USDOT FTA 1999).

Property damaged during transit operations is another performance measure. In 1997, directly operated transit was responsible for $55.7 million in property damage, and purchased transportation service was responsible for another $5 million.[22] This totals $1.39 per 1,000 revenue passenger-miles in 1997, about the same as in 1993, when accounting for inflation (USDOT FTA 1999).

Rail

Revenue ton-miles reached 1,349 billion in 1997, an increase of 47 percent since 1980, although revenue-ton miles increased only 16 percent in the eastern United States, but climbed

[22] A transit agency may provide transit service itself (directly operated service) or contract with another public or private entity (purchased transportation).

Table 2-13
Urban Transit Indicators: 1987 and 1997 (thousands)

	Revenue vehicle-miles			Passenger miles			Ridership (unlinked trips)		
	1987	1997	Change (%)	1987	1997	Change (%)	1987	1997	Change (%)
Demand responsive	113,100	350,076	210	176,800	531,078	200	28,800	88,203	206
Bus	1,484,334	1,605,721	8	17,094,900	17,509,219	2	4,794,300	4,602,031	–4
Commuter rail	169,901	229,608	35	6,806,300	8,037,486	18	311,000	357,199	15
Heavy rail	473,921	539,670	14	11,198,000	12,056,068	8	2,402,100	2,429,455	1
Light rail	18,015	39,802	121	404,400	1,023,708	153	131,300	259,404	98
Ferryboat	1,559	2,015	29	114,100	254,219	123	18,800	42,048	124
Total	**2,281,275**	**2,853,330**	**25**	**36,102,300**	**40,180,219**	**11**	**7,847,900**	**7,982,371**	**2**

SOURCE: U.S. Department of Transportation, Federal Transit Administration, *National Transit Database, 1987, 1997* (Washington, DC: 1989, 1999).

to 68 percent in the western United States (AAR 1998, 61). Figure 2-12 illustrates the geography of rail tonnage.

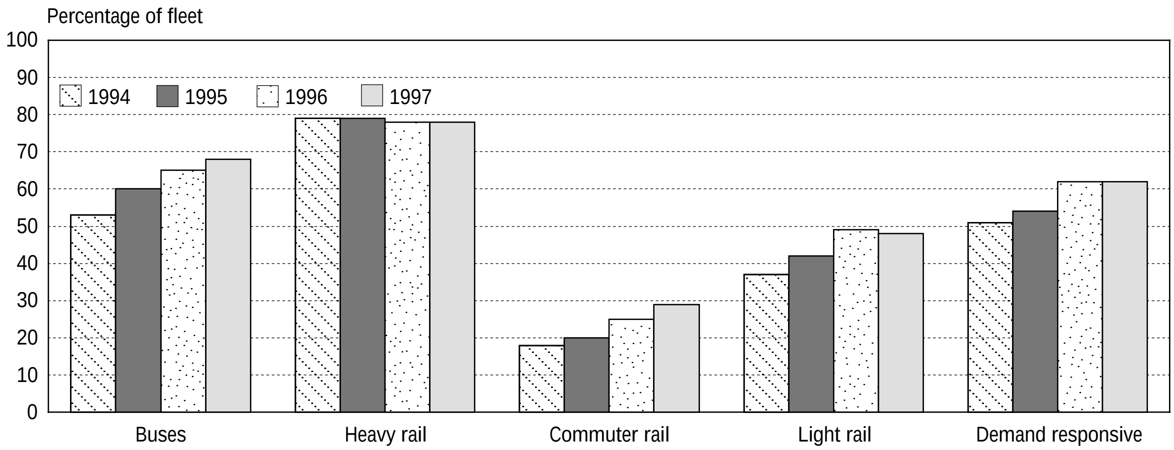
Figure 2-13 shows that intermodal (trailer or container on flatcar) and coal are the largest categories of rail traffic, each accounting for approximately one-quarter of the carloadings of the railroad industry. Intermodal traffic increased from 3.1 million loadings in 1980 to 8.7 million in 1997 (AAR 1998). The introduction of doublestack container trains in the early 1980s played a major role in this growth. Since the late 1970s, when the Powder River Basin opened in Wyoming, coal shipments grew from 4.4 million carloads in 1978 to 6.7 million carloads in 1997, reflecting the increased demand for low sulfur western coal by electric utilities to comply with clean air standards (AAR 1980; 1998). A combination of chemicals, motor vehicles and equipment, and farm products account for roughly 20 percent of rail traffic.

Table 2-14 presents 1997's top 10 state-to-state rail freight flows, as well as the major commodities handled for these flows. These 10 flows accounted for 17 percent of all rail carloads and 15 percent of all rail tonnage. Miscellaneous mixed shipments (i.e., intermodal traffic), which accounted for 67 percent of all rail intermodal traffic, and coal are the major commodities for 7 of these 10 flows. The largest rail intermodal flows in the United States were between California and Illinois predominantly representing the U.S. land portion of U.S. exports to and imports from Asia's Pacific Rim countries. The largest coal flows originated in the Powder River Basin and terminated at electric power generating plants in Illinois, Texas, and Missouri.

Freight rates (freight revenue per ton-mile) adjusted for inflation declined 2 percent per year between 1993 and 1997, and 1 to 2 percent per year since the passage of the Staggers Act in 1980, compared with an increase of nearly 3 percent per year between 1975 and 1980.[23] From 1993 to 1997, the Class I freight railroads averaged an 8 percent return on their net investment, up from an average of 2 percent in the 1970s[24] (AAR Various years).

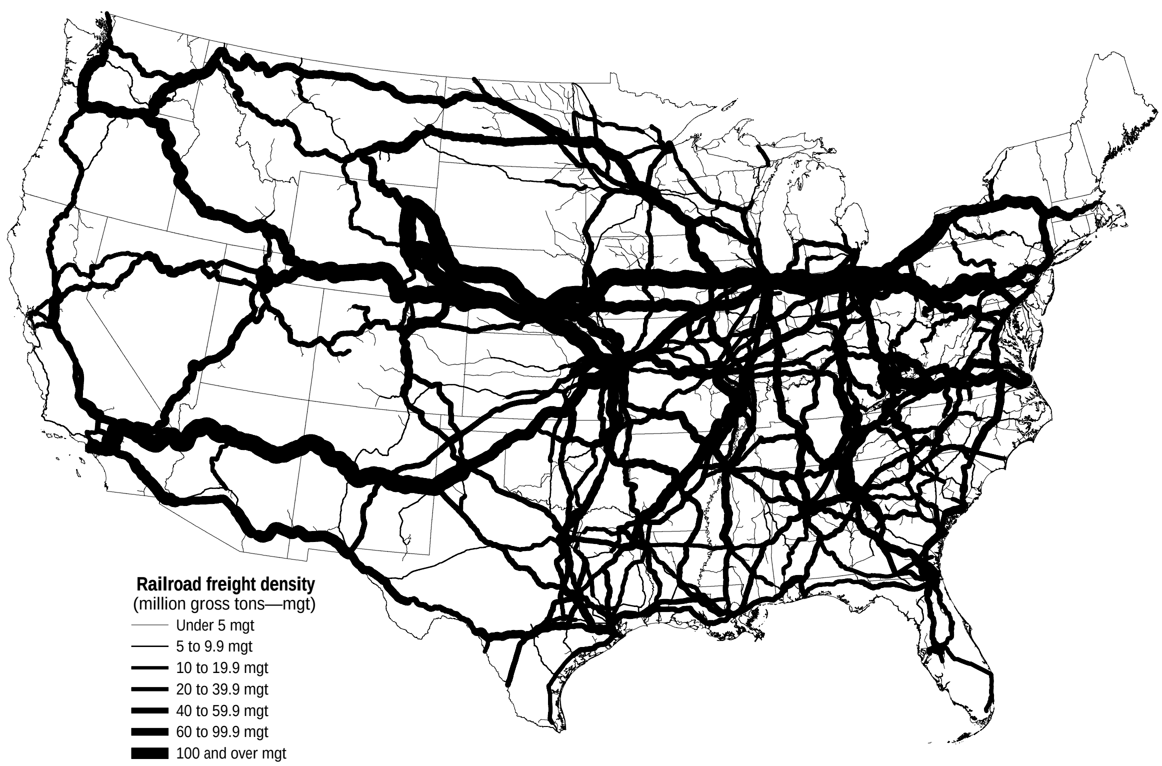
[23] Calculated using the Bureau of Labor Statistics' Producer Price Index for Line-Haul Operating Railroads (SIC 4011).
[24] In 1997, Class I railroads had operating revenues of $256.4 million or more.

Figure 2-11
ADA-Accessible Vehicles by Mode: 1994–97



SOURCE: U.S. Department of Transportation, Federal Transit Administration, *1996 National Transit Summaries and Trends* (Washington, DC: 1998), p. 25.

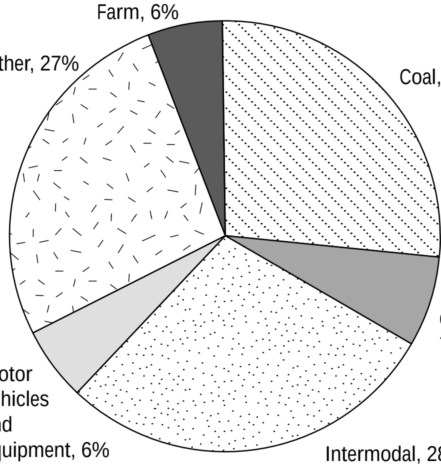
Figure 2-12
Railroad Network Showing Volume of Freight: 1997



NOTE: Alaska and Hawaii are not shown here as they have no railroad networks.

SOURCE: U.S. Department of Transportation, Federal Railroad Administration.

Figure 2-13
Rail Carload Mix: 1997



SOURCE: Association of American Railroads, *Railroad Facts, 1998* (Washington, DC: 1998).

Railroad labor productivity grew from 4.2 million revenue ton-miles per employee in 1988 to 7.6 in 1997 (USDOT BTS 1998a). Because of railroad mergers over the past few years, crews are smaller and fewer freight interchanges between railroads are necessary. Revenue ton-miles increased due to more frequent and heavier traffic moving longer distances.

The value of goods damaged in 1997 was $113 million. Although the total damage done has increased from the late 1980s, the rate has declined 40 percent from $142 per million ton-miles in 1988 to $84 in 1997 (AAR 1980; 1998).

While freight rail traffic increased, passenger rail traffic remained relatively constant. There were 20.2 million Amtrak passengers in fiscal year (FY) 1997, about the same number as in FY 1987. Amtrak's passenger load factor, however, has declined over the past decade, decreasing from 53 percent in 1988 to 47 percent in 1997 (NRPC 1996; 1999).

Amtrak operated approximately 22,000 route-miles in FY 1997, serving 516 stations and providing 11.1 billion available seat-miles. Accessibility to service decreased, however, with Amtrak providing service to 26 fewer stations than in the previous year, the fewest number of stations served since 1990. This is down only slightly from Amtrak's average over the past decade of 523 stations (Amtrak 1999).

Table 2-14
Top 10 State Rail Freight Flows and Major Commodities: 1997

			Total flow		Major commodity		
Rank	Origin state	Destination state	Carloads (thousands)	Tons (thousands)		Carloads (thousands)	Tons (thousands)
1	IL	CA	793	13,782	Misc. mixed shipments[a]	510	8,259
2	FL	FL	768	57,501	Nonmetallic minerals	419	41,356
3	CA	IL	753	11,827	Misc. mixed shipments[a]	580	8,172
4	TX	TX	557	45,425	Nonmetallic minerals	172	16,627
5	WY	IL	382	43,573	Coal	355	41,160
6	WY	TX	372	38,936	Coal	352	37,060
7	TX	CA	372	10,669	Misc. mixed shipments[a]	221	4,032
8	MN	MN	365	28,334	Metallic ores	308	23,280
9	IL	NJ	364	6,870	Misc. mixed shipments[a]	288	4,200
10	WY	MO	362	40,365	Coal	357	39,900

[a] In 1997, miscellaneous mixed shipments accounted for 67 percent of all rail intermodal (trailer on flatcar/container on flatcar shipments).

SOURCE: U.S. Department of Transportation, Federal Railroad Administration,Carload Waybill Sample, 1997.

The quality of Amtrak's passenger rail service in 1997 was not significantly different from trends established over the past decade, though slight fluctuations in individual performance statistics were observed. Amtrak's on-time percentages between 1988 and 1997 do not show much fluctuation. Shorter trips (i.e., those under 400 miles) were more reliable, arriving on schedule 79 percent of the time in 1997. Trains on longer trips were less punctual, arriving on schedule just over half of the time (53 percent). Amtrak trains experienced a total of 25,800 hours of delay in 1997. Of this total, 18 percent of the delays were due to Amtrak, 52 percent to freight railroads, and the remaining 30 percent to other factors, including weather (NRPC 1999).

According to Amtrak, overall consumer satisfaction is rising. The systemwide consumer satisfaction index rose from 81 in FY 1995 to 84 in FY 1997 (based on a 100-point scale). This index represents customer satisfaction with a wide range of factors such as facility cleanliness, service, reservations, and bathrooms, as taken from customer surveys.

REFERENCES

Association of American Railroads (AAR). 1980. *Railroad Facts, 1980 Edition*. Washington, DC.

_____.1998. *Railroad Facts, 1998 Edition*. Washington, DC.

_____. Various years. *Railroad Facts*. Washington, DC.

Mallett, W.J. 1999. Long Distance Travel by Women, Results from the 1995 American Travel Survey, presented at the Annual Meeting of the Transportation Research Board, Washington, DC. January.

McGuckin, N. and E. Murakami. 1999. Examining Trip-Chaining Behavior: A Comparison of Travel by Men and Women. Available at www-cta.ornl.gov/npts/1995/Doc/publications.shtml.

National Railroad Passenger Corp. (NRPC). 1996. *Amtrak Annual Report*. Washington, DC.

_____. 1999. *Amtrak Annual Report*. Washington, DC.

Strathman, J.G. and K.J. Dueker. 1995. *Understanding Trip Chaining, Special Report on Trip and Vehicle Attributes*, 1990 NPTS Report Series. Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

Texas Transportation Institute (TTI). 1998. *Urban Roadway Congestion Annual Report: 1998*. College Station, TX.

U.S. Army Corps of Engineers (USACE). 1998. *Waterborne Commerce of the United States, Calendar Year 1997*. New Orleans, LA.

____. 1999. Lock Performance Monitoring System, Lock Summary. Available at www.wrsc.usace.army.mil/ndc/lpms.htm.

U.S. Department of Commerce (USDOC), Census Bureau. 1979. *National Travel Survey, 1977*. Washington, DC.

_____. 1985. *Statistical Abstract of the United States 1985*. Washington, DC.

_____. 1994. *Statistical Abstract of the United States 1994*. Washington, DC.

_____. 1995. *1993 Commodity Flow Survey: United States*, TC92-CF-52. Washington, DC.

_____. 1998. *Statistical Abstract of the United States 1998*. Washington, DC.

_____. 1999. *1997 Commodity Flow Survey: United States Preliminary*, EC97TCF-US(P). Washington, DC.

U.S. Department of Commerce (USDOC), Census Bureau, Foreign Trade Division (FTD). 1997. *FT920 U.S. Merchandise Trade: Selected Highlights, December 1997*. Washington, DC.

U.S. Department of Commerce (USDOC), International Trade Administration (ITA). 1998. *GDP and U.S. International Trade in Goods and Services, 1970–1998: National Income and Product Accounts Basis*. Available at www.ita.doc.gov/industry/otea/usfth/aggregate/Hl9805.txt. As of Aug. 31, 1998.

_____. 1999. *U.S. Trade in Goods, 1972–1998, Census Basis*. Available at www.ita.doc.gov/industry/otea/usfth/aggregate/Hl9803.txt. As of Feb. 19, 1999.

U.S. Department of Transportation (USDOT), Office of Aviation Enforcement and Proceedings, Office of Consumer Affairs. Various issues. *Air Travel Consumer Report*. Washington, DC.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS). 1997. American Travel Survey data.

_____. 1998a. National Transportation Statistics 1998. Available at www.bts.gov.

_____. 1998b. Transborder Surface Freight Data. Washington, DC.

____. In press. *National Transportation Statistics 1999*. Washington, DC.

U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA). 1997a. *Transportation User's Views of Quality*. Washington, DC. December.

___. 1997b. *User's Guide for the Public Use Data Files: 1995 Nationwide Personal Transportation Survey*. Washington, DC. October.

___. 1997c. *Our Nation's Travel: 1995 NPTS Early Results Report*. Washington, DC.

_____. 1999a. NPTS website. Available at www.cta.ornl.gov/npts/1995/Doc/Index.shtml.

_____. 1999b. Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey, prepared by Oak Ridge National Laboratory.

_____. Various years. *Highway Statistics*. Washington, DC.

U.S. Department of Transportation (USDOT), Federal Transit Administration (FTA). 1999. *1997 National Transit Summaries and Trends*. Washington, DC.

U.S. Department of Transportation (USDOT), Maritime Administration (MARAD), Office of Statistical and Economic Policy. 1998. *U.S. Waterborne Exports and General Imports, Annual 1997*. Washington, DC.

U.S. International Trade Commission (USITC). 1998. *International Economic Review*, January/February 1998. Washington, DC.

Transportation and the Economy

Transportation continues to play a key role in a growing U.S. economy. It contributes a sizable proportion to the Gross Domestic Product (GDP), consumes a large amount of the economy's goods and services, and employs millions of people. Transportation is also an important revenue source and expenditure item for federal, state, and local governments.

Using the most recent data, this chapter focuses on some of the major aspects of transportation's relationship to the U.S. economy. First, it discusses measures of transportation's role in the U.S. economy. Then, the chapter examines how much Americans spend on transportation, using Consumer Expenditure Survey data, and reviews employment and productivity in the transportation sector. Finally, it discusses government transportation-related revenues and expenditures.

TRANSPORTATION AND GROSS DOMESTIC PRODUCT

There are several ways to measure transportation's role in the economy. The broadest measure, which consists of purchases of all transportation-related goods (e.g., cars and gasoline) and services (e.g., trucking and automobile insurance) is called transportation-related final demand (TRFD). Using this broad measure, transportation-related purchases, including exports, accounted for $905 billion or 11.2 percent of GDP in 1997. When this figure is adjusted for inflation and expressed in chained

1992 dollars, TRFD totaled $811.6 billion. As shown in tables 3-1 and 3-2, TRFD grew by about one-tenth of a percentage point every year since 1993.

When compared with other components of final demand, transportation ranked fourth. As in previous years, housing was the largest component, followed by health care and food (see table 3-3).

A narrower measure of transportation's importance in the economy is the value-added by transportation services, both for-hire and in-house. This measure includes only those services that move people and goods on the transportation system.

In 1997, the for-hire transportation industry, together with warehousing, contributed $255.5 billion to the U.S. economy (see table 3-4). The trucking and warehousing industry group contributed $97.9 billion to U.S. GDP. Although information regarding the for-hire trucking industry alone is not available, operating revenue data from the U.S. Census Bureau's annual Motor Freight Transportation and Warehousing Survey can be used to estimate the for-hire trucking industry's contribution to GDP. Using these data, it is estimated that for-hire trucking operations accounted for 94 percent of the trucking and warehousing group totals in the 1990s. Applying this indicator to 1997, the for-hire trucking industry alone contributed about $92 billion to U.S. GDP, almost $18 billion more than air transportation's contribution.

Although the government has collected data on most for-hire transportation services on a regular basis for many years, this has not been the case for in-house transportation services (e.g., grocery companies that use their own truck fleets to move goods from their warehouses to their retail outlets). To fill this gap, the Bureau of Transportation Statistics (BTS) in conjunction with the Bureau of Economic Analysis (BEA) in the U.S. Department of Commerce developed an accounting tool called the U.S. Transportation Satellite Accounts (TSAs) to measure the contribution of in-house transportation to the economy. The results of this joint effort are available in the recently released BTS report, *Transportation Satellite Accounts: A New Way of Measuring Transportation Services in America.*

The TSAs show in-house transportation totaled $121 billion in 1992 (the latest year for which data are available). Together, in-house and for-hire transportation services contributed about $313 billion, or 5 percent of the value-added in GDP in 1992. This is roughly comparable to the value-added by the wholesale/retail trade industry.

To provide data on in-house and for-hire transportation in a unified system and on a more comprehensive and timely basis, BTS and BEA are implementing a joint program that will extend the TSAs to more recent years.

Consumer Expenditures on Transportation[1]

American households spent, on average, about $6,400 for transportation in 1996, an increase of 6.7 percent from the previous year’s average of $6,000. This increase was due to rising household income and may also reflect delayed expenditures due to the recession in the early 1990s. The average income of American households increased from $37,000 in 1995 to $38,000 in 1996, a 2.9 percent increase.

Table 3-5 shows changes in household spending on transportation over the 1994 to 1996 period. As shown, vehicle purchases are the largest component of household transportation expenditures.

[1] Data in this section are from USDOL BLS 1996a.

Table 3-1

Transportation-Related Components of U.S. GDP: 1993–98

(Current $ billions)

	1993	1994	1995	1996	1997	1998
Personal consumption of transportation						
Motor vehicles and parts	226.2	246.6	255.4	264.8	269.5	289.4
Gasoline and oil	107.6	109.4	115.6	124.5	126.5	112.6
Transportation services	170.2	186.2	203.1	222.3	240.3	252.5
Total	***504.0***	***542.2***	***574.1***	***611.6***	***636.3***	***654.5***
Gross private domestic investment						
Transportation structures	4.1	4.3	4.4	5.4	6.1	U
Transportation equipment	99.9	118.6	126.2	137.2	152.0	U
Total	***104.0***	***122.9***	***130.6***	***142.6***	***158.1***	***U***
Exports(+)						
Civilian aircraft, engines, and parts	32.7	31.5	26.1	30.8	41.4	54.6
Automotive vehicles, engines, and parts	52.5	57.8	61.8	65.0	74.0	72.6
Passenger fares	16.6	17.1	18.9	20.4	20.9	20.8
Other transportation	23.1	24.9	26.8	27.0	27.9	27.5
Total	*124.9*	*131.3*	*133.6*	*143.2*	*164.2*	*175.5*
Imports(–)						
Civilian aircraft, engines, and parts	11.3	11.3	10.7	12.7	16.6	21.7
Automotive vehicles, engines, and parts	102.4	118.3	123.8	128.9	140.8	150.3
Passenger fares	11.3	12.9	14.7	15.8	18.2	18.2
Other transportation	25.7	27.3	27.4	27.7	29.3	30.0
Total	*150.7*	*169.8*	*176.6*	*185.1*	*204.9*	*220.2*
Net exports of transportation-related goods and services	***–25.8***	***–38.5***	***–43.0***	***–41.9***	***–40.7***	***–44.7***
Government transportation-related purchases						
Federal purchases	17.6	18.8	18.1	18.9	19.7	U
State and local purchases	99.8	106.5	110.0	115.5	123.1	U
Defense-related purchases	9.5	8.2	8.5	8.9	8.2	8.2
Total	***126.9***	***133.5***	***136.6***	***143.2***	***151.0***	***U***
Transportation-related final demand[1]	**709.1**	**760.3**	**798.3**	**855.5**	**905.0**	**U**
Gross Domestic Product (GDP)	6,558.1	6,947.0	7,269.6	7,661.6	8,110.9	8,508.9
Total transportation in GDP (percent)	**10.8**	**10.9**	**11.0**	**11.2**	**11.2**	**U**

[1]Demand for goods and services produced in the United States, regardless of where they are consumed. The measure counts exported goods and services, but does not include imports.

KEY: GDP = Gross Domestic Product; U = data are unavailable.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* various issues, 1998, National Income and Product Accounts tables.

Table 3-2
Transportation-Related Components of U.S. GDP: 1993–98
(Chained 1992 $ billions)

	1993	1994	1995	1996	1997	1998
Personal consumption of transportation						
Motor vehicles and parts	218.9	230.	230.6	235.0	239.3	258.7
Gasoline and oil	108.7	109.8	114.3	116.0	117.9	119.8
Transportation services	163.1	175.2	186.4	200.5	212.2	220.3
Total	***490.7***	***515.0***	***531.3***	***551.5***	***569.4***	***598.8***
Gross private domestic investment						
Transportation structures	3.9	3.9	3.9	4.6	4.9	U
Transportation equipment	98.3	113.2	119.4	127.6	140.3	U
Total	***102.2***	***117.1***	***123.3***	***132.2***	***145.2***	***U***
Exports (+)						
Civilian aircraft, engines, and parts	31.7	29.7	23.8	27.0	35.0	45.7
Automotive vehicles, engines, and parts	52.1	56.7	59.9	62.4	70.4	68.9
Passenger fares	16.4	16.4	17.2	18.6	19.7	19.8
Other transportation	22.7	24.6	26.0	25.5	26.3	26.8
Total	*122.9*	*127.4*	*126.9*	*133.5*	*151.4*	*161.2*
Imports (–)						
Civilian aircraft, engines, and parts	10.9	10.6	9.8	11.2	14.1	18.1
Automotive vehicles, engines, and parts	100.9	112.9	114.8	118.8	129.4	137.9
Passenger fares	11.5	13.0	14.1	15.0	16.3	16.1
Other transportation	25.6	27.2	26.5	26.1	28.1	29.4
Total	*148.9*	*163.7*	*165.2*	*171.1*	*187.9*	*201.5*
Net exports of transportation-related goods and services	***–26.0***	***–36.3***	***–38.3***	***–37.6***	***–36.5***	***–40.3***
Government transportation-related purchases						
Federal purchases	16.9	17.9	16.2	16.5	16.8	U
State and local purchases	97.5	101.5	101.5	104.2	108.8	U
Defense-related purchases	9.5	8.0	8.2	8.7	7.9	7.6
Total	***123.9***	***127.4***	***125.9***	***129.4***	***133.5***	***U***
Transportation-related final demand[1]	**690.8**	**723.2**	**742.2**	**775.5**	**811.6**	**U**
Gross Domestic Product (GDP)	6,389.6	6,610.7	6,761.7	6,994.8	7,269.8	7,549.9
Total transportation in GDP (percent)	**10.8**	**10.9**	**11.0**	**11.1**	**11.2**	**U**

[1]Demand for goods and services produced in the United States, regardless of where they are consumed. The measure counts exported goods and services, but does not include imports.

KEY: GDP = Gross Domestic Product; U = data are unavailable.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, various issues, 1998, National Income and Product Accounts tables.

Table 3-3
Major Societal Functions in GDP
(Current $ billions)

Societal function	1992	1997
GDP	6,244	8,111
Housing	1,469	1,969
Health	880	1,151
Food	803	956
Transportation	669	905
Education	428	559
Other	1,995	2,572
Percent		
GDP	100.0	100.0
Housing	23.5	24.3
Health	14.1	14.2
Food	12.9	11.8
Transportation	10.7	11.2
Education	6.9	6.9
Other	32.0	31.7

KEY: GDP = Gross Domestic Product.

NOTE: Percentages may not add due to rounding.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, various issues, 1998, National Income and Product Accounts tables.

► Regional Differences

Historically, households in the West, on average, spent more on transportation than those in the Midwest, South, and Northeast. In the past decade, however, household transportation expenditures in the Midwest and South increased faster than in the West and Northeast. In 1995, midwestern households spent more on transportation than any of the other three regions. The picture changed in 1996, however, with southern households spending the most—$6,937, an increase of 15 percent over the previous year. In 1996, transportation's share in total household expenditures in the South was 21 percent, 3 percent higher than in the West and Midwest and 5 percent higher than in the Northeast. This increase in the South was fueled by new vehicle purchases. For example, the South was the only region in which households, on average, spent more than one-half of their transportation expenditures on purchasing vehicles. The share of vehicle purchases in household

Table 3-4
U.S. Gross Domestic Product by For-Hire Transportation Industries
($ billions)

	Current dollars			Chained 1992 dollars		
	1990	**1992**	**1997**	**1990**	**1992**	**1997**
Gross Domestic Product	5,743.8	6,244.4	8,110.9	6,136.3	6,244.4	7,269.8
Trucking and warehousing	75.8	82.2	97.9	73.7	82.2	87.3
Transportation by air	39.4	43.0	74.4	39.5	43.0	63.5
Railroad transportation	19.6	22.1	24.1	18.7	22.1	28.2
Incidental services	17.8	19.6	26.8	19.2	19.6	25.1
Transit	9.0	10.9	13.8	10.3	10.9	11.3
Water transportation	9.5	10.3	12.8	10.7	10.3	11.0
Pipelines, except natural gas	5.0	4.9	5.6	4.8	4.9	6.8
Total	**176.4**	**192.8**	**255.5**	**176.7**	**192.8**	**241.5**

SOURCE: U.S.Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* November 1998, GDP by Industry table.

Table 3-5
Household Transportation Expenditures: 1994–96

Type of expenditure	1994	1995	1996
Average annual household transportation expenditures ($ current)	$6,044	$6,016	$6,382
	Percentage of components		
Vehicle purchases			
Cars and trucks, new	23.0	19.8	18.9
Cars and trucks, used	21.3	23.5	24.6
Other vehicles	0.7	0.6	0.6
Total	**44.0**	**43.9**	**44.1**
Gasoline and motor oil	**16.3**	**16.7**	**16.9**
Other vehicle expenses			
Vehicle finance charges	3.9	4.3	4.3
Maintenance and repairs	11.3	10.9	10.1
Vehicle insurance	11.4	11.8	10.9
Vehicle rental, lease, license, and other charges	5.7	6.5	6.9
Total	**32.3**	**33.5**	**32.3**
Purchased transportation service	**6.3**	**5.9**	**6.7**

SOURCES: U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Expenditure Survey," 1995, 1996, and 1997.

transportation expenditures in the South was 57 percent in 1996, compared with 47 percent for the national average and 37 percent for the Northeast.

▶ Urban and Rural Areas

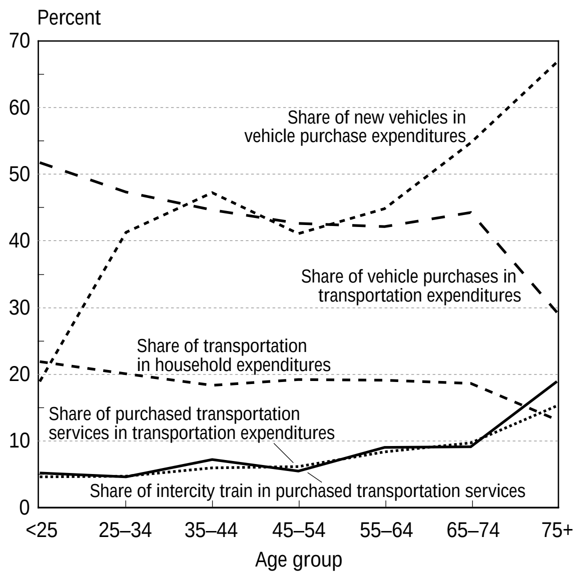
Since 1992, rural households have spent more on transportation in absolute dollar amounts than urban households. In 1996, rural households spent, on average, $6,767 on transportation, $440 more than their urban counterparts. Transportation's share of total rural household expenditures reached a high of 23.5 percent, while its share in urban households stayed at 18 percent. This increase indicates that rural household spending on transportation grew faster than total expenditures. In 1995, rural households, on average, spent $3,300, or 55 percent of their transportation expenditures, on purchasing vehicles (including vehicle finance charges); in 1996, this expenditure reached $3,773. Transportation's share of rural household expenditures, however, remained about the same in 1996. Moreover, rural households spent more on purchasing used vehicles than on new ones. Used vehicle purchases accounted for 64 percent of rural household expenditures, compared with 54 percent in urban households. Both rural and urban households sharply increased their spending on purchased transportation services—17 percent and 19 percent, respectively.

▶ Age Effect

Household transportation expenditures, in absolute dollar amounts, rise as the age of the head of the household increases, peaking at the 45 to 54 years of age bracket, and then declining. In 1996, households in which the head was between 45 and 54 years of age spent, on average, $8,233, while households in the under 25 years of age bracket spent $4,029. For households in which the head was 75 years of age or older, transportation expenditures were $2,573. Transportation as a share of household expenditures was highest in young households. In 1996, households in the under 25 age bracket spent, on average, 22 percent of their total household expenditures on transportation. The percentage decreased gradually as age increased, reaching its lowest point—13 percent—in households in the 75 and over age bracket (see figure 3-1).

Young households also spent a higher proportion of their transportation expenditures on purchasing used vehicles than older households. For example, households in the youngest age group spent 81 percent of their transportation expendi-

Figure 3-1
Characteristics of Household Transportation Expenditures by Age Group



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Expenditure Survey," 1996.

tures on purchasing used vehicles, while households in the oldest age group spent 67 percent on new vehicles.

The age of the head of the household also affected the amount of money spent on purchased transportation services, such as air, ship, mass transit, and taxi fares. In 1996, households in the youngest age bracket spent the least proportionally on purchased transportation services—4.6 percent of their transportation expenditures; the oldest age group spent the most—15 percent of their transportation expenditures. Moreover, households in the oldest age group spent more on intercity train services—19 percent of purchased transportation services, which was the highest percentage among all age groups.

Employment in Transportation Services

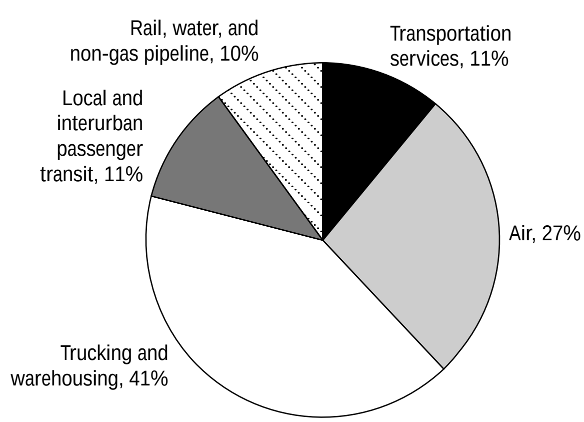
This section examines employment in for-hire transportation industries by sector and by occupation. It also discusses wages and salaries, and labor productivity. Employment in for-hire transportation industries includes all jobs, regardless of what an employee actually does (e.g., driving a truck or bookkeeping). Employment in transportation occupations includes jobs that are specific to transportation, regardless of employer (e.g., driving a truck for a trucking company or for a retail company).

► Employment in For-Hire Transportation Industries

Transportation industries employed about 4.2 million workers, which was 3.3 percent of the total U.S. civilian labor force in 1997. In the 1990s, changes in the share of transportation industry employment in the total U.S. labor force have been within a range of 0.2 percentage points (USDOT Forthcoming b).

The trucking and warehousing industry group has been the largest transportation employer throughout the 1980s and 1990s. As figure 3-2 shows, trucking and warehousing accounted for 41 percent of total transportation industry employment in 1997, much larger than

Figure 3-2
Modal Share of Transportation Industry Employment: 1997



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming).

the combined total of railroad, water, transit, pipeline, and transportation services. In terms of annual growth, however, trucking and warehousing lagged behind some modes in different years. For example, transit employment grew by 4.7 percent in 1991, while trucking and warehousing employment grew by 2.8 percent (see USDOT Forthcoming b). In 1997, the two groups grew by 3.2 and 1.8 percent, respectively. Two trends are worth noting. First, railroad industry employment persistently declined in the 1990s, although the decline recently slowed down from that experienced in the early part of the decade. Second, in recent years, employment in the transportation services industry grew faster than all other modes except for transit.

In 1997, the transportation industry as a whole paid $134 billion in wages and salaries, accounting for 3.4 percent of total wage and salary accruals in the entire economy. The transportation industry's share in the total declined from 5.3 percent in 1960 to 4.3 percent in 1980 and remained stable at 3.5 percent between 1990 and 1996 (USDOT Forthcoming b).

The slight decline of transportation wages and salaries relative to total wages and salaries can be explained by several factors. One influencing factor is the decline of transportation industry employment as a share of the total U.S. labor force. Another factor is the relative decrease in the average transportation wage rate (the level of wage or salary per full-time equivalent employee). In 1980, the annual wage rate in the transportation industry was 32 percent higher than the average wage for the entire U.S. labor force. That advantage declined to 20 percent in 1985 and to 10 percent in 1990. By 1997, the transportation wage rate was only about 3 percent higher than the national average (USDOT Forthcoming b).

Not surprisingly, the distribution of the transportation industry's total wages and salaries among modes follows a pattern similar to that in the employment data, with the trucking and warehousing industry group's share accounting for a little over 38 percent of the total in 1997. The railroad industry's share decreased dramatically, from almost 38 percent in 1960 to less than 9 percent in 1997. In contrast, the air transportation industry's share went from under 9 percent in 1960 to over 30 percent in 1997 (USDOT Forthcoming b).

Wage rates for a particular industry indicate how well paid employees are in that industry. The average wage rate for the transportation industry as a whole has declined relative to the average wage rate for the entire U.S. labor force.

The local and interurban passenger transit industry falls below all other modes in wage rates. The next lowest was the trucking and warehousing industry. At $31,700 in 1997, trucking and warehousing industry wages were more than 8 percent lower than the average for the transportation industry as a whole and 5 percent lower than the national average. The pipeline industry, which has the lowest wage and salary total, pays the highest wage rate. In 1997, the pipeline industry's wage rate, at $60,000, was almost triple the transit wage rate and nearly double the trucking and warehousing industry wage rate (USDOT Forthcoming b).

► Employment in Transportation Occupations

Employment in transportation occupations covers every industry but includes only people with skills specific to transportation, such as truck drivers and airline pilots. As the only employment measure that includes transportation-specific employment within nontransportation industries, transportation occupation data are useful in estimating transportation operations outside as well as within for-hire transportation industries (USDOT Forthcoming b).

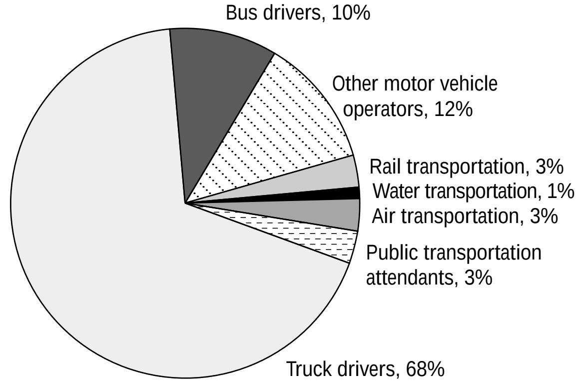
In 1997, employment in transportation occupations was 4.5 million workers, or 3.5 percent of all employed workers 16 years of age and over. Although employment in transportation occupations increased by 85,000 workers in 1997, transportation's share in the total employment decreased slightly because total employment increased faster than transportation employment. From 1990 to 1997, however, differences between the growth rates of transportation industry employment and transportation occupational employment have been small.

As mentioned earlier, information on the distribution of transportation occupational employment provides an indicator of the magnitude of transportation operations inside and outside transportation industries. The National Industry-Occupation Employment Matrix from the Bureau of Labor Statistics provides data on the industrial distribution of occupational employment. The latest matrix is for 1996 and shows that within the transportation industry group 1.5 million workers (36 percent of the total) were employed in transportation occupations (USDOL BLS 1996b). Most were truck drivers, 62 percent, and bus drivers, 12 percent.

Nontransportation industries employed nearly two-thirds of the workers in transportation occupations in 1996. The wholesale and retail trade industry employed almost half of these workers, with truck driving as the predominant occupation. The service industry is the third largest employer of transportation occupational workers—mostly bus drivers. The government employed more people in transportation occupations than the agriculture, mining, communications and utilities, and finance, insurance, and real estate industries combined.

Figure 3-3 shows the distribution of total transportation occupational employment in 1997. Truck drivers, including drivers of heavy and light trucks, accounted for the largest percentage (67.8 percent) of those employed in transportation occupations. This percentage,

Figure 3-3
Employment in Transportation Occupations: 1997



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming).

which was the same as in the previous year, was 2.7 percent higher than in 1990 (USDOT Forthcoming b). Throughout the 1980s and early 1990s, truck drivers accounted for about 65 percent of all employed transportation occupational workers, although the higher shares in more recent years may point to a new pattern. Employment in air transportation occupations grew the fastest in 1997, posting a 12.4 percent gain. In contrast, in 1997, employment in trucking occupations grew 1.9 percent, while bus drivers and water transportation occupations declined by 8 and 26 percent, respectively.

Information on occupational wages and salaries for transportation is not as extensive as that on industry wages and salaries. Based on available data, airplane pilots and navigators are paid the highest wage, while bus drivers and taxi drivers are paid the lowest.

Although earnings differentials among major transportation occupations have remained stable since the mid-1980s, earnings for different transportation occupations often fluctuated (USDOT Forthcoming b).

Labor Productivity in Transportation

Transportation labor productivity measures the ratio of transportation output and transportation labor input. Transportation output is usually measured by quality-adjusted ton-miles and passenger-miles, and transportation input is usually measured by the number of transportation employees or employee-hours. Because of data limitations, this section discusses productivity measures based on the number of employees only. Regardless of how output and input are measured, labor productivity measures only show how productive labor is, not why labor is productive. Also, because labor productivity measures are most often conducted on an industry-by-industry basis, they do not provide information about the productivity of workers in transportation occupations (USDOL BLS OPT 1999).

From 1990 to 1996, the output of the railroad industry (measured by an index of passenger-miles, freight ton-miles, revenue, and other factors) went up by 21.2 percent, while its input went down by 16.1 percent. As a result, railroad labor productivity went up by 44.5 percent. Productivity increased even more in the 1980s, posting a 106 percent increase. On average, railroad labor productivity improved by 4.5 percent annually from 1947 to 1996 (USDOL BLS OPT 1999).

In contrast, labor productivity in the trucking industry increased much more slowly. From 1990 to 1996, output per employee went up by 17.7 percent. As in the railroad industry, labor productivity in the trucking industry increased much faster from 1981 to 1990—32.9 percent—but still much slower than the railroad industry during the same period. From 1954 to 1996, labor productivity in the trucking industry rose by 2.8 percent each year, considerably less than that recorded by the railroad industry (USDOL BLS OPT 1999).

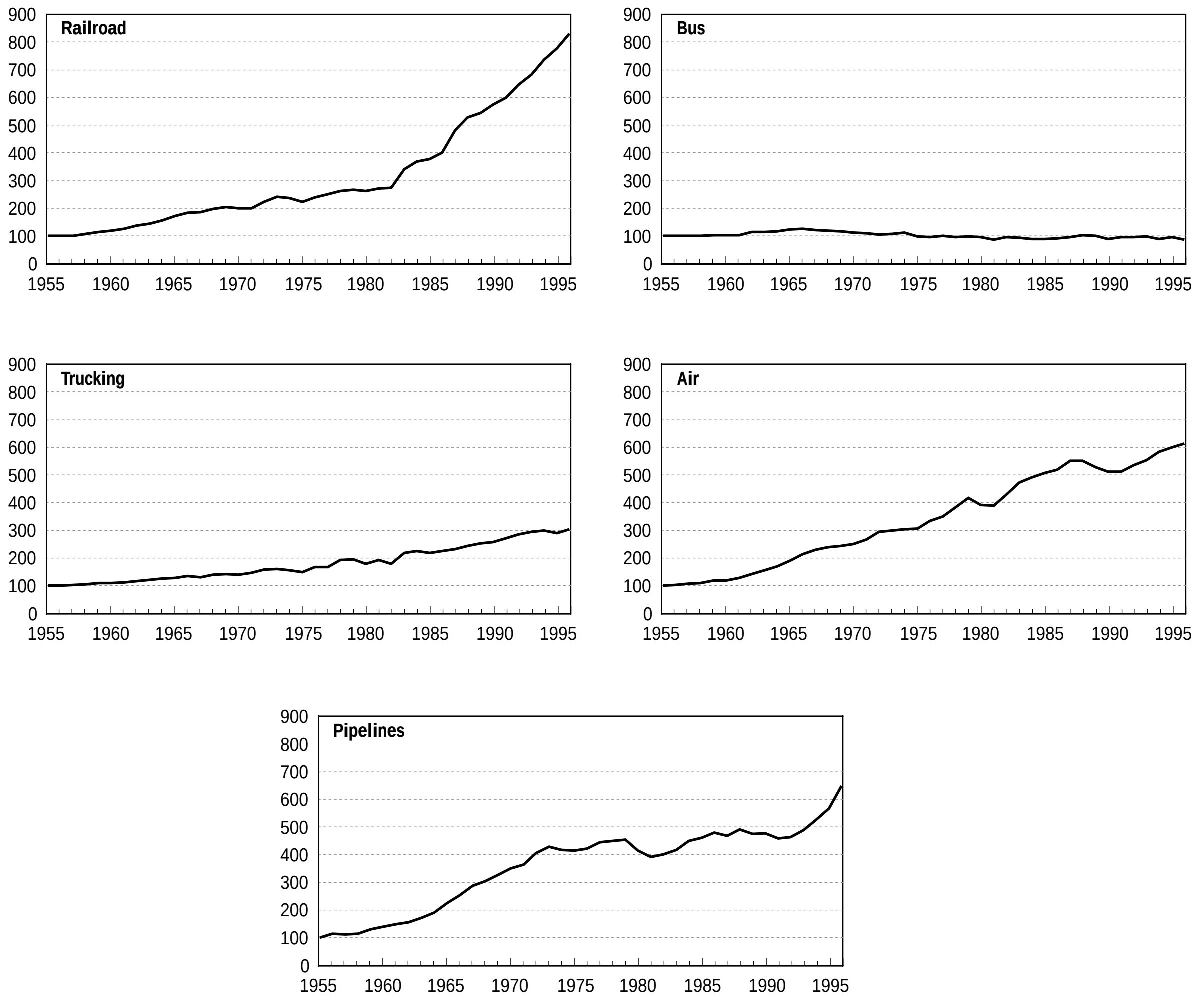
The air transportation industry (both passenger and freight) enjoyed the fastest labor productivity growth over the 1947 to 1996 period—5.6 percent annually. Its growth rate between 1990 and 1996 was 19.5 percent, faster than the trucking industry but much slower than the railroad industry (USDOL BLS OPT 1999).

From 1947 to 1996, the average annual growth in labor productivity in the petroleum pipelines industry was similar to that in the air transportation industry. In the 1990s, however, productivity growth in the petroleum pipelines industry exceeded that in the air transportation industry (36.1 percent vs. 19.5 percent) (USDOL BLS OPT 1999).

Of all the modes, Class I bus carriers had the lowest productivity, with considerable industry fluctuation in the 1980s and 1990s. From 1954 to 1996, labor productivity decreased 0.3 percent each year on average, the combined result of decreasing labor input and a more rapidly decreasing output (USDOL BLS OPT 1999).

Figure 3-4 displays trends in labor productivity between 1955 and 1996 for the five transportation industries discussed above. Many factors contribute to the level of labor productivity and its changes over time. One factor is the availability of transportation capital and the level of technologies embodied in the capital. Transportation capital includes both transportation equipment, such as locomotives, and transportation-related structures, such as airports. Other factors include transportation-related human capital, infrastructure, and government regulations. It is not clear how these factors interact to influence labor productivity growth or how important each factor is. In some cases, changes in labor productivity may have been driven by factors that have nothing to do with labor. For example, improvements in a road or business logistics may make truck driving more productive.

Figure 3-4
Labor Productivity Trends by Mode
Index: 1955 = 100



NOTES: Output is measured by quality-adjusted ton-miles and passenger-miles for railroad and air transportation, quality-adjusted ton-miles for trucking and pipelines, and passenger-miles for buses. No data are available for water transportation.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology, 1999.

PUBLIC TRANSPORTATION REVENUES AND EXPENDITURES

All levels of government play important roles in transportation by contributing to transportation-related final demand and labor productivity growth. This section provides summary information on government revenues and expenditures on transportation, including capital investment.[2]

Government Revenues from Transportation

In fiscal year (FY) 1995, government revenues from all transportation modes reached $93.7 billion (current dollars). Adjusted for price increases, government transportation revenues increased from $83.5 billion in 1994 to $86.7 billion in 1995 (USDOT Forthcoming a, tables A-1, A-2). Figure 3-5 shows that the annual growth rate in government transportation revenues fluctuated considerably between 1986 and 1995. The parallel trend in constant and current dollar growth rates indicates that the inflationary impact on government transportation revenues stayed fairly constant over this period, although it seems to have declined slightly in the first half of the 1990s.

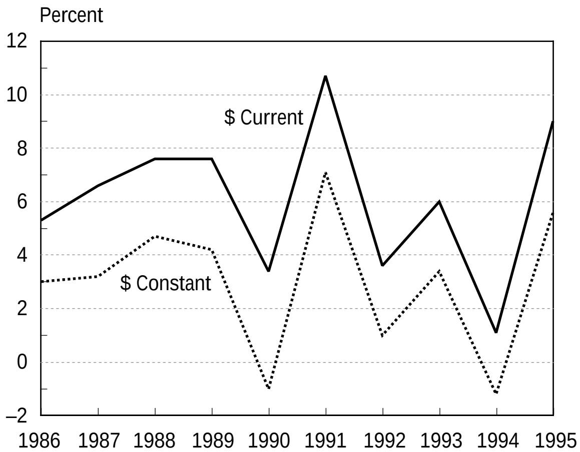
Almost half of the government transportation revenues are raised by states. In 1995, state government revenues accounted for 48 percent of the total, while federal and local revenues were 32 and 20 percent, respectively (USDOT Forthcoming a). Since the mid-1980s, the share of total transportation revenues among the three levels of government has remained stable. For example, in 1985 the federal government's share was 34 percent, while state and local governments' shares were 48 percent and 18 percent, respectively.

Highways generated $66.74 billion (71 percent) in government transportation revenues in 1995 (see figure 3-6). Pipeline transportation revenues were the lowest of all modes, accounting for just $35 million out of $93.7 billion in 1996. The proportions of revenues collected by various levels of government from different modes fluctuates from year to year. In 1996, for example, state governments received a large share of revenues from highway transportation, while local governments received the most from air transportation and transit, and the federal government received the largest share from pipelines and water transportation. At other times, the pattern has differed. For example, local governments collected half the water revenues from 1985 to 1989, and until 1993 the federal government's share of revenues from air transportation was larger than those of state and local governments.

Fuel taxes are important sources of revenue for federal and state governments. The bulk of fuel taxes comes from the highway mode. At the federal level, gasoline and diesel fuel taxes provided more than 85.8 percent of total highway trust fund revenues in fiscal year (FY) 1995. At the state level, motor fuel taxes accounted for almost 60 percent of total state highway revenues. Motor fuel tax receipts are a far less important portion of revenues for local governments than for federal and state governments. Property tax revenues are a far greater income source for local governments than motor fuel taxes. Fuel taxes are less important as a source of government revenues from other modes of transportation. Fuel taxes accounted for only 3.4 percent of total Federal Airport and Airway Trust Fund revenues in FY 1995. In the same year, the inland waterway fuel tax accounted for 6.1 percent of the total federal receipts from water transportation

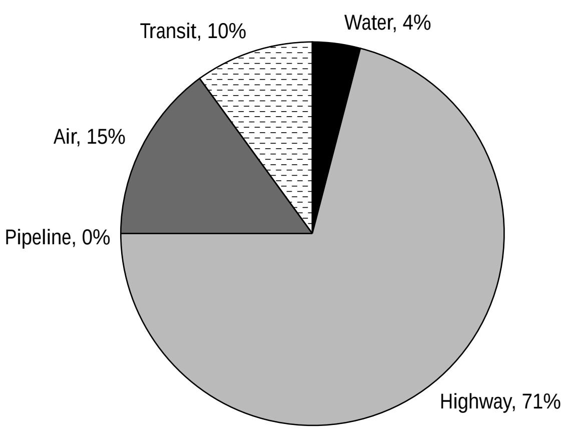
[2]Statistics in this section are based on data from the U.S. Department of Commerce, Census Bureau, which uses different definitions and accounting methods from those used by some modal administrations of the U.S. Department of Transportation. For example, revenues in this section are limited to gasoline taxes, tolls, and other sources that are collected directly from transportation users. Revenue statistics published by the Federal Highway Administration also include items such as investment income and other taxes and fees.

Figure 3-5
Growth in Government Transportation Revenues: 1986–95



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics: Fiscal Years 1985–95, forthcoming on the BTS website at www.bts.gov.

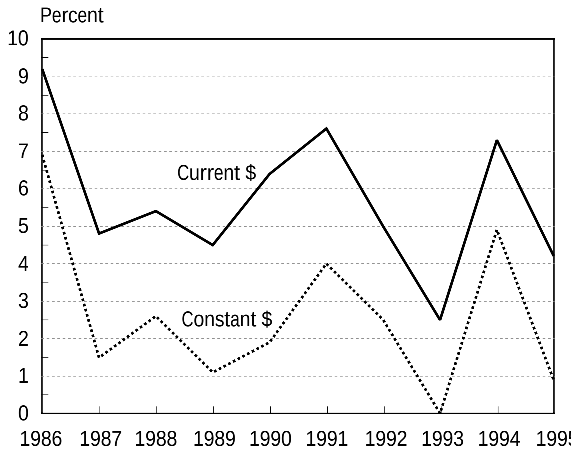
Figure 3-6
Government Transportation Revenues by Mode: Fiscal Year 1995



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics: Fiscal Years 1985–95, forthcoming on the BTS website at www.bts.gov.

(USDOT Forthcoming a). Similar information is not available for state and local government revenues from these and other modes.

Figure 3-7
Growth in Government Transportation Expenditures: 1986–95



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics: Fiscal Years 1985–95, forthcoming on the BTS website at www.bts.gov.

Government Expenditures on Transportation

In FY 1995, all levels of government spent $129.3 billion (current dollars) on all modes of transportation. (Federal grants are included but not double counted.) Figure 3-7 shows that growth in government transportation expenditures in current and constant dollars followed a similar trend, but it is important to note that price changes had a greater impact on current dollar expenditures in the late 1980s and early 1990s.

Excluding federal grants, state and local governments spent $89.36 billion (current dollars) or about 69.1 percent of total government transportation expenditures in 1995. This is about the same as their shares in total transportation revenues. Since the mid-1980s, the distribution of total transportation expenditures among the three levels of governments is almost identical to the distribution of total transportation revenues. From 1985 to 1995, the federal and the state and local governments' shares in total government transportation revenues and expenditures averaged 32 and 68 percent, respectively.

As discussed here, the near equality of the shares of revenues and expenditures is due to expenditures reflecting each level of government using their own funds before federal grants are transferred. Since most federal government expenditures on transportation are in the form of grants to states and localities, expenditures after federal grants present a very different picture. In FY 1995, 63 percent of the $39.93 billion in federal government expenditures on transportation were grants to state and local governments. The balance was spent directly by the federal government. Including federal grants, state and local governments accounted for about 86 percent of the $129.3 billion of total government transportation expenditures. Between state and local governments, local governments spend more than state governments overall. In 1995, the local government share of the state and local total direct expenditures was 54 percent (USDOT Forthcoming a).

Governments spent more on highways than on all other modes combined. In 1995, total highway spending was $79.2 billion, about 61 percent of total government transportation expenditures. Nearly three-quarters of this amount was spent by state and local governments. Transit expenditures accounted for nearly 20 percent of the total; pipelines received only $42 million, less than one-third of one-tenth of a percent (USDOT BTS Forthcoming a). A comparison among modes indicates that the federal government spends more on air, water, and rail; state and local governments, using their own funds, spend more on highways, transit, and pipelines. In 1995, federal government spending (directly and through grants) on air and water amounted to about 61 percent of total government expenditures on these modes and almost all of government expenditures on rail (USDOT Forthcoming a). In contrast, state and local government expenditures on transit and pipelines amounted to 82.6 percent and 57.1 percent, respectively, of total government spending on these modes.

CAPITAL INVESTMENT AND CAPITAL STOCK

An important category of government transportation expenditures is capital investment, which includes infrastructure and equipment. Transportation infrastructure is a comprehensive term used to describe a variety of fixed structures and facilities used by all modes of transportation.

Generally, transportation infrastructure in its physical form includes railroads, highways and streets, bridges and tunnels, airports and airways, ports and waterways, mass transit facilities, and pipelines. Except for railroads and pipelines, transportation infrastructure in the United States relies largely on public investments and some joint investments between the public and private sectors.

In 1995, all levels of government invested $60.6 billion, accounting for 46.9 percent of total government transportation expenditures. Not surprisingly, highways received the lion's share, with 71 percent of the total, while air transportation and transit received 12.9 and 12.4 percent of the total, respectively (USDOT Forthcoming a).

In terms of the investment proportion of total government expenditures, the ranking among different modes is slightly different. For example, for each dollar spent on railroad transportation, more than 55 cents was invested in capital stock; for each dollar spent on highways, 54 cents went to capital investments. For all other modes, except air, the government invested 26 cents of every dollar spent on these modes in capital stock. Air transportation had the lowest government investment ratio of 23.7 percent (USDOT Forthcoming a).

Table 3-6
Net Capital Stock of Highways and Streets
(Current $ billions)

	1986	1988	1990	1992	1994	1996
Federal	18.7	19.8	20.7	20.7	22.2	23.8
State and local	798.6	866.7	950.4	997.6	1,111.4	1262.5
Total	**817.3**	**886.5**	**971.1**	**1,018.3**	**1,133.6**	**1,286.3**

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* September 1997.

Over a period of decades, government investments in transportation infrastructure have resulted in a huge transportation infrastructure capital stock that constitutes a significant and integral component of the total national wealth and productive capacity. Based on estimates from the national economic accounts, public capital stock in highways and streets was worth $1.3 trillion in 1996. State and local governments own nearly all (98.1 percent) of this capital stock (see table 3-6).

Governments invest in other types of transportation infrastructures as well, but detailed data are not available on these investments. To better manage transportation infrastructure, calculate its contribution to the U.S. economy, and plan its future expansion, estimates are needed on the size and scope of the total capital stock and also for specific types of assets. These and other data needs are discussed in chapter 6.

DATA NEEDS

Since the mid-1980s, many attempts have been made to understand how public investments in transportation infrastructure contribute to private production and changes in productivity and economic growth. Inadequate capital stock data often hinder these analyses.

Although total transportation infrastructure cost can be calculated from past investments, capital stock data are required to determine how much of the cost is embodied in commodities and services provided by various sectors of the economy because of their use of the infrastructure.

Another important use of transportation infrastructure capital stock data is to assist in determining investment needs. From the perspective of maintaining capital stock value and long-term national wealth, information on the level and condition of capital stock can be used to estimate how much capital stock has depreciated. To keep capital stock intact, investments are needed to compensate for depreciation. From the perspective of maintaining or expanding capital stock to meet the need for capital services, information on the existing stock's capacity to provide such services is required to estimate investment needs.

The current official statistics, however, do not completely satisfy these information requirements because they either do not provide the necessary details or are developed within frameworks that are appropriate to some, but not all, data needs. Since market transactions do not exist for most uses of public transportation infrastructure, data on infrastructure cost at the user level cannot be directly collected. To fill this data gap, the Bureau of Transportation Statistics is currently implementing a statistical program to estimate transportation infrastructure capital stock of all transportation modes at national and individual state levels.

REFERENCES

U.S. Department of Commerce (USDOC), Bureau of Economic Analysis (BEA). 1997. *Survey of Current Business*. September.

____. 1998. *Survey of Current Business.*

U.S. Department of Labor (USDOL), Bureau of Labor Statistics (BLS). 1996a. Consumer Expenditure Survey.

____. 1996b. *National Industry Occupation: Employment Matrix*. Available at www.stats.bls.gov/asp/oep/nioem/empiohm.asp.

U.S. Department of Labor (USDOL), Bureau of Labor Statistics (BLS), Office of Productivity and Technology (OPT). 1999. Personal communication.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics. Forthcoming a. Government Transportation Financial Statistics: Fiscal Years 1985–95. Available on the BTS website: www.bts.gov.

____. Forthcoming b. *National Transportation Statistics 1999.* Washington, DC.

Transportation Safety

The highest priority of the U.S. Department of Transportation (DOT) is to "promote public health and safety by working toward the elimination of transportation-related deaths, injuries, and property damage" (USDOT NHTSA 1997). Although great progress has been made in the last few decades, transportation crashes remain the leading cause of accidental deaths and injuries in the United States, claiming tens of thousands of lives, and injuring millions of people each year. Most of the transportation deaths (about 95 percent) and injuries (an even higher percentage) occur on the nation's highways.

Although many safety issues are specific to a particular mode, others cut across modes. This chapter briefly discusses mode-by-mode trends, but concentrates on cross-modal issues.[1] Following a review of long-term transportation safety trends, the chapter discusses four special concerns—safe transportation to and from schools, pedestrian and bicycle safety, security of transportation systems against crime and terrorism, and international trends in road safety—as well as data needs.

Safely transporting students to and from schools is of particular interest to the public. Congress, in the Transportation Equity Act for the 21st Century (Public Law 105-178), known as TEA-21, mandated DOT to undertake a special study of safety

[1] For a more detailed discussion of mode-by-mode trends, see chapter 3 in the past three issues of the *Transportation Statistics Annual Report* (TSAR). Cross-modal topics discussed in these issues include: in TSAR98—transportation and the elderly, causes of crashes, and alcohol and drug involvement; in TSAR97—child safety, safety of transportation workers, and hazardous materials; in TSAR 96—fatigue, highway-rail grade crossings, safety technologies, and alcohol and drug involvement.

issues in transporting school children using various modes, which is due in 2001.

Walking and biking are often promoted as healthy, nonpolluting forms of transportation that could help alleviate congestion. However, walkers and bicyclists account for roughly 15 percent of fatalities involving motor vehicles, and their safety is an important concern.

In a pervasively integrated world economy, with more Americans traveling abroad for business and pleasure, international trends in transportation safety and security are of interest. Transportation, particularly air travel and mass transit can be targets of terrorists: for example, the gas attack on the Tokyo subway. Air travelers now regard precautions against terrorism as a routine part of air travel. In addition, this chapter briefly highlights road safety issues in other countries, as U.S. citizens traveling abroad who use taxis, buses, or rental cars may encounter traffic safety conditions that can differ from those in the United States.

LONG-TERM TRENDS

Table 4-1 shows historical trends in absolute numbers of fatalities, injuries, and crashes/accidents for all modes. The data show that in the last three decades, transportation fatalities have decreased for most modes. The figures for rail and transit include fatalities and injuries arising from certain types of incidents involving no moving vehicle (e.g., falls on transit property or fires in railroad repair sheds). Thus, the data in table 4-1 for transit and rail include many nonpassengers, making comparisons with other modes difficult.

Table 4-2 shows the distribution of fatalities in 1997. Occupants of cars and light trucks accounted for nearly three-quarters of the fatalities, and motorcyclists slightly under 5 percent, while pedestrians and pedalcyclists hit by motor vehicles accounted for just under 14 percent of the fatalities. Recreational boating and general aviation accounted for over 3 percent of the fatalities—more than all of the listed commercial passenger modes and freight trains combined.

Table 4-3 provides historical detail for the highway mode, which accounts for most transportation fatalities and injuries. As shown, there are fewer fatalities involving motor vehicles today than in the mid-1970s or early-1980s, even though miles of travel have increased. The decline is evident across most highway submodes, with the conspicuous exception of light trucks (e.g., sport utility vehicles, vans, and pickup trucks). The number of such vehicles increased dramatically over the period; they now account for about one-third of the motor vehicle fleet. The implications of these vehicles for highway safety is receiving considerable scrutiny. For example, sport utility vehicles have the highest rollover involvement rate by far of any vehicles in fatal crashes—36 percent compared with 15 percent for passenger cars (USDOT NHTSA 1998b).

Considerable concern also exists about the increasing number of crashes involving light trucks and passenger cars. A study sponsored by the National Highway Traffic Safety Administration (NHTSA) concluded that approximately twice as many car drivers would die in collisions with light trucks than in similar collisions involving cars of the same weight as the light truck (Joksch 1998, xi).

For systematic analyses of transportation safety trends, it is customary to calculate safety rates by dividing the absolute numbers of fatalities (or other adverse outcome) by some measure of activity, such as number of trips, miles traveled, or hours of vehicle operation. The logic for doing this is straightforward; people are exposed to transportation risks primarily when they travel. Hence, everything else remaining the same, the more travel there is, the more risk people incur. Thus, it can be misleading to use absolute numbers of, say, fatalities to compare the safety of a

Table 4-1

Fatalities, Injuries, and Accidents/Incidents by Transportation Mode

Year	Air carriers[a]	Commuter air[a]	On demand air-taxi[b]	General aviation[d]	Highway[c]	Rail[d]	Transit[e]	Waterborne[f]	Recreational boating	Gas and hazardous liquid pipeline
Fatalities: 1960–98										
1960	499	N	N	N	36,399	924	N	N	819	N
1965	261	N	N	N	47,089	923	N	N	1,360	N
1970	146	N	N	1,310	52,627	785	N	178	1,418	30
1975	124	28	69	1,252	44,525	575	N	243	1,466	15
1980	1	37	105	1,239	51,091	584	N	206	1,360	19
1985	526	37	76	956	43,825	454	N	131	1,116	33
1990	39	7	50	765	44,599	599	339	85	865	9
1995	168	9	52	734	41,817	567	274	46	829	21
1996	380	14	63	632	R42,065	551	264	50	709	R53
1997	R8	R46	R39	R660	R42,013	602	275	46	821	10
1998	P1	P0	R45	P621	P41,471	577	U	P31	813	18
Injuries: 1985–98										
1985	30	16	43	R483	N	31,617	N	172	2,757	126
1990	R29	11	36	R402	3,231,000	22,736	54,556	175	3,822	76
1995	25	25	14	395	3,465,000	12,546	57,196	145	4,141	64
1996	77	2	20	359	R3,483,000	10,948	55,288	129	4,442	R127
1997	39	1	23	365	R3,348,000	10,227	56,132	109	4,555	77
1998	P28	P2	P11	P332	3,192,000	10,156	U	P83	4,613	75
Accidents/Incidents: 1985–98										
1985	21	R18	R157	2,739	N	3,275	N	3,439	6,237	517
1990	24	R15	R107	2,215	6,471,000	2,879	90,163	3,613	6,411	378
1995	36	R12	75	R2,053	6,699,000	2,459	62,471	4,196	8,019	349
1996	38	R11	R90	R1,907	6,842,000	2,443	59,392	3,799	8,026	382
1997	49	17	82	1,858	6,764,000	2,397	61,561	3,704	8,047	350
1998	P48	P8	P79	P1,907	U	2,575	U	P2,837	8,175	386

[a] Large carriers operating under 14 CFR 121, all scheduled and nonscheduled service. Includes only injuries classified as serious.

[b] All scheduled and nonscheduled service operating under 14 CFR 135 and all those operations other than those operating under 14 CFR 121 and 14 CFR 135.

[c] Includes occupants of passenger cars, light trucks, large trucks, buses, motorcycles, other or unknown vehicles, nonmotorists, pedestrians, and pedalcyclists. Motor vehicle fatalities at grade crossings are counted here. The U.S. Department of Transportation, National Highway Traffic Safety Administration uses the term "crash" instead of accident in its highway safety data.

[d] Includes fatalities and injuries resulting from train accidents, train incidents, and nontrain incidents, except at grade crossings. Injury figures also include occupational illness. Railroad accidents include train accidents only. Motor vehicle fatalities at grade crossings are counted in the motor vehicle column. Accidents and fatality figures include Amtrak.

[e] Includes motor bus, commuter rail, heavy rail, light rail, demand responsive, van pool, and automated guideway. Some transit fatalities are also counted in other modes. Reporting criteria and source of data changed between 1989 and 1990. Starting in 1990, fatality figures include those occurring throughout the transit station, including nonpatrons. Fatalities and injuries include those resulting from incidents of all types. Accidents/incidents include collisions, derailments/vehicles going off the road, fires, and personal casualties. Injuries and fatalities include those resulting from all reportable incidents, not just accidents.

[f] Vessel casualties only.

KEY: N = data nonexistent; P = preliminary; R = revised; U = data are unavailable.

NOTE: Some fatalities in this table may be counted in more than one mode. Hence, the numbers in a row should not be totaled. Table 4-2 shows the total number of fatalities in 1997 without double counting.

SOURCES: **Aviation** (1997): National Transportation Safety Board, Press release 1998 SB-12, February 1998. **Highway** (1996 and 1997): U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts 1997: Overview, 1998, available at www.nhtsa.dot.gov. **Rail** (1997): U.S. Department of Transportation, Federal Railway Administration, *Railroad Safety Statistics Annual Report 1997* (Washington, DC: September 1998). **Transit** (all years): U.S. Department of Transportation, Federal Transit Administration, *Safety Management Information Statistics (SAMIS) 1996 Annual Report* (Washington, DC: May 1998). **Pipeline** (1997): U.S. Department of Transportation, Research and Special Programs Administration, data available at www.ops.dot.gov/lq10_97.htm; www.ops.dot.gov/ng_97a.htm; www.ops.dot.gov/ng_97b.htm. **All other data:** U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at www.bts.gov, tables 3-1, 3-2, and 3-3.

Table 4-2
Detailed Distribution of Transportation Fatalities by Mode: 1997

Category[a]	1997	Percent
Passenger car occupants	22,199	50.0
Light-truck occupants	10,249	23.1
Pedestrians struck by motor vehicles	5,321	12.0
Motorcyclists	2,116	4.8
Recreational boating	821	1.8
Pedalcyclists struck by motor vehicles	814	1.8
Large-truck occupants	723	1.6
General aviation	660	1.5
Railroad[b]	602	1.4
Other and unknown motor vehicle occupants	420	0.9
Other nonoccupants in highway crashes[c]	153	0.3
Heavy-rail transit (subway)	77	0.2
Waterborne transportation (vessel casualties only)	46	0.1
Commuter air	46	0.1
Grade crossings, not involving motor vehicles[d]	42	0.1
Air taxi	39	0.1
Bus occupants (school, intercity, and transit)	18	0.04
Gas distribution pipelines	9	0.02
Transit buses, fatalities not related to accidents[e]	9	0.02
Part 121 air carriers	8	0.02
Demand responsive/vanpool transit, fatalities not related to accidents[f]	5	0.01
Light rail	3	<0.01
Gas transmission pipelines	1	<0.01
Total	**44,381**	
Other counts, redundant with above[g]		
Grade crossings, with motor vehicles	419	
Transit buses, accident-related fatalities	100	
Commuter rail	79	
Passengers on railroad trains	6	
Demand responsive service, accident-related fatalities	2	

[a] Unless specified as occupants, includes fatalities outside the vehicle.
[b] Includes fatalities outside trains, except at grade crossings.
[c] Includes all nonoccupant fatalities, except pedalcyclists and pedestrians.
[d] Grade-crossing fatalities involving motor vehicles are included in counts for motor vehicles.
[e] Includes school, intercity, and transit bus occupants.
[f] Fatalities not related to accidents for transit buses and demand responsive transit are not included under highway submodes. Accidents include collisions and derailments/buses leaving the road.
[g] Fatalities at grade crossings with motor vehicles are included under relevant motor vehicle modes. Commuter rail fatalities are counted under railroad. For transit bus and demand responsive transit accidents, occupant fatalities are counted under "bus" and nonoccupant fatalities are counted under "pedestrians," "pedalcyclists," or other motor vehicle categories.

SOURCES: **Aviation** (1997): National Transportation Safety Board, Press release 1998 SB-12, February 1998. **Highway** (1996 and 1997): U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts 1998: Overview, 1999, available at www.nhtsa.dot.gov. **Rail** (1997): U.S. Department of Transportation, Federal Railway Administration. *Railroad Safety Statistics Annual Report 1997* (Washington, DC: September 1998). **Transit** (all years): U.S. Department of Transportation, Federal Transit Administration, *Safety Management Information Statistics (SAMIS) 1997 Annual Report* (Washington, DC: March 1999). **Pipeline** (1997): U.S. Department of Transportation, Research and Special Programs Administration, data available at www.ops.dot.gov/lq10_97.htm; www.ops.dot.gov/ng_97a.htm; www.ops.dot.gov/ng_97b.htm. **All other data:** U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at www.bts.gov, tables 3-1, 3-2, and 3-3.

Table 4-3

Highway Fatalities and Injuries by Occupant and Nonoccupant Category

	Vehicle occupants by vehicle type						Nonoccupants			Total
Year	Passenger car	Light truck	Large truck	Bus	Motorcycle	Other/ unknown vehicle occupants	Pedestrians	Pedalcyclists	Other/ unknown nonoccupants	All occupant and nonoccupant categories
Fatalities: 1975–98										
1975	25,929	4,856	961	53	3,189	937	7,516	1,003	81	44,525
1976	26,166	5,438	1,132	73	3,312	981	7,427	914	80	45,523
1977	26,782	5,976	1,287	42	4,104	959	7,732	922	74	47,878
1978	28,153	6,745	1,395	41	4,577	622	7,795	892	111	50,331
1979	27,808	7,178	1,432	39	4,894	579	8,096	932	135	51,093
1980	27,449	7,486	1,262	46	5,144	540	8,070	965	129	51,091
1981	26,645	7,081	1,133	56	4,906	603	7,837	936	104	49,301
1982	23,330	6,359	944	35	4,453	525	7,331	883	85	43,945
1983	22,979	6,202	982	53	4,265	362	6,826	839	81	42,589
1984	23,620	6,496	1,074	46	4,608	440	7,025	849	99	44,257
1985	23,212	6,689	977	57	4,564	544	6,808	890	84	43,825
1986	24,944	7,317	926	39	4,566	442	6,779	941	133	46,087
1987	25,132	8,058	852	51	4,036	436	6,745	948	132	46,390
1988	25,808	8,306	911	54	3,662	429	6,870	911	136	47,087
1989	25,063	8,551	858	50	3,141	424	6,556	832	107	45,582
1990	24,092	8,601	705	32	3,244	460	6,482	859	124	44,599
1991	22,385	8,391	661	31	2,806	466	5,801	843	124	41,508
1992	21,387	8,098	585	28	2,395	387	5,549	723	98	39,250
1993	21,566	8,511	605	18	2,449	425	5,649	816	111	40,150
1994	21,997	8,904	670	18	2,320	409	5,489	802	107	40,716
1995	22,423	9,568	648	33	2,227	392	5,584	833	109	41,817
1996	22,505	9,932	621	21	2,161	455	5,449	765	154	[R]42,065
1997	[R]21,199	[R]10,249	[R]723	[R]18	[R]2,116	[R]420	[R]5,321	[R]814	[R]153	[R]42,013
1998	21,164	10,647	728	36	2,284	500	5,220	761	131	41,471
Injuries (thousands): 1988–98										
1988	2,585	478	37	15	105	4	110	75	8	3,416
1989	2,431	511	43	15	83	5	112	73	11	3,284
1990	2,376	505	42	33	84	4	105	75	7	3,231
1991	2,235	563	28	21	80	4	88	67	11	3,097
1992	2,232	545	34	20	65	12	89	63	10	3,070
1993	2,265	601	32	17	59	4	94	68	9	3,149
1994	2,364	631	30	16	57	4	92	62	9	3,266
1995	2,469	722	30	19	57	4	86	67	10	3,465
1996	[R]2,458	[R]761	33	20	[R]55	4	82	[R]58	11	[R]3,483
1997	[R]2,341	[R]755	31	17	[R]53	[R]6	77	58	11	[R]3,348
1998	2,201	763	29	16	49	4	69	53	8	3,192

KEY: R = revised.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1997* (Washington, DC: 1998). Revised and 1998 data: _____, Traffic Safety Facts: Overview 1998, available at www.nhtsa.dot.gov/people/ncsa/factsheet/html.

given mode for two different years, since any change in fatalities might be explained solely by a change in the amount of transportation activity.

Figure 4-1 shows fatality rates for selected modes for a time period of about two decades. Clear improvement is apparent for several modes and submodes. While it is valid to compare fatality rates in two different years for the same mode, comparisons between modes should be done only with great caution. As seen in figure 4-1, the denominators used are not the same for all modes. For highway and rail, exposure to risk is approximately proportional to distance traveled, hence the use of vehicle-miles as the denominator. For aviation, the greatest proportion of crashes occur during takeoff and landing; hence risk is approximately proportional to the number of operations (measured as departures). Data availability for general aviation is limited, so hours flown is used instead. For rail, it can be argued that the analog of highway vehicle-miles is railcar-miles rather than train-miles, but lack of railcar data necessitates the use of train-miles.

Considerable confidence can be placed in comparisons of different highway submodes. As shown in figure 4-1, occupants of passenger cars and light trucks have much higher fatality rates than occupants of large trucks and buses. Motorcycle riders have fatality rates more than an order of magnitude greater than for other highway submodes. A large number of factors influence differences in fatality rates. For example, the greater size and mass of large trucks and buses serves to protect the occupants of these vehicles in crashes with smaller vehicles or less massive objects. These weight differences explain why most of the people killed in crashes involving large trucks are in other vehicles. In 1997, 4,871 large trucks were involved in fatal crashes. While 717 occupants of large trucks died in these crashes, 4,638 other people died in these collisions (USDOT NHTSA 1998c).

There are various possible explanations for decreasing fatality rates for all modes. For highway modes, promotion of safety belt, child safety seat, and motorcycle helmet usage, and measures to discourage drunk driving have all had a beneficial effect. For example, the portion of drivers in fatal crashes who were intoxicated (blood alcohol concentrations of 0.10 grams per deciliter) declined from 30 percent in 1982 to 17.8 percent in 1997 (USDOT NHTSA 1998b, p. 34, table 15). Box 4-1 discusses safety belt and air bag use. Some of the decrease in transportation fatalities may be a consequence of better and prompter medical attention for victims of transportation crashes and accidents.

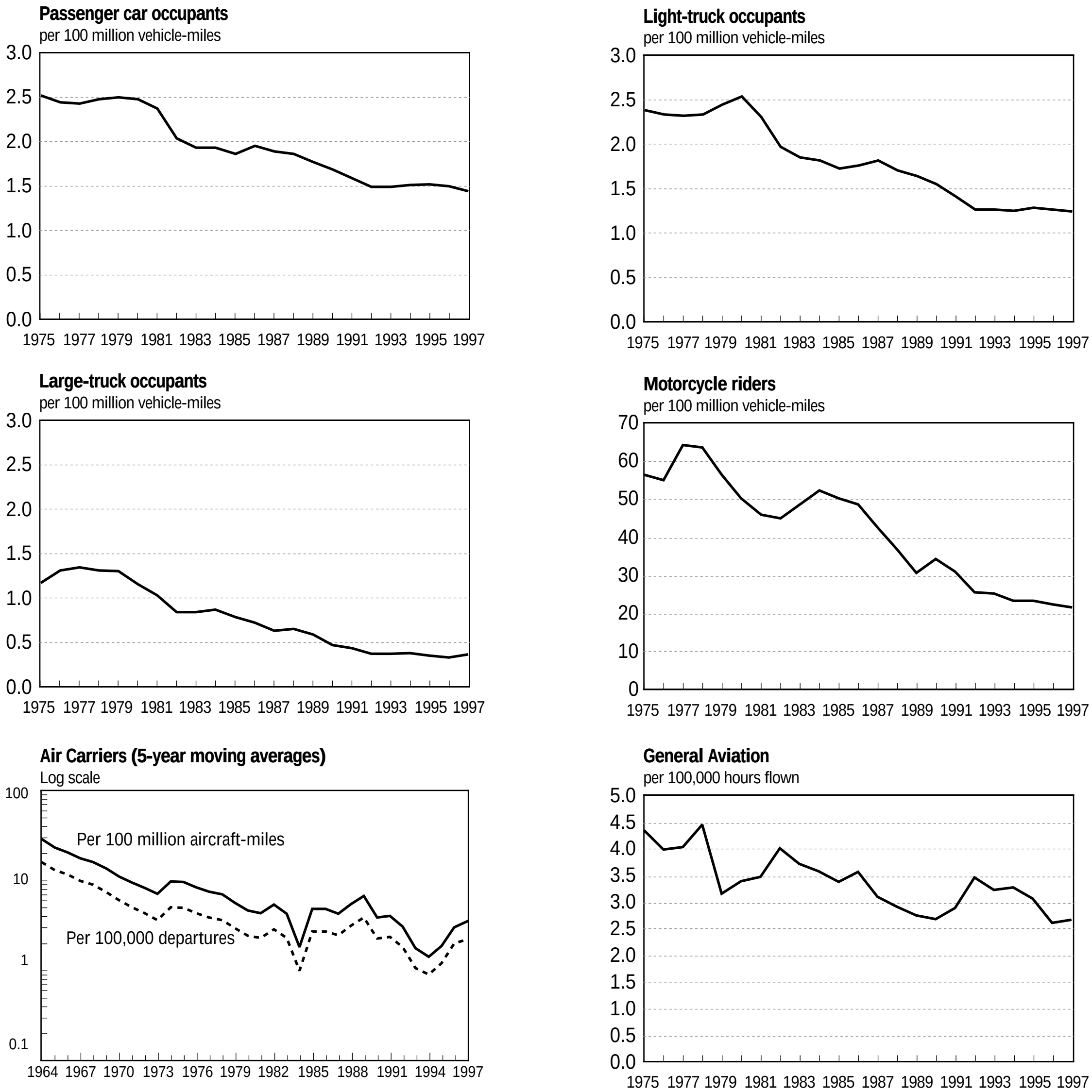
TRANSPORTATION OF SCHOOL CHILDREN

Tens of millions of children travel to and from school each day during the school year and protecting them is an important public concern. School bus safety has received the most notice, but other issues—the safety and security of children transported in cars, by transit, or while walking or biking to school—are also key.

DOT's 1995 Nationwide Personal Transportation Survey (NPTS) indicates that the leading mode of school transportation is the privately owned vehicle (POV)—private automobiles, vans, trucks, or sport utility vehicles—followed by the school bus[2] (see figure 4-2). In fact, POVs accounted for half of the annual person trips for school transportation. School buses provided 32

[2] The NPTS collected travel information from a sample of U.S. households for calendar year 1995 and then used demographic statistics to expand the results to nationwide estimates. Among other types of data, the NPTS collected information on trips of a daily nature (e.g., commuting, shopping, and transporting children to school), sorted by the type of vehicle, the nature of the trip, trip length, and other parameters. The NPTS thus allows users to calculate both the number of person trips and the number of person-miles traveled by almost any subgroup of the population for almost any type of trip.

Figure 4-1
Fatality Rates for Selected Modes



NOTE: For numbers of fatalities, see table 4-1. For Part 121 air carriers, a 5-year moving average was used to track fatality rates, because of the year-to-year fluctuation in fatalities. The departure data and hence the denominator of the rates are not strictly comparable between pre- and post-1977 eras, but the difference is small.

SOURCES: Activity measures: **Highway:** U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at www.bts.gov, tables 3-20, 3-21, 3-22, and 3-23. **Rail (1990–95):** _____. National Transportation Statistics, 1998, available at www.bts.gov, table 3-35. **(1996)** Sum of intercity train-miles from National Railroad Passenger Corp., *Amtrak 1996 Annual Report* (Washington, DC: 1997), U.S. Department of Transportation, Federal Transit Administration, Form 406 reports for the National Transit Database, unpublished data. **General Aviation (1975–81):** U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics Historical Compendium, 1960–1992* (Washington, DC: 1993), table 26. **General aviation (1982–97):** National Transportation Safety Board, Press release SB-12, February 1998, table 10. **Part 121 air carriers (1978–81):** National Transportation Safety Board, *Annual Review of Aircraft Accident Data: U.S. Air Carriers* (Washington, DC: Annual issues). **(1982–97):** _____. Press release SB-12, February 1998, table 5.

Box 4-1
Occupant Protection

Many fatalities and injuries in motor vehicle crashes could be avoided if more passengers used their safety belts. The National Highway Traffic Safety Administration (NHTSA) estimates that safety belts saved 10,750 lives in 1997. If *all* occupants of passenger vehicles buckled up, an additional 9,601 lives could have been saved (USDOT NHTSA 1997).

Safety belt use has increased since 1984, when states first began to mandate seat belt use. Today, 49 states and the District of Columbia have laws in effect. In 1997, observed belt use ranged from 62 percent among states that enforce belt requirements only when motorists are stopped for other infractions to 79 percent among states where police are authorized to pull motorists over solely for not wearing belts. Different methods exist for estimating safety belt use nationwide, and the resulting estimates are difficult to compare. NHTSA's National Occupant Protection Use Survey found shoulder belt use to be 61.3 percent in 1996 (USDOT NHTSA NCSA 1997). An estimate based on state observational survey data reported to NHTSA found that 69 percent of passenger vehicle occupants used safety belts in 1997.

Air bags combined with the use of lap/shoulder belts provide more protection for passenger vehicle occupants than safety belts alone. NHTSA estimates that in 1997 there would have been 842 more occupant fatalities from motor vehicle crashes had it not been for air bags. The portion of the passenger vehicle fleet equipped with air bags is growing steadily. In 1997, 63 million vehicles—roughly 30 percent of passenger cars and light trucks—were equipped with at least one air bag, and 33 million vehicles had dual air bags.

Some children riding in front seats and adults have been injured or killed by inflating air bags in low severity crashes. Far more lives have been saved by air bags than have been lost, however. As of September 1, 1998, according to NHTSA, air bags had saved 3,448 lives. The number of confirmed deaths from injuries caused by air bags was 113, including 66 children riding in the front seat (USDOT NHTSA 1998). If children under the age of 13 ride in the back seat of passenger vehicles and are secured by appropriate restraint systems, risk of injuries or death from air bags can be avoided. For adults and teenagers, the risk can be mostly averted through use of safety belts, and adjusting the seat to keep at least a 10-inch distance between the air bag cover and the individual's breastbone (USDOT NHTSA 1998).

In 1995, NHTSA authorized manufacturers to install on-off switches for air bags in vehicles without a rear seat that can accommodate suitable child safety seats. Since 1998, consumers who fit certain eligibility profiles can receive NHTSA authorization to have a dealer or service outlet install an air bag on-off switch in their vehicle (USDOT 1997).

REFERENCES

U.S. Department of Transportation (USDOT), Office of the Assistant Secretary for Public Affairs. 1997. DOT Announces New Policy for Air-Bag On-Off Switches. *News*. 18 November.

U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). 1997. Traffic Safety Facts 1997: Occupant Protection. Available at www.nhtsa.dot.gov/people/ncsa/OccPrt97.html. As of 27 August.

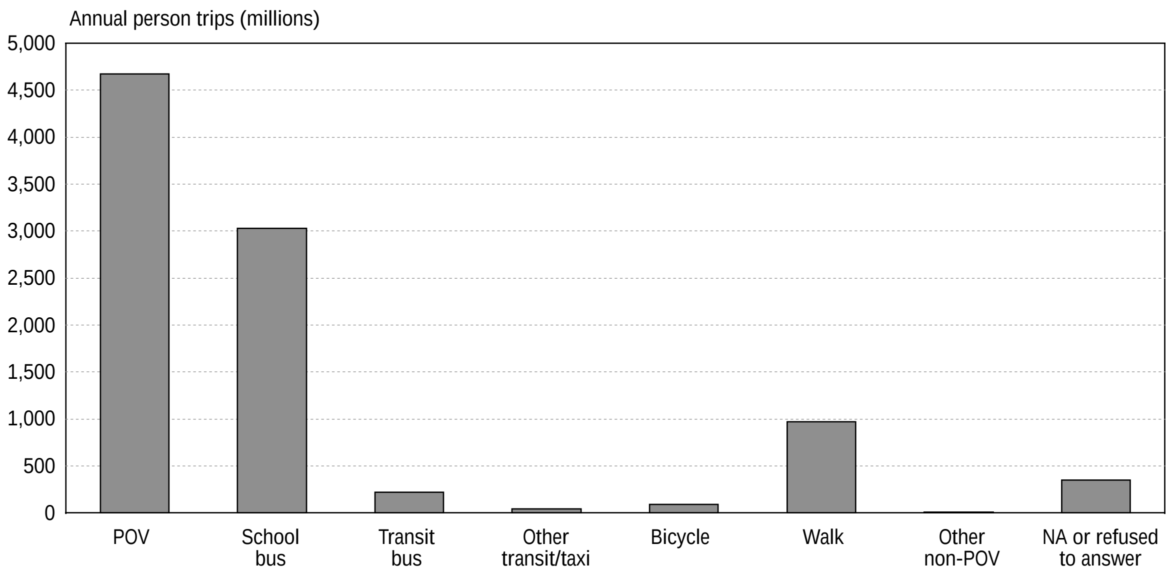
____. 1998. Safety Fact Sheet. Available at www.nhtsa.dot.gov/airbags/factsheets/numbers.html. As of 27 August.

U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), National Center for Statistics and Analysis (NCSA). 1997. Observed Safety Belt Use in 1996, Research Note. April.

percent of annual person trips and public transportation just 3 percent. Walking made up 10 percent of annual person trips to and from school and bicycling made up 1 percent.

The majority of fatal crashes involving school-age occupants occur when children are riding in an automobile or other private vehicle. Derived from NHTSA's Fatality Analysis Reporting System (FARS) data for 1997, figure 4-3 shows the number of fatal crashes and fatalities among occupants aged 5 to 19 that occurred during the school year between the hours of 6:00 a.m. and

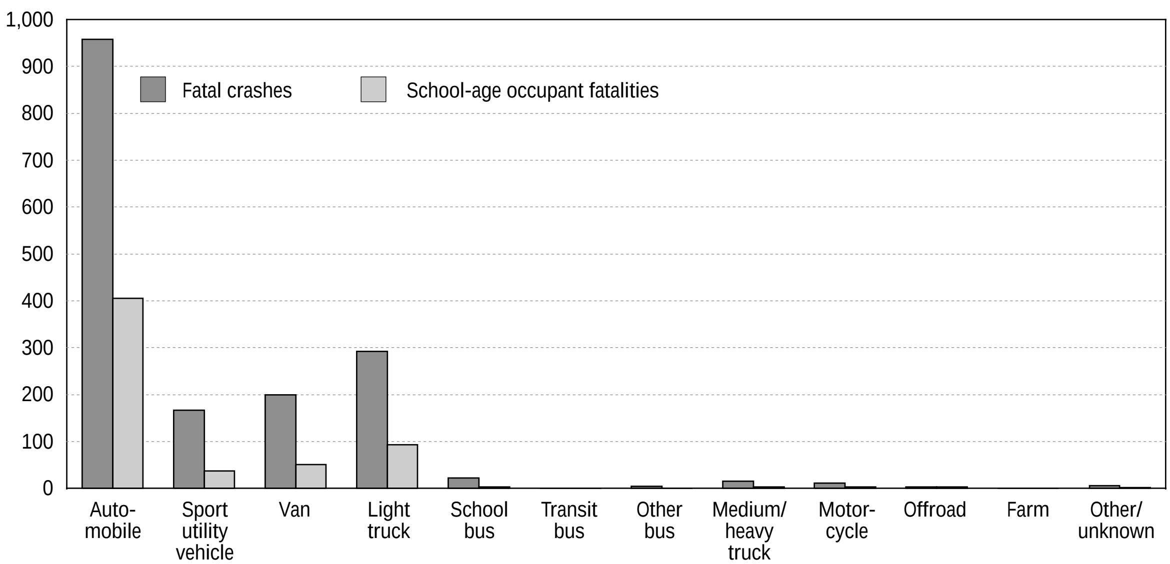
Figure 4-2
School Transportation by Mode: 1995



KEY: NA = not ascertained; POV = privately owned vehicle.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey 1995, available at www-cta.ornl.gov/cgi.npts.

Figure 4-3
Fatal Crashes and Occupant Fatalities Among School-Age Children by Vehicle Type: 1997



NOTE: Data are for children aged 5–19 for crashes occurring September–June between the hours of 6:00–9:00 a.m. and 2:00–5:00 p.m. Totals do not include fatal crashes occurring in July and August or fatalities among pedestrians, bicyclists, or other nonoccupants.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, Fatality Analysis Reporting System, 1997, available at www-fars.nhtsa.dot.gov

9:00 a.m. and 2:00 p.m. and 5:00 p.m., when most school-related trips take place. Automobiles and other private vehicles accounted for most of these incidents. Automobiles alone accounted for 57 percent of all fatal crashes involving school-age occupants and 47 percent of occupant fatalities.

A better way of assessing the safety of various modes used in school transportation is to look at occupant fatality rates. Combining 1995 data from NPTS with FARS statistics reveals that fatal injury rates are far higher for POVs than for buses: 2.6 fatalities per 100 million person-miles for POVs used in school transportation, but only 0.06 for school buses.

School Bus Safety

According to NHTSA (1998a), school buses provide one of the safest forms of transportation in the United States. In 1987 through 1997, there were about 420,000 fatal traffic crashes: of these, 1,298 (just over 0.3 percent) were school bus-related (USDOT NHTSA 1998f). Nevertheless, while the statistics show that it is far safer to travel on a school bus than in a POV, school bus safety draws great attention whenever an incident occurs.

Each day, about 440,000 public school buses transport 23.5 million children to and from school and school-related activities. These buses travel 4.3 billion miles each year (USDOT NHTSA 1998a).

From 1987 through 1996, an average of 10 school bus occupants and 25 school age pedestrians (under 19 years of age) per year died in school bus-related crashes. From 1977 through 1986, an average of 12 school bus occupants and 47 pedestrians died annually (NHTSA 1998a, 2). NHTSA also estimates that an average of about 8,500 injuries occurred each year in school buses between 1988 and 1996. Most were minor injuries, but 885 were moderate and 350 were serious to critical (USDOT NHTSA 1998a).

The debate over whether school buses should be equipped with seat belts goes back to at least 1977, when NHTSA tightened school bus safety standards. At that time, following extensive research and analysis, NHTSA instituted "compartmentalization" as the primary means of occupant protection in large school buses: strong, well-padded, well-anchored, high-backed, evenly spaced seats. (The compartmentalization standard does not apply to small school buses, those with a gross vehicle weight rating of less than 10,000 pounds. A number of other safety requirements apply to such buses, including the installation of lap belts.)

Studies by both the National Transportation Safety Board—NTSB (1987) and the Transportation Research Board—TRB (1989) supported the effectiveness of compartmentalization for occupant protection on large school buses. Moreover, these reports recommended that school departments spend their limited resources on other safety improvements, such as pedestrian safety and higher seat backs, rather than on seat belts.[3] The debate continues, however.

As mentioned previously, a majority of children killed in school bus-related crashes were outside the bus. Most of these children were struck by the school bus they were exiting or boarding. To reduce the risk to children in the "danger zone" outside the school bus, TRB's 1989 report called for such measures as improved driver training and stop signal arms (now required by NHTSA on all buses). Educating children about safety is also key.

[3] TRB, however, concluded that properly used seat belts on large buses built after 1977 may reduce school bus passenger deaths or injuries in crashes by up to 20 percent (TRB 1989, 83).

School Children Riding Transit Buses

On November 26, 1996, near Cosmopolis, Washington, a utility truck fatally injured a 10-year-old child who darted from behind a transit bus transporting him home from school. During its investigation of the crash, NTSB determined that school children who ride in transit buses are not provided the same level of safety as those who use school buses, because of differences in the buses' operational practices and equipment (NTSB 1997). For example, while bus drivers are responsible for the safety of children on school buses, even when they are boarding and exiting, children riding transit buses are responsible for their own safety. Moreover, transit buses do not have the identifying markings and flashing lights used on school buses to signal motorists that the bus is carrying children, nor are motorists required to stop for transit buses unloading passengers.

Estimates of the number of children using transit to get to and from school vary. The American Public Transit Association estimates that about 2 million children used transit buses for at least some of their school-related trips in 1994, or approximately 8 percent of public school students. The NPTS indicates that just 2 percent of person trips for school involve transit.

Vans in School Transportation

Some school districts purchase or lease passenger vans to transport students. If these vans carry more than 10 passengers, they are subject to federal safety standards for school buses, and need modifications to make them suitable for school bus use. Vans that have not been modified to conform to the federal safety standards are considered "noncomforming" vans. Federal law prohibits dealers from selling or leasing new nonconforming vans for transporting students.

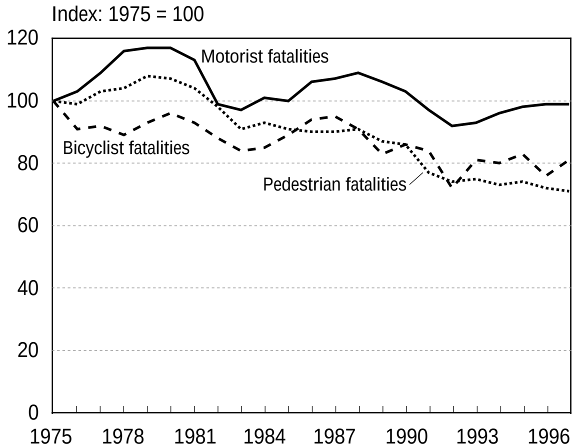
Passenger van manufacturers have notified their dealers of the federal law against selling or leasing nonconforming vans to schools for pupil transportation (NASDPTS n.d.). Dealers are responsible for determining the intended use of the van and are subject to substantial penalties for violations. Federal regulations, however, apply only to the manufacture and sale or lease of new vehicles. Moreover, although there are no statistics on the number of school children who ride in such vans, a 1997 survey by the National School Transportation Association found that 22 states allow the use of 11- to 15-passenger vans for pupil transportation (NSTA 1999). Just two of these states require that the vans meet the minimum school bus safety standards.

PEDESTRIAN AND BICYCLE SAFETY

Walking and bicycling are a means of transportation used by many people for recreation and exercise. In 1997, there were more than 6,100 pedestrians and bicyclists killed in crashes with motor vehicles. Although pedestrian and bicycle fatalities have declined more rapidly than motorist fatalities since 1976 (see figure 4-4), this does not necessarily mean that the risk has decreased. The NPTS shows that walking trips declined from 9.3 percent to 5.5 percent of trips between 1977 and 1995, while bicycle trips increased from 0.6 percent to 0.9 percent during that period (Pickrell and Schimek 1997).

Although pedestrians and bicyclists are frequently combined in the category of nonmotorized transportation, they are very different in terms of demographics, sources of injuries, and legal responsibilities. Bicyclists travel at three to five times the speed of pedestrians, and are vehicle operators both in terms of physics and according to traffic laws. For example, bicyclists are expected to use the roadway in the direction of traffic. Pedestrians, on the other hand, are expected to use the sidewalk, or, if none, walk facing traffic.

Figure 4-4
Relative Change in Motorist, Bicyclist, and Pedestrian Fatalities: 1975–97



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts 1997: Overview, available at www.nhtsa.dot.gov.

Pedestrian Safety

Pedestrians are particularly vulnerable in a collision with motor vehicles. This is one reason that walkers accounted for only 77,000 (2 percent) of the 3.3 million highway injuries in 1997, but 5,321 (13 percent) of the 42,013 highway fatalities (USDOT NHTSA 1999). Six percent of pedestrians involved in injury crashes were killed and 24 percent had incapacitating injuries; by comparison, only 1 percent of motor vehicle occupants involved in injury crashes were killed and 12 percent received incapacitating injuries (calculated from USDOT NHTSA 1998b, table 53).

Some types of pedestrians are disproportionately represented in the casualty statistics, including children, the elderly, people walking after dark, and intoxicated pedestrians. The relative risks of these groups are unknown, since little information is available about their exposure, that is, the extent and circumstances of their walking. Children 5 to 15 years old accounted for 16 percent of the U.S. population in 1997 but 29 percent of pedestrian injuries in 1997 and 9 percent of pedestrian fatalities. The large number of children injured may be due to a combination of frequent walking and actions that make them vulnerable to collisions. Older people may have lower than average exposure to traffic dangers as pedestrians, but if they are involved in a crash they have a high rate of mortality. Adults 65 years and older accounted for 13 percent of the population, 8 percent of injuries, but 22 percent of fatalities (USDOT NHTSA 1998b, table 95).

It is estimated that 29 percent of pedestrians killed in crashes in 1997 were intoxicated (with a blood alcohol concentration of 0.10 or more). The rate was highest for pedestrians 25 to 34 years old (50 percent were intoxicated) and pedestrians aged 35 to 44 (47 percent) (USDOT NHTSA 1998e). Alcohol use by motorists is also a factor related to fatal pedestrian-motor vehicle collisions. NHTSA estimates that 12 percent of drivers in such collisions were intoxicated. The percentage of intoxicated pedestrians 14 years old and over killed by motor vehicles decreased from 39 percent in 1982 to 32 percent in 1997 (USDOT NHTSA 1998e, table 20).

Visibility is a major factor in pedestrian fatalities. In 1997, two-thirds of pedestrian fatalities occurred during low-light conditions (dusk, dawn, or dark). Among pedestrians 21 to 44 years old, 81 percent of fatalities happened in low-light conditions (calculated from USDOT NHTSA 1997).

The major circumstances of motor vehicle-pedestrian collisions are shown in table 4-4. Most intersection collisions involve pedestrian dash-outs, turning vehicle conflicts, and motorist traffic signal control violations. Midblock crossings are the next most common type. About half of these incidents involved pedestrians darting out suddenly. Almost half of the collisions involving a backing vehicle or a pedestrian not in the roadway occurred in public or private parking lots (Hunter et al. 1996).

Table 4-4
Pedestrian Crash Types

Crash type	Percentage of crashes
Crossing at intersection	32
Crossing midblock	26
Not in road (e.g., parking lot, near curb)	9
Walking along road/crossing expressway	8
Backing vehicle	7
Working or playing in road	3
Other	16
Total	**100**

SOURCE: W.W. Hunter, J.C. Stutts, W.E. Pein, and C.L. Cox, *Pedestrian and Bicycle Crash Types of the Early 1990s* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, 1996).

Based on the traffic rules and the descriptions in police accident reports, researchers judged that in car-pedestrian collisions the pedestrian was solely at fault 43 percent of the time, the motorist solely at fault in 35 percent of collisions, and both were at fault 13 percent of the time (calculated from Hunter et al. 1996; in the remaining crashes, the culpability of one or both parties was unknown). Many of the pedestrians at fault on the basis of traffic rules were children. For pedestrians 15 years and older, only 33 percent were judged to be at fault (Hunter et al. 1996, 26).

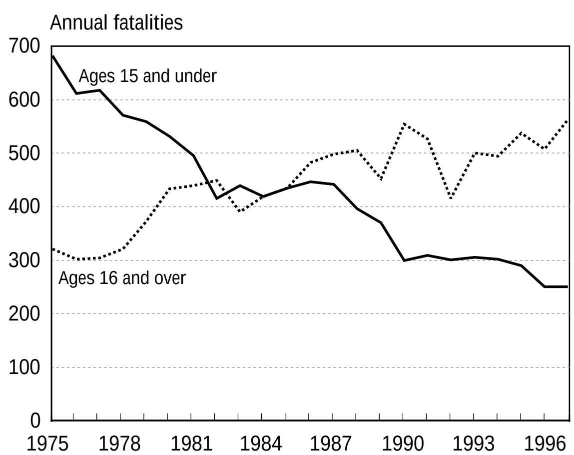
Bicycle Safety

Bicycling accounts for many fewer deaths than walking, but nearly as many traffic injuries. In 1997, 814 bicyclists were killed and 58,000 were injured in traffic crashes (USDOT NHTSA 1999). Although 90 percent of bicycle *fatalities* involve a collision with a motor vehicle, most bicycle *injuries* do not involve a motor vehicle. There are 500,000 bicycle-related emergency room visits annually (Tinsworth et al. 1993). The most common types of bicycle mishaps leading to injury were falls and collisions with fixed objects. Collisions with motor vehicles accounted for about 15 percent of emergency room visits for bicycle injuries (Rivara et al. 1996). Since states do not generally record data about crashes (on-or offhighway) that do not involve motor vehicles, most bicycle crashes are definitionally excluded from traffic injury data.

As with pedestrian data, exposure data for bicycling is limited, which makes it difficult to make statements about changes in risk over time or for different behaviors. For example, it is notable that fewer than one-third (31 percent) of the bicyclists killed in traffic crashes in 1997 were 15 years old or younger, a large change compared with the 1975 figure of 68 percent (see figure 4-5). This change may be the result of an increase in bicycling by adults, a decrease by children, or a change in their relative safety rates.

Either the motorist or bicyclist was considered to be intoxicated in 25 percent of the traffic crashes that resulted in bicyclist fatalities in 1997. The bicyclist was intoxicated in 17 percent of all such bicyclist fatalities (USDOT NHTSA 1998d).

Figure 4-5
Bicycle Fatalities by Age of Bicyclist: 1975–97



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, Fatality Analysis Reporting System (FARS) database, available at www.nhtsa.dot.gov.

A special analysis of police accident reports from six states found the bicyclist alone to be at fault in 50 percent of the crashes, the motorist alone in 28 percent, and both in 14 percent. There was insufficient information to determine fault in the remaining cases (Hunter et al. 1996, table 39). Table 4-5 shows the most common circumstances of car-bicycle collisions. Most crashes occurred when the bicyclist and motorist were on intersecting paths or when one was turning. Only 9 percent involved motorists overtaking cyclists, and 36 percent of these occurred under low-light conditions when visibility of the cyclist may have been a factor (Hunter et al. 1997).

Nearly one-third (32 percent) of bicyclists involved in crashes were riding against traffic (Hunter et al. 1996, table 37). Since most cyclists do not ride against traffic, this figure suggests that this behavior is very risky. In fact, a study that calculated relative risk based on exposure rates found that bicycling against traffic increased the risk of a collision with a motor vehicle by a factor of 3.6 (Wachtel and Lewiston 1994).

There are a number of steps that can be taken to increase bicycle safety:

- wearing a helmet reduces the risk of head and brain injury among cyclists by about 70 percent (Rivara et al. 1996),
- obeying traffic rules,
- using lights and reflectors at night, and
- establishing more bicycle lanes on or near urban roads.

Riding on sidewalks does not reduce the risk of injury; in fact, the relative risk of injury when riding on sidewalks is much greater than when riding on roads (Aultman-Hall and Hall 1998; Wachtel and Lewiston 1994). The greater danger of sidewalk bicycling can be explained by the presence of pedestrians and other obstructions, the danger from turning vehicles at intersections with roads and driveways, and the inexperience of bicyclists who habitually use sidewalks.

Table 4-5
Bicycle-Motor Vehicle Crash Types

Crash type	Percentage of crashes
Crossing paths	57
Parallel paths	
Motorist turned into path of bicyclist	12
Motorist overtaking bicyclist	9
Bicyclist turned into path of motorist	7
Bicyclist overtaking motorist	3
Operator on wrong side of road	3
Operator or motorist loss of control	2
Other circumstances	7
Total	**100**

SOURCE: W.W. Hunter, J.C. Stutts, W.E. Pein, and C.L.Cox, *Pedestrian and Bicycle Crash Types of the Early 1990s* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, 1996).

TERRORISM AND TRANSPORTATION SECURITY

The past several years have seen mounting concern over the security of transportation facilities and operations, both in the United States and overseas. This has been stimulated both by criminal activity in transportation-related locations, as well as terrorist activity in several parts of the world.

The United States has not escaped this trend. Americans have witnessed worrisome bombings involving parked vehicles at major public facilities: the World Trade Center in New York City (1993), which killed 6 people; and the Murrah Federal building in Oklahoma City (1995), which killed 168 people and injured a total of 759 people. Overseas, U.S. military barracks in Saudi Arabia (1996) and our diplomatic facilities in Dar es Salaam, Tanzania, and Nairobi, Kenya (1998) were attacked by vehicle bombs, leading to more deaths, injuries, and damage.

Credible terrorist threats against many other overseas U.S. government facilities are continually being identified and evaluated, and transportation-related attacks have occurred in other nations. These include the release of sarin nerve gas in the Tokyo subway system (1998), as well as assaults against transit vehicles and systems in France, Israel, China, and several Latin American nations.

The State Department's Office of the Coordinator for Counter-Terrorism issues an annual report on *Patterns of Global Terrorism* (USDOS 1999). In recent years, the incidence of international terrorism has fluctuated greatly. Although the number of incidents has remained relatively constant at about 300 to 400 annually, the casualties resulting from these events have varied widely from under 1,000 to nearly 7,000 (see table 4-6). A single incident can range from the attempted kidnapping of an individual to a massive bombing of a public facility with numerous casualties and significant destruction.

The most recent report lists 273 acts of international terrorism in 1998, a decrease of 31 from 1997. However, these attacks resulted in the largest number of casualties—741 deaths and 5,952 injuries for a total of 6,693—in any year on record. More than 5,500 casualties were related to the bombings of the U.S. embassies in Nairobi and Dar es Salaam. The 12 U.S. citizens who died in the Nairobi incident were the only Americans to lose their lives to terrorism in 1998. About 40 percent of the 1998 incidents—or 111 of the 273 events—involved U.S. targets. Most of these were bombings of U.S. oil company pipelines in Colombia.

Table 4-6
International Terrorist Incidents and Casualties: 1993–98

Year	1993	1994	1995	1996	1997	1998
Incidents	431	322	440	296	304	273
Casualties	1,510	988	6,454	3,225	914	6,693

SOURCE: U.S. Department of State, *Patterns of Global Terrorism, 1998* (Washington, DC: 1999), appendix C.

According to DOT's Federal Aviation Administration, there were 216 criminal incidents involving attacks against civil aviation around the world from 1993 through 1997. About 40 percent of the incidents (87) involved hijackings. Another 50 involved attacks at airports, and 32 involved attacks at off-airport facilities (USDOT FAA 1997).

Several recent initiatives by Congress and the Executive Branch emphasized security issues. In 1997, the Commission on Aviation Safety and Security recommended 77 improvements in aviation safety, security, disaster response, and air traffic control (USEOP 1997). Agencies responsible for implementing these recommendations are the Departments of Defense, State, and Transportation; the Federal Bureau of Investigation; the National Transportation Safety Board; the U.S. Customs and Postal Services; and the Bureau of Alcohol, Tobacco and Firearms.[4]

In July 1996, Executive Order 13010 established the President's Commission on Critical Infrastructure Protection (PCCIP). PCCIP conducted a comprehensive review of both the physical and electronic, or "cyber," vulnerabilities of five of the nation's critical infrastructure sectors, defined as systems that, if damaged or disrupted, would have serious negative consequences to economic activities or national security. These five sectors were: information and communications; banking and finance; energy, including electrical power, oil, and gas; vital human services, such as emergency medical response; and physical distribution, including transportation as its major component.

[4] DOT's annual status report (USDOT 1998) on the implementation progress is available on the Internet at www.dot.gov/affairs/whcoasas.htm.

PCCIP's report, issued in October 1997 (USEOP 1997) contained recommendations to improve the nation's response capability. PCCIP identified three areas where transportation was potentially vulnerable. The first would exist if the satellite-based Global Positioning System became the sole source for radionavigation for aircraft landings by the year 2010, as scheduled. The second is related to vulnerabilities as a result of the modernization of the National Airspace System. The third concern arises from the potential vulnerability of advanced electronic information and communications systems used throughout the transportation system. For example, disruptions in computer-based systems used in pipeline operations to monitor flow and pressure and issue automatic electronic commands to remote pumping stations and valves could lead to pipeline failures, environmental damage, and supply shortages. In May 1998, *Presidential Decision Directive (PDD) 62 on Combating Terrorism* (USEOP 1998a) and *PDD 63 on Protecting America's Critical Infrastructure* (USEOP 1998b) established a number of new interagency organizations to oversee the implementation of the PCCIP recommendations.

INTERNATIONAL TRENDS IN ROAD SAFETY

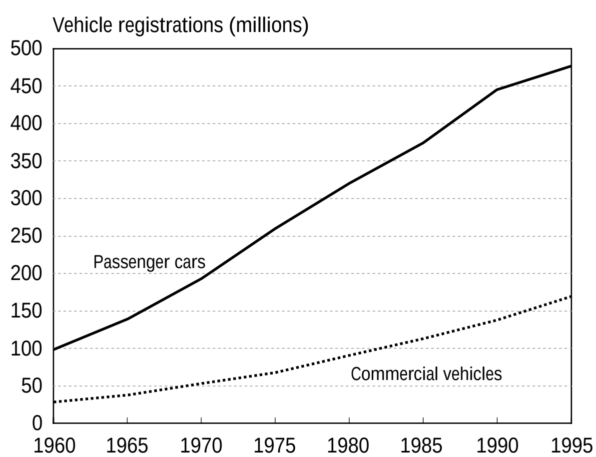
Long the dominant mode of travel in the United States, motor vehicles are becoming a preferred means of transportation both in other industrialized countries and in the developing world. In Western Europe, despite its extensive and well-traveled transit and rail networks, automobiles account for more than 86 percent of passenger-kilometers traveled (ECMT 1998).

In 1996, more than 671 million vehicles were registered in the world, up from 411 million in 1980. Although the United States has the most vehicles by far, well over 200 million, its share of the world total declined from 44 percent in 1970 to 31 percent in 1995 (AAMA 1994; 1998). As figure 4-6 shows, in 1960 there were 100 million passenger cars registered in the world; by 1995, there were 480 million. Proportionally, the growth in commercial vehicles was even greater, growing from 30 million in 1960 to 170 million in 1995.

World Motor Vehicle Fatalities

Data on the number of fatalities and injuries involving motor vehicle crashes worldwide are limited. Britain's Transport and Road Research Laboratory (TRRL) estimates that 300,000 persons die and 10 million to 15 million persons are injured each year in road crashes around the world (TRRL 1991). Other estimates are higher. One estimate, cited by the International Federation of Red Cross and Red Crescent Societies, is that 500,000 people died in traffic crashes in 1990, and 15 million were injured worldwide (IFRC 1998, 20). According to the World Health Organization (WHO), road traffic accidents in 1998 were the largest cause of ill

Figure 4-6
World Motor Vehicle Registration Trends: 1960–95



SOURCES: American Automobile Manufacturers Association, *World Motor Vehicle Data* (Washington, DC: 1994).

_______. *Motor Vehicle Facts & Figures, 1998* (Washington, DC: 1998).

health or early death for males between the ages of 15 and 44 worldwide, and the second largest cause in developing countries. WHO warned that the burden from traffic accidents would likely increase, especially in developing countries (WHO 1999, 17–18).

Although some countries have made great strides in recent years to reduce vehicle-related deaths and injuries, in others, the number of vehicles is growing far faster than the physical, legal, and institutional infrastructure needed to safely accommodate them. Table 4-7 shows the number of motor vehicle fatalities in selected countries in 1980 and 1996. Most of the countries cited in the table had fewer fatalities in 1996 than 16 years earlier. Many of these countries improved motor vehicle safety through better road design, planning, and operations. Conversely, countries with a greater number of deaths in 1996 are generally those in which vehicle use has risen both quickly and relatively recently.

Table 4-7
Motor Vehicle Fatalities in Selected Countries: 1980 and 1996
(Thousands)

Country	1980	1996
Australia	3.27	1.97
Austria	2.00	1.03
Belgium	2.40	1.36
Denmark	0.69	0.51
Egypt	N	[a]4.40
Finland	0.55	0.40
France	13.67	8.54
Hong Kong	0.46	0.26
Hungary	1.63	1.11
Iceland	0.03	0.01
Ireland	0.56	0.45
Israel	0.40	0.52
Japan	11.39	11.67
Kenya	N	[b]2.67
Korea, Republic of	6.45	10.09
Morocco	[c]3.52	2.81
Netherlands	1.97	1.18
New Zealand	0.60	0.58
Norway	0.36	0.26
Oman	[c]0.47	0.51
Portugal	2.94	2.08
Senegal[d]	0.47	0.79
Spain	6.52	5.48
Sri Lanka	0.63	[e]1.92
Sweden	0.85	0.57
Switzerland	1.21	0.62
Taiwan	[c]2.72	2.99
Turkey	[c]6.19	5.43
United Kingdom	6.24	3.74
United States	51.10	42.07

[a] Data are for 1994.
[b] Data are for 1992.
[c] Data are for 1982.
[d] Data are for 1992 and 1995.
[e] Data are for 1995.

KEY: N = data are nonexistent; OECD = Organization for Economic Cooperation and Development.

NOTE: Not all countries adhere to the rule that counts deaths occurring within 30 days of an event; data for the United States and OECD countries are harmonized.

SOURCES:
International Road Federation, *World Road Statistics* (Geneva, Switzerland: 1998).
National Safety Council, *International Accident Facts* (Itasca, IL: 1995).
Organization for Economic Cooperation and Development, International Road Traffic and Accident Database, 1998, available at www.bast.de/irtad.
U.S.Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1997* (Washington, DC: 1998).

Safety Issues in Developing Countries

While road safety in most industrialized countries is improving, for many newly developed or developing nations safety problems are worsening. For example, between 1968 and 1985, the number of motor vehicle fatalities in some African countries rose by more than 300 percent and in Asian countries by over 170 percent. In that same period, the number of motor vehicle fatalities in industrialized countries decreased by 25 percent (TRRL 1991).

According to Britain's TRRL, growth in motorization and urbanization in emerging and developing nations has increased traffic on roads that were never designed to carry the volumes that they do today. Moreover, unplanned growth has led to incompatible land use in sprawling urban areas and created significant driving hazards. In many countries, poor road conditions, badly designed intersections, and inadequate protection have exacerbated these dangers for pedestrians (TRRL 1991).

TRRL identifies at least four conditions contributing to road safety problems in developing countries:

- *Inadequate design standards.* In many developing countries, highway design standards are either outdated (sometimes going back to colonial times) or inappropriate (usually because standards in industrialized countries are applied without considering local needs). Such standards may ignore pedestrians or other nonmotorized transportation or may be too costly for countries to afford.
- *Limited resources.* Developing nations often lack the engineers and other professionals, as well as the financial resources, needed to modify design standards to accommodate local conditions or to properly maintain roads and other infrastructure.
- *Operational and control deficiencies.* Operational practices have not kept pace with road building in the developing world. For example, roads are often poorly maintained, traffic signage may be inadequate, walkways for pedestrians are often nonexistent or in poor condition, and control measures to channel vehicles are rarely available (TRRL 1991, 4).
- *Inadequate driver training.* Drivers in developing countries typically lack the experience of their counterparts in the industrialized world. Many such drivers have never been adequately tested or trained. Moreover, enforcement of traffic laws in developing countries is often ineffective and driver compliance poor.

Safety improvements implemented in the industrialized world have the potential to significantly reduce road hazards in less developed nations. According to TRRL, among the most successful strategies are more safety-conscious road planning and elimination of hazardous locations on roadways through traffic engineering.

DATA NEEDS

While a great deal is known about transportation accidents and incidents and the resulting fatalities, injuries, and property damage, there is much that is not known. This section briefly describes areas where the data available at present are insufficient.

Safety data are, broadly speaking, of two types: outcome data, such as numbers of accidents, fatalities, and injuries; and exposure data, typically expressed as vehicle-miles, passenger-miles, or aircraft departures. The latter are traditionally harder to collect. The following is a list of major exposure data needs:

- exposure measures for the commercial waterborne mode and for pipelines;
- a better exposure measure for recreational boating and better estimates of the number of registered boats;
- data separated by air taxi and general aviation exposures (number of landings), as these data are available only in a combined form since 1994;
- because the common exposure measure for the highway mode, vehicle-miles traveled (vmt), is derived from a sample, error bars on vmt would be very useful in interpreting fatality and crash rates; and
- measures of exposure of specific populations (e.g., elderly drivers or children) and exposure to specific conditions (e.g., adverse weather) are not available, particularly for the highway mode.

Some outcome data are also either not available, or available in combination with fatalities, injuries, and incidents, which are not strictly transportation-related. Some of these data needs are:

- transit and rail fatalities presented in a clear, easy-to-understand format, distinguishing occupants from nonoccupants, and transportation incidents (e.g., collisions and derailments) from nontransportation incidents (e.g., homicides).

- property damage from highway crashes.

REFERENCES

American Automobile Manufacturers Association (AAMA). 1994. *World Motor Vehicle Data.* Washington, DC.

_____. 1998. *Motor Vehicle Facts & Figures, 1998.* Washington, DC.

Aultman-Hall, L. and F.L. Hall. 1998. Ottawa-Carleton Commuter Cyclist On- and Off-Road Incident Rates. *Accident Analysis and Prevention* 30, no. 1:29–43.

European Conference of Ministers of Transport (ECMT). 1998. *Trends in the Transport Sector 1970–1996.* Paris, France: OECD Publications Service.

Hunter, W.W., J.C. Stutts, and W.E. Pein. 1997. *Bicycle Crash Types: A 1990's Informational Guide,* FHWA-RD-96-104. Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

Hunter, W.W., J.C. Stutts, W.E. Pein, and C.L. Cox. 1996. *Pedestrian and Bicycle Crash Types of the Early 1990s.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

International Federation of Red Cross and Red Crescent Societies (IFRC). 1998. *World Disasters Report 1998.* Geneva, Switzerland.

Joksch, H. 1998. Fatality Risks in Collisions Between Cars and Light Trucks, DOT/HS-808-802, prepared for the U.S. Department of Transportation, National Highway Traffic Safety Administration. University of Michigan Transportation Research Institute. October.

National Association of State Directors of Pupil Transportation Services (NASDPTS). n.d. Passenger Vans Used as School Buses, position paper. Available at www.stnonline.com/core2_files/bbs/nasdpts/sd_pp1.htm.

National School Transportation Association (NSTA). 1999. NSTA Transportation Survey. Available at www.stnonline.com/core2_files/statistics/vans11ormore.htm.

National Transportation Safety Board (NTSB). 1987. *Crashworthiness of Large Poststandard School Buses,* Report No. NTSB/SS-87/01. Available at www.stnonline.com/core2_files/bbs/ntsb/largebusstudy.htm.

_____. 1997. *Highway Accident/Incident Summary Report: Collision with a Pedestrian by a Utility Truck Near Cosmopolis, Washington, November 26, 1996,* Report No. NTSB/HAR-97/01/SUM. Washington, DC.

Pickrell, D. and P. Schimek. 1997. *Trends in Personal Motor Vehicle Ownership and Use: Evidence from the Nationwide Personal Transportation Survey.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration. Also available at www-cta.ornl.gov/npts/1995/Doc/publications.shtml.

Rivara, F.P., D.C. Thompson, and R.S. Thompson. 1996. *Circumstances and Severity of Bicycle Injuries.* Seattle, WA: Snell Memorial Foundation, Harborview Injury Prevention and Research Center.

Tinsworth, D., C. Polen, and S. Cassidy. 1993. *Bicycle-Related Injuries: Injury, Hazard, and Risk Patterns,* Technical Report. Washington, DC: U.S. Consumer Product Safety Commission.

Transportation Research Board (TRB), National Research Council. 1989. *Improving School Bus Safety,* Special Report 222. Washington, DC.

Transport and Road Research Laboratory (TRRL), Overseas Development Administration. 1991. *Towards Safer Roads in Developing Countries: A Guide for Planners and Engineers.* United Kingdom: Ross Silcock Partnership.

U.S. Department of State (USDOS). 1999. *Patterns of Global Terrorism: 1998*, Publication 10610. Washington, DC. April.

U.S. Department of Transportation (USDOT). 1998. *White House Commission on Aviation Safety and Security: The DOT Status Report*. Available at www.dot.gov/affairs/whcoasas.htm, as of 7 June 1999.

U.S. Department of Transportation (USDOT), Federal Aviation Administration (FAA). 1997. Criminal Acts Against Civil Aviation. Available at http://cas.faa.gov/cas/crim97.htm.

U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). 1997. Fatality Analysis Reporting System. Available at www.fars.nhtsa.dot.gov.

_____. 1998a. School Bus Safety: Safe Passage for America's Children. Available at www.nhtsa.dot.gov/people/injury/buses/schbus/schbussafe.html.

_____. 1998b. Traffic Safety Facts 1997. Available at www.nhtsa.dot.gov/people/ncsa/TSF97.html.

____.1998c. Traffic Safety Facts 1997: Large Trucks. Available at www.nhtsa.dot.gov/people/ncsa/Truck97.html.

_____. 1998d. Traffic Safety Facts 1997: Pedalcyclists. Available at www.nhtsa. dot.gov/people/ncsa/PedCycle97.html.

_____. 1998e. Traffic Safety Facts 1997: Pedestrians. Available at www.nhtsa.dot.gov/people/ncsa/Ped97.html.

_____. 1998f. Traffic Safety Facts 1997: School Buses. Available at www.nhtsa.dot.gov/people/ncsa/factshet.html.

____. 1999. Traffic Safety Facts: Overview 1998. Available at www.nhtsa.dot.gov/people/ncsa/factsheet.html

U.S. Executive Office of the President (USEOP). 1997. *Final Report of the White House Commission on Aviation Safety and Security.* Washington, DC. February.

____. 1998a. *Presidential Decision Directive 63: Combating Terrorism*, Fact Sheet. Washington, DC. May.

____. 1998b. *Presidential Decision Directive 62: Protecting America's Critical Infrastructure*, Fact Sheet. Washington, DC. May.

Wachtel, A. and D. Lewiston. 1994. Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections. *ITE Journal.* September.

World Health Organization (WHO). 1999. *World Health Report 1999.* Geneva, Switzerland.

Transportation, Energy, and the Environment

Without energy, vehicles and other forms of transportation cannot move. The U.S. transportation sector requires great quantities of energy, about a quarter of the national total. Petroleum supplies about 97 percent of the energy used in transportation in the form of gasoline, diesel fuel, or other light oils (USDOE 1998b). For more than a century, no other fuel has been able to compete successfully with petroleum for motorized transportation. Were it not for its environmental impacts, petroleum's portability (light weight and high energy content) and ease of control make it a nearly ideal transportation fuel. The only other significant sources are natural gas, used to drive compressors on pipelines, electricity for rails and subways, and alcohol for blending into gasoline.

Energy supply is not a problem at this time. Petroleum production capability worldwide is so much greater than demand that prices in 1998 reached virtually all-time lows (in real terms). Resource constraints that could lead to rising prices are thought to be at least a decade away, and possibly much further. Even U.S. production, which had been in a seemingly inexorable decline since 1970, has almost leveled out, despite low prices. The supply system works so effectively that even local disruptions are rare except for occasional weather problems or natural disasters.

Nevertheless, serious energy and environmental issues are associated with transportation. The current abundance of petroleum cannot be assured in the future. Over half the petroleum used in the United States must now be imported. Most U.S. imports are from suppliers who have been reliable, but political instability in any of the major producer regions could disrupt world supplies, leading to steep price increases, as has occurred several times since the early 1970s. Economic damage could be serious. The Strategic Petroleum Reserve was established to provide additional supplies when imports are disrupted, but, as discussed below, its ability to do so is diminishing. The transportation sector uses over 65 percent of all the petroleum consumed in this country (up from 60 percent in 1975) (USDOE 1998b). The lack of significant alternatives leaves transportation particularly vulnerable should a disruption occur in the supply system.

Furthermore, heavy dependence on petroleum is the root of most environmental problems caused by transportation. Despite major improvements in emission rates over the last two decades, transportation continues to be the primary source of pollutants that affect air quality: carbon monoxide, nitrogen oxides, and volatile organic compounds. Fuel consumption by mobile sources also results in a large percentage of the key hazardous air pollutants released in urban and rural areas of the nation. Moreover, the transportation sector contributes to other environmental impacts such as oil spills and hazardous waste. Upcoming federal efforts to reduce these impacts will influence technology and operational changes across the sector.

In addition, the carbon dioxide (CO_2) created by combustion of petroleum in the transportation sector is responsible for about 26 percent of all greenhouse gases emitted in the United States, which in turn accounts for about one-quarter of all anthropogenic emissions of greenhouse gases in the world (USDOE 1998e). Mounting evidence shows that global climate change is potentially a very serious problem. If efforts to control greenhouse gas emissions are undertaken, overall costs will be minimized if the lowest cost options are implemented. Each economic sector, including transportation, has potential low-cost reductions.

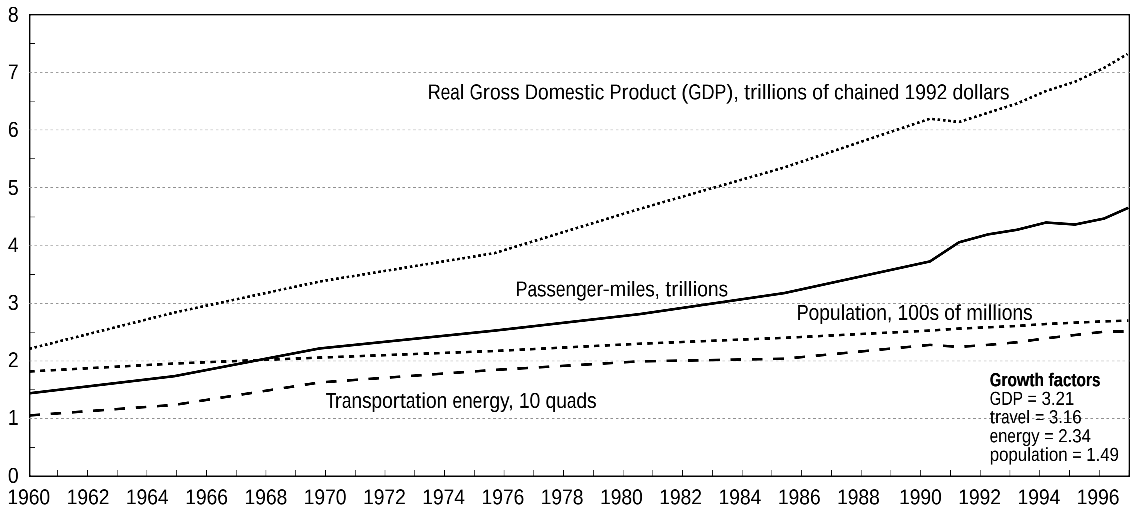
This chapter describes the current status of energy and environmental issues. It also reviews various technologies that could alleviate the problems.

ENERGY[1]

As the economy has grown, so has transportation and the use of energy. There are, however, marked differences in the growth rates, as shown in figure 5-1. Energy use in the transportation sector has grown by a factor of about 2.34 since 1960, less than passenger-miles, despite the increased size of cars and engines now. Improved vehicular efficiency is largely responsible for this difference, as discussed in the next section. Figure 5-2 shows energy consumption by mode for 1997. Total energy for transportation was 24.8 quadrillion (quads) British thermal units (Btu). Highway vehicles account for about 80 percent of total transportation energy use and 84 percent of transportation petroleum consumption (USDOE 1998b and USDOT BTS Forthcoming).

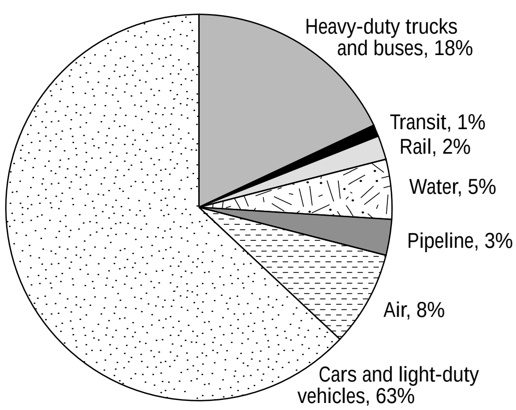
[1] Energy Information Administration (EIA) data are used throughout this chapter. EIA relies on surveys to collect its energy data and models to forecast energy supply and demand. For information about survey methodology and statistical reliability, the reader is referred to EIA references cited in this chapter or the EIA website at www.eia.doe.gov. For information about EIA's modeling standards, please see www.eia.doe.gov/oss/standard.html.

Figure 5-1
Transportation Energy and Economic Activity: 1960–97



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming); U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, December 1998.

Figure 5-2
Transportation Energy Use by Mode: 1997



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming).

Vehicle Economy

Automobiles and other vehicles are far more efficient today than at the start of the energy crisis in 1973, and improvements are still being implemented. Manufacturers have reduced vehicle weight, improved the rolling resistance of tires, and added lockup torque conversion to transmissions to eliminate slippage at highway speeds. Engines have been improved by switching from carburetors to fuel injection, improving combustion control, and adding valves to improve engine breathing. Trucks as well as cars have benefited from these improvements, but heavier frames and poorer aerodynamics mean that trucks are necessarily less efficient.

Since 1988, however, essentially all the gain in new motor vehicle efficiency has been offset by increases in weight and power within classes, and by consumer shifts to lower economy vehicles, especially light-duty trucks (sport utility vehicles, minivans, and pickup trucks). The sales-weighted average weight of new cars rose from 2,805 pounds in 1988 to 3,071 pounds in 1997 (average weight was 3,349 pounds at the start of fuel economy standards in 1978). Also, engines gained about 35 horsepower during this period (USDOT NHTSA 1998).

Figure 5-3 shows the trends in fuel consumption for highway vehicles. It is clear from the figure that fuel mileage has leveled off, mirroring the leveling off of new car mileage. Average fuel economy for the new passenger car fleet has been in the range of 27.9 to 28.8 miles per gallon (mpg) since 1988 and is now slightly below the peak. The Corporate Average Fuel Economy (CAFE) standard has been constant at 27.5 mpg since 1990 (USDOT NHTSA 1998).

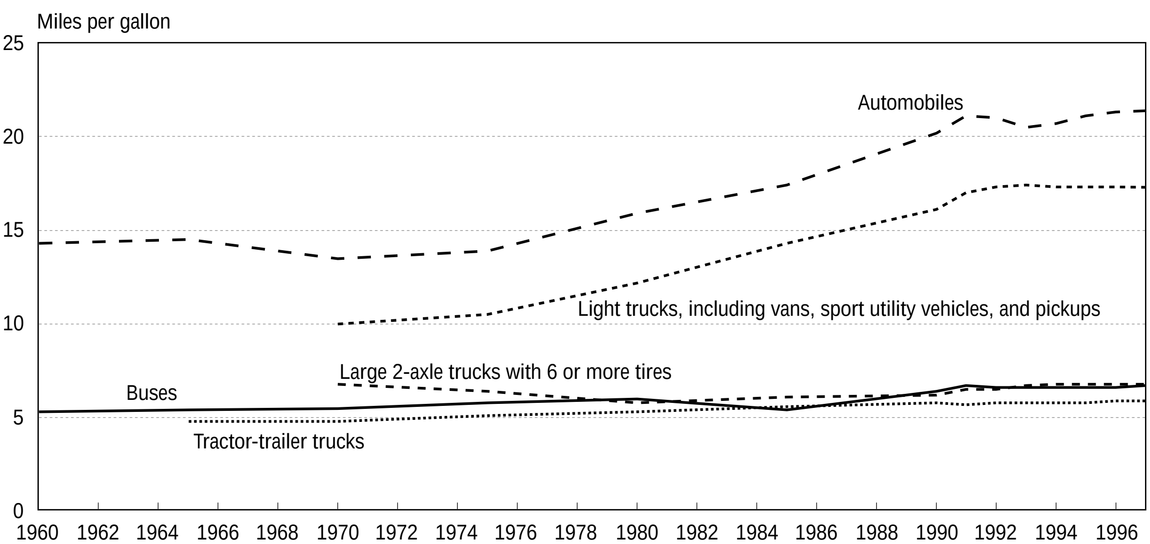
On average, foreign and domestic cars meet the CAFE standard, but Ford Motor Company and several high-end imported cars were below it in model year 1997. All domestic light trucks and several imported ones are below CAFE standards (20.7 mpg) and have been for several years (USDOT NHTSA 1998).

Manufacturers are liable for civil penalties for noncompliance with the standard unless they have accumulated credits from the previous three years for exceeding the standard. They may also borrow ahead if they can demonstrate expected future performance above the standard. Penalties are assessed at $5.50 for each tenth of an mpg multiplied by the number of cars sold by the manufacturer. Thus, a company selling a million cars averaging 26.5 mpg (one mpg below the standard) could be penalized $55 million if the company had no credits accumulated and/or borrowing rights (USDOT NHTSA 1998).

Manufacturers who meet the standard and expect to continue to do so have little regulatory incentive to further raise mileage. The only exception is for those who have to heavily promote their smaller cars to stay above the standard. In those cases, raising their average fuel economy would permit them to sell more heavy, powerful cars, which are generally more profitable.

Light-duty trucks have become quite popular in recent years. Sales of minivans grew rapidly in the 1980s and early 1990s but have declined slightly since 1994. Sales of sport utility vehicles have continued growing, and they are now the fourth most popular vehicle class. More cars than

Figure 5-3
Highway Vehicle Average Fuel Consumption: 1960–97



NOTE: This figure shows the results for the entire fleet of operating vehicles, not just new ones, and is derived from estimates of vehicle travel and total fuel consumed.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: Forthcoming).

trucks are sold in this country, but the difference is narrowing. In 1988, 10,370,000 cars and 4,740,000 light trucks were sold; in 1997, there were 8,260,000 cars and 6,530,000 trucks sold. Figure 5-4 shows sales of light vehicles by class (excluding classes of less than 100,000 sales). Sales of most light truck classes gained, while most automobile classes declined (Davis 1998).

Some of this trend may be short-term in duration, but, clearly, many buyers are finding what they want in light trucks rather than cars: interior spaciousness, carrying capacity, visibility, and a perception of safety (at least for themselves if not for occupants of other cars in a collision.) However, the trend does have implications for energy consumption because light trucks average about 5 mpg less than cars. Figure 5-5 shows the sales-weighted CAFE rating for the same classes of light vehicles, divided into those that increased sales and those that lost sales from 1990 to 1997. Only midsize cars gained in sales, and that was very slight. The biggest sales loser among trucks was the one with the highest mileage, small pickups. Overall, figure 5-5 shows a marked shift from high mileage to lower mileage vehicles.

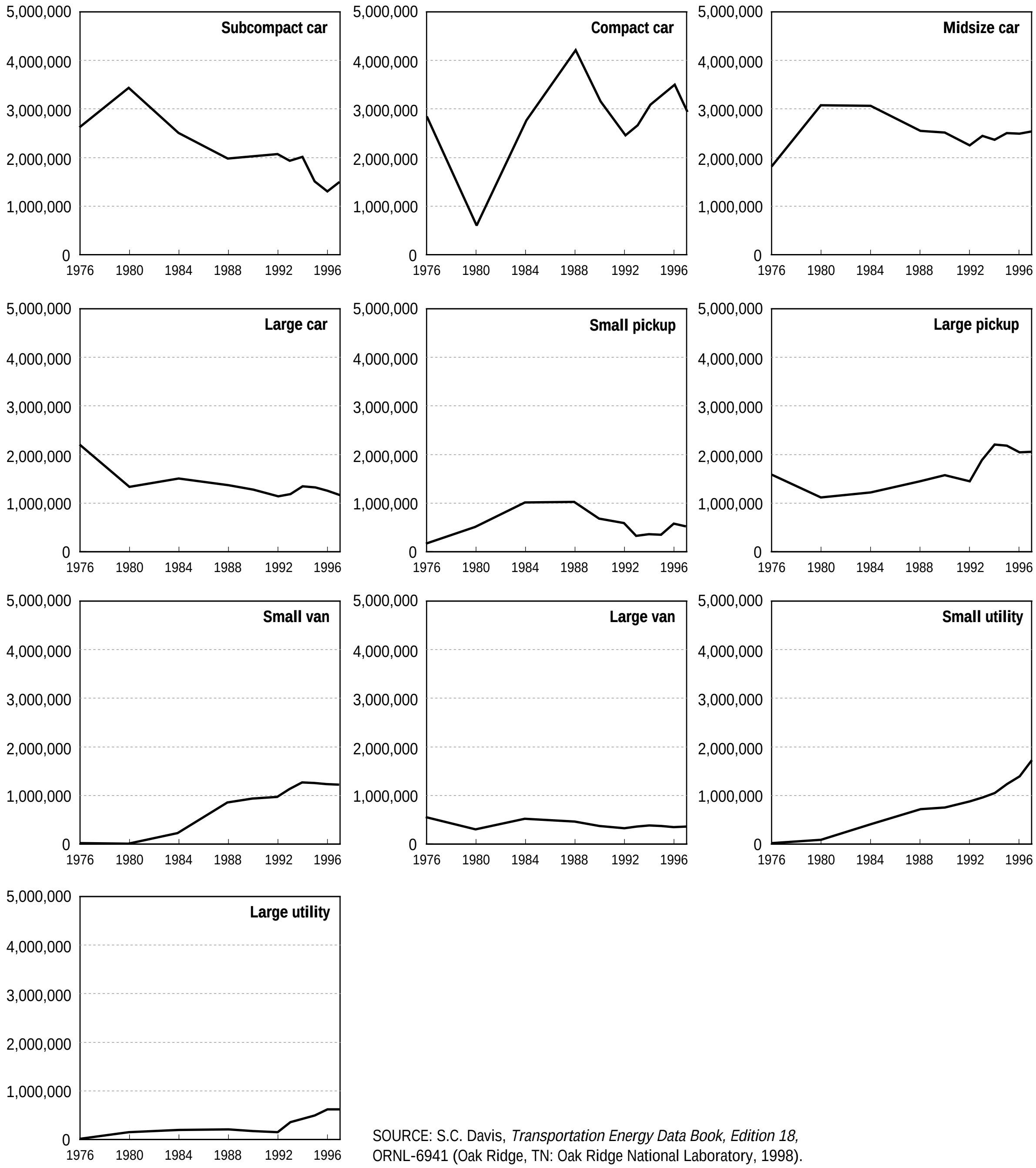
A variety of technologies for further raising efficiency are available or are emerging from the laboratory. Improving aerodynamics to reduce drag is one of the most important in the near term. Internal engine improvements such as variable valve timing and lower rolling resistance tires can also be important. In the longer term, transmissions may have improved electronic controls to select the gear that will allow the engine to operate most efficiently for the given load. A continuously variable transmission would be even better, allowing the engine to operate at peak efficiency at all times. These improvements, and more radical technologies such as the diesel hybrid engine or fuel cells, could be introduced by automobile manufacturers if they saw sufficient demand or were induced by regulations.

Absent higher fuel prices or tightened regulations, however, these advances will be implemented slowly at best. Most manufacturers meet the current standards, and consumers are not demanding greatly increased economy. Therefore, petroleum consumption is likely to continue to increase in the transportation sector.

Energy consumption per passenger-mile (energy intensity) for some other means of travel differs surprisingly little from automobiles. However, intermodal comparisons should be considered approximations. Data for the different modes are collected in a variety of ways and are based on different assumptions. For example, airlines record passenger-miles, but data on occupancy of private automobiles are estimated from surveys. Even relatively hard data, such as state sales of gasoline, must be modified to resolve anomalies, and transit data, which cover light and heavy rail, are more difficult to reconcile.

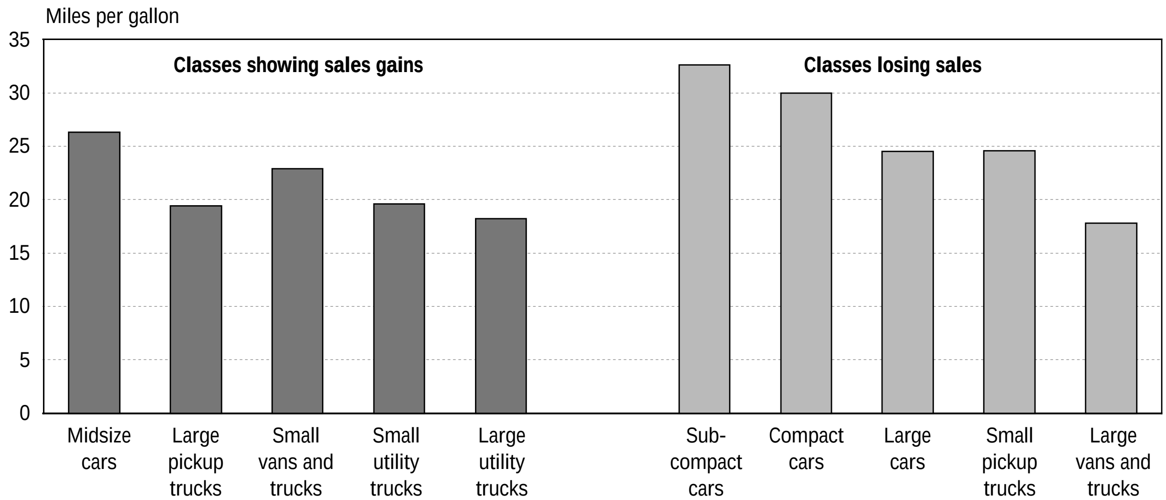
With these caveats in mind, in 1996 passenger car energy intensity was about 3,700 Btu per passenger-mile, down slightly from 3,900 in 1990 and 4,200 in 1980. (Even though new vehicle fuel economy has leveled off, the entire fleet is still more efficient today than years ago, which indicates why energy intensity has declined somewhat.) Light-truck energy intensity was 4,529 Btu per passenger-mile in 1996, down from 4,859 in 1990 and 5,384 in 1980 (assuming the same occupancy rates as automobiles). Air carrier energy intensity was 4,100 Btu per passenger-mile in 1996 (versus 4,800 in 1990 and 5,800 in 1980) (Davis 1998). The decline in energy intensity of air travel is due largely to higher occupancy. Flying a full plane requires considerably less than twice the fuel of a half-full one, but yields twice the passenger-miles. Airlines have been increasingly successful in filling their planes. Some have even reconfigured seating to

Figure 5-4
U.S. Sales of Domestic and Foreign Light-Duty Vehicles by Class



SOURCE: S.C. Davis, *Transportation Energy Data Book, Edition 18,* ORNL-6941 (Oak Ridge, TN: Oak Ridge National Laboratory, 1998).

Figure 5-5
Fuel Economy of Light Vehicles by Class and Sales Change: 1990–97



SOURCE: S.C. Davis, *Transportation Energy Data Book, Edition 18,* ORNL-6941 (Oak Ridge, TN: Oak Ridge National Laboratory, 1998).

fit in more passengers. Newer airplanes are more efficient, but that probably has less effect on energy intensity than the greater number of passengers sharing the fuel. If the economy declines, occupancy may drop and energy intensity rise (Davis 1998).

Energy intensity of Amtrak trains was about 2,400 Btu per passenger-mile in 1996, down from 2,600 in 1990 and 3,200 in 1980. By contrast, energy intensity of rail transit (commuter trains and subways) actually rose from 3,000 in 1980 to 3,500 in 1990. Intercity buses show the lowest energy intensity, about 1,000. Transit buses are higher, at about 4,500 Btu per passenger-mile, as might be expected from their stop-and-go duty cycles (but transit bus data are particularly weak since passenger-miles are not automatically recorded with ticket sales) (Davis 1998).

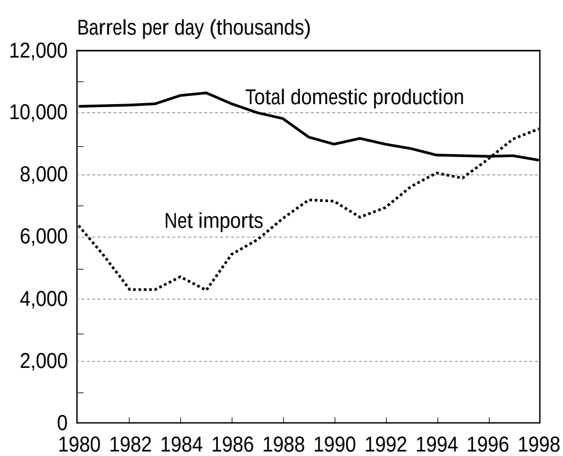
National Security Issues

Energy became a national security issue when imports of petroleum grew to a significant fraction of total consumption during the energy crises of the 1970s. Petroleum shortages can cause considerable economic damage and great inconvenience to many people. Future price and availability of oil are key uncertainties. Transportation is the sector most responsible for oil demand. It is also the sector most vulnerable to oil disruptions and price increases. In addition, the price of oil has a great impact on oil exporting countries, many of which are important allies of the United States.

For the most part, the current low prices are economically beneficial, but they encourage consumption, which generally means more imports. The oil import dependence issue was explored in *Transportation Statistics Annual Report 1998* (TSAR98) (USDOT BTS 1998b). The points made there, such as the potential future dominance of the Organization of Petroleum Exporting Countries (OPEC), potential price increases and their impact on the economy, and the inelasticity of the transportation sector's demand for oil, are still valid although some of the concerns seem far in the future. Moreover, some threats are difficult to foresee. Political problems can arise even with countries with which the United States currently has stable relations. For example, Venezuela is the largest supplier of oil to the United States, with 17 percent of all imports. The recently elected President of Venezuela has expressed concern over its high level of exports, especially when the price is so low. Persian Gulf nations supply another 18 percent of imports, and all members of OPEC supply 45 percent (USDOE 1998b).

The volume of imported oil and petroleum products surpassed that of U.S. production in 1997, as shown in figure 5-6. In terms of energy value, imported petroleum exceeded domestic production in 1994, and has taken an increased share every year since. In 1997, the United States produced 16.2 quadrillion Btu (quads) of petroleum, including crude oil, natural gas plant, and other liquids. Net imports of crude oil and petroleum products totaled 19.6 quads (USDOE 1999). The transportation sector required 24 quads of petroleum, equivalent to all U.S. production plus 40 percent of all imports (USDOE 1998b).

Figure 5-6
Petroleum Production and Imports: 1980–98



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review* (Washington, DC: January 1999), tables 3.1a and b.

Never before in U.S. history, even at the height of concern over energy in the 1970s, have imports of petroleum exceeded production. U.S production may stay level for a period or even increase slightly, but growth in demand basically means growth in imports. When world oil supplies tighten, the United States could be more vulnerable to disruptions than ever before.

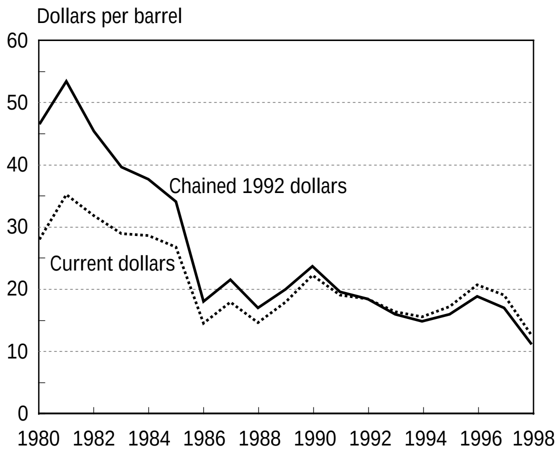
The Strategic Petroleum Reserve was created in 1977 to help the country ride out disruptions. The size of the storage has stayed roughly constant since 1988, but imports have risen significantly. Therefore, the protection provided has dropped steadily. In 1977, it held 563 million barrels, equivalent to 63 days of imports. The peak, in 1985, was 115 days (USDOE 1998b).

It is very unlikely that a high fraction of U.S. imports would be disrupted, but the Reserve is intended to protect against price shocks as well as physical shortages. The transportation sector, with its relatively inelastic demand, would not be able to quickly reduce consumption by more than a few percent without seriously inconveniencing many people. If just 20 percent of imports had to be replaced, the Reserve would last about 10.5 months at current levels. While that is more than supplied by any one country, petroleum exporting countries could well use any sizable disruption in world supplies to further restrict exports and raise prices.

The situation now is the exact opposite of this potential problem. Asian economic difficulties have reduced world oil demand appreciably, lowering prices and causing serious problems for oil producers. The Russian economy has been particularly hurt by the drop in revenues because oil is by far its most important export.

Oil prices are unlikely to rise very much until Asian economies improve. Figure 5-7 shows past oil price trends. Prior to the economic crises, oil

Figure 5-7
World Oil Price: 1980–98



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Review of Energy 1998,* DOE/EIA-0384(98) (Washington, DC: July 1999), table 5.19.

demand for 10 East Asian countries (Indonesia, South Korea, Thailand, Malaysia, Philippines, Singapore, Taiwan, Japan, China, and India) had been growing at 5.6 percent per year, the fastest growth of any large region of the world. In 1998, East Asian oil demand was essentially unchanged, and world oil demand growth from 1997 to 1998 was about 300,000 barrels per day. This is 25 percent lower than the 1.2 million barrels per day that the Energy Information Administration (EIA) had forecast before the crisis, even with low prices encouraging consumption in other importing countries (USDOE 1998c).

It is unclear how quickly the East Asian economies will recover. Quite likely the recovery schedule will be different for the various countries, particularly since Japan's problems are different from the others. Japan is taking some important steps to stabilize its banks and restore economic growth, but some analysts are skeptical that its efforts will be adequate. Other Asian countries are showing signs of a turnaround, but it is too soon to tell if a recovery is underway. Asian problems could contribute to soft oil prices for several years. Recently, EIA lowered its projected price of oil by about $5 per barrel for the next several years (USDOE 1998c).

Alternative Fuels

Petroleum provides about 97 percent of all transportation energy as shown in table 5-1. In 1992, it provided about 98 percent. The use of alternative and replacement fuels doubled from 1992 to 1998 while the use of gasoline rose only 10 percent, but that 10 percent increase (11.3 billion gallons) was more than twice as large as the entire use of alternative fuels (about 4.3 billion gallons) in 1998 (USDOE 1998a).

Nevertheless, there is considerable interest in alternative fuels for two reasons—reducing air emissions and oil dependence. TSAR98 discussed the use of blending alternatives such as ethyl alcohol (ethanol) and methyl-tertiary-butyl-ether (MTBE) with gasoline to reduce emissions. MTBE and ethanol, which is mixed with gasoline to form gasohol, are oxygenates, which improve the combustion of gasoline. They are called replacement fuels because they directly replace some gasoline out of each gallon that consumers buy. This application accounts for most of the nonpetroleum fuel used. Replacement fuels also slightly reduce carbon emissions and oil consumption, as discussed elsewhere in this chapter, but the main incentive for using them is to reduce local air pollution.

In theory, alternative fuels have far greater potential than replacement fuels to reduce oil consumption, because they can replace all or almost all the petroleum-based fuel that a vehicle uses, rather than the few percent that oxygenates replace. There are a variety of options for alternative fuels. Of the 418,000 alternative-fueled vehicles (AFVs) operating in 1998, 274,000 (about two-thirds) used liquefied petroleum gas (LPG), primarily propane (USDOE 1998a). LPG

Table 5-1
Alternative Transportation Fuels
(Million gasoline-equivalent gallons per year)

	1992	1994	1996	1998[P]
Alternative fuels				
Liquified petroleum gas	208	249	239	253
Compressed natural gas	17	24	47	77
Liquefied natural gas	1	2	3	6
Methanol	4	6	2	3
Ethanol	—	—	3	2
Electricity	—	—	1	1
Total	**230**	**281**	**296**	**335**
Replacement fuels/oxygenates				
MTBE[a]	1,175	2,019	2,750	3,081
Ethanol in gasohol	701	846	660	857
Traditional fuels				
Gasoline[b]	110,135	113,144	117,783	121,465
Diesel	23,866	27,293	30,101	32,461
Total	**134,001**	**140,437**	**147,884**	**153,926**
Total fuel consumption[c]	**134,231**	**140,719**	**148,180**	**154,260**

[a] Includes a very small amount of other ethers, primarily tertiary-amyl-methyl-ether and ethyl-tertiary-butyl-ether.
[b] Gasoline consumption includes ethanol in gasohol and MTBE.
[c] Total fuel consumption is the sum of alternative fuels and traditional fuels. Oxygenate consumption is included in gasoline consumption.

KEY: MTBE = methyl-tertiary-buytl-ether; P = preliminary.

NOTE: Totals may not equal sum due to rounding.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1997* (Washington, DC: 1998).

has been popular because it is widely available, relatively inexpensive, about as portable as gasoline, and engines can be easily converted to burn it. While LPG burns more cleanly than gasoline or diesel, it is a petroleum-based fuel and thus offers little advantage for reducing petroleum dependence or carbon emissions.

The next most popular alternative fuel is natural gas; in 1998, 96,000 vehicles used compressed natural gas and another 1,500 used liquefied natural gas (USDOE 1998a). As with LPG, natural gas is widely available and engines can be converted easily to burn it very cleanly. However, storage is not as straightforward as for LPG or gasoline. Natural gas must be either compressed to very high pressures or cooled to very low temperatures to liquefy it. Then it must be stored that way in the vehicle until it is used. One or the other approach is necessary to reduce the volume sufficiently for the vehicle to carry enough fuel for a reasonable range. Both approaches entail elaborate and expensive vehicle fuel tanks and major changes to the fuel supply infrastructure. Natural gas vehicles directly reduce consumption of petroleum and greatly reduce emissions of urban air pollutants. They reduce emissions of carbon by at least 25 percent and more if the engine is modified to take advantage of the high octane value of natural gas.

AFVs that use ethanol or methyl alcohol (methanol) also are being tested. About 22,000 vehicles burn a mixture of 85 percent methanol and 15 percent gasoline. A few hundred more burn pure methanol, but these vehicles can be difficult to start, especially in cold weather. Another 18,000 burn ethanol, usually with 15 percent gasoline (USDOE 1998a).

Some vehicles are designed as flexible-fuel vehicles, capable of burning either alcohol or gasoline. Alcohol-fueled vehicles still use the basic automobile engine but require substantial modification to it. They will require radical changes to the fuel supply system if many of them are to operate. Methanol usually is produced from natural gas but is much more portable. Thus, it solves the storage problem for natural gas but entails much more difficult production and distribution problems. Ethanol usually is made from grain using an energy-intensive process. Currently, ethanol does not offer major petroleum-reduction or carbon dioxide-reduction advantages because fossil fuels are typically used to produce ethanol. Moreover, CO_2 is produced in the fermentation process.

Advanced technologies, however, could allow alcohol to be produced much less expensively from renewable, nonfood sources such as wood and plant wastes. If successful, alcohol-fueled vehicles could contribute significantly to reduced petroleum dependence, local air pollution, and carbon dioxide emissions. Raising crops for the production of alcohol could slow the conversion of marginal farmland to forest, which would be good for farmers but might create some negative environmental impacts, depending on the crops raised and the land used. In fact, a farming resurgence could reduce the credit the United States is expected to receive for sequestration of carbon in trees, which is discussed below.

Yet another option is electric vehicles (EVs), the ultimate in flexible-fuel vehicles, because electricity used to charge the batteries can be produced from almost any energy source. These are considered to be the only zero-emissions vehicles (ZEVs) because they do not burn any fuel themselves. Some pollution may be produced while generating power to charge the batteries, but net pollution from EVs frequently will be lower than from conventional vehicles. If the power is generated from renewable energy or nuclear powerplants, air pollution is negligible.

There are still many uncertainties over the full environmental impact of the entire fuel cycle for both conventional and electric vehicles. The relative advantage of each will vary in different parts of the country. At present, batteries are the only means of storage, and they hold much less energy than the same volume of liquid fuels. As a result, EV performance is distinctly inferior to conventional vehicles. They have a range of about 100 miles on today's battery technology and require lengthy recharging periods. Emerging technology (e.g., nickel-metal hydride) promises to be much better than lead-acid batteries. Several manufacturers now are offering EVs with nickel-metal batteries. EVs can offer major advantages in carbon reduction and oil independence as well as reduced urban air pollution if the technological problems can be solved.

Only about 6,000 EVs are currently operating in the United States (USDOE 1998a). However, this number could rise rapidly. California and New York have aggressively promoted the use of EVs because of severe urban air pollution problems. Both states were to have required automobile manufacturers to introduce ZEVs in 1998, but both programs have been postponed. California has reached an agreement with manufacturers that 10 percent of the new vehicles sold in the state in 2003 will be ZEVs. Manufacturers hope that by then the technology, particularly batteries, will have improved to the point that EVs will be sufficiently attractive that people will want them. New York's intended requirement of 2 percent of all cars sold in the state in 1998 to be ZEVs was overturned by the

Circuit U.S. Court of Appeals in August 1998 on the grounds that it was preempted by the federal Clean Air Act (*EV World* 1998).

GREENHOUSE GASES

Controlling the emissions of greenhouse gases, which most scientists believe could cause global climate change with a potentially disastrous impact, is a contentious and complex issue for the international community. Nevertheless, international agreements to lessen the risk exist:

- In 1992, the United Nations Framework Convention on Climate Change, in Rio de Janeiro, established the principle that nations should take voluntary steps to reduce emissions.
- In 1997, parties to the Convention met in Kyoto, and agreed to a Protocol setting targets for individual industrialized countries.
- The 1998 meeting of the parties in Buenos Aires adopted a plan of action to resolve by 2000 the numerous uncertainties of the Kyoto Protocol.

The United States signed the Kyoto Protocol, but the Clinton Administration has stated that it will not submit the Protocol to the Senate for its advice and consent until there is meaningful participation by developing countries. Many in Congress have expressed opposition to the Protocol for several reasons. Some say redirecting our natural resources to meet this goal could reduce the economic growth rate and hurt the competitiveness of the United States relative to countries that are not affected (especially developing countries). Others believe that climate change has not been adequately shown to be a problem. Proponents of control argue that it is essential to take steps now to avoid likely environmental catastrophes in coming years; that it is incumbent on the United States, by far the biggest emitter of greenhouse gases, to take the lead; and that, if approached intelligently, reductions in greenhouse gases will not be prohibitively expensive, and could create business opportunities for companies and countries selling energy efficient technologies. These issues are beyond the scope of this report, which will discuss transportation's role in greenhouse gas emissions and how those emissions might be reduced.

Table 5-2 shows carbon emissions from energy consumption in transportation and other sectors. Transportation emissions grew 9.5 percent from 1990 to 1997, which was less than in the residential and commercial sectors but more than in industry. In absolute numbers, however, transportation emissions grew the most—about 41 million metric tons of carbon (mmtc) during this period. The transportation sector's carbon emissions in 1997 were 473 mmtc, or about 32 percent of all energy-related carbon emissions. Other greenhouse gases covered by the Kyoto Protocol include methane, nitrous oxide (N_2O), halocarbons, and several others. Collectively, these are equivalent to less than 300 mmtc. The transportation sector is responsible for about 20 percent of the N_2O, which is equivalent to about 17 mmtc. Mobile sources emitted only a trivial amount of methane, but a substantial amount came from refineries producing transportation fuels. That, however, is usually counted under

Table 5-2
Carbon Emissions by Sector
(Million metric tons of carbon)

	1990	1995	1996	1997
Transportation	432	459	471	473
Industrial	454	465	478	483
Residential	253	270	286	287
Commercial	207	218	226	237
Total	**1,346**	**1,412**	**1,461**	**1,480**

SOURCE: U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1997,* DOE/EIA 0673 (97) (Washington DC: October 1998).

the industry sector. Overall, these compounds are converted to carbon equivalents. In 1997, the transportation sector contributed about 26 percent of U.S. emissions covered by the Kyoto Protocol.

If the U.S. Congress consents to the Kyoto Protocol, the announced target for the United States will be 7 percent below the 1990 level for all greenhouse gases averaged over the 2008 to 2012 period. The actual reduction target, however, will be more difficult because of three factors that cannot yet be quantified.

First, the Kyoto Protocol accounts for net carbon sequestration in forests in meeting the target, but not in setting the target. Sequestration is substantial in the United States because of reforestation of former farmland. The Protocol also allows nations to purchase credits for reductions made in other countries. It is not yet clear how many credits can be purchased, but they could represent a substantial amount of the reduction required. Finally, the target is based on the collective impact of all greenhouse gases. Carbon dioxide is by far the most important, but other gases may be easier or more difficult to control, affecting the reduction that will be required from carbon. A realistic lower limit for the carbon target is the 1990 level, 1,346 mmtc, not 7 percent below it. Thus, emissions would have to be reduced 134 mmtc from the 1997 level of 1,480 mmtc (USDOE 1998f).

Of course, emissions will continue to climb if actions are not taken. A variety of projections have been made for the period 2008 to 2012. In October 1998, EIA released a report analyzing some of the economic consequences of implementing the Kyoto Protocol. This report projects that without government actions, carbon emissions from energy will rise to 1,791 mmtc by 2010. The transportation sector is responsible for 617 mmtc of that total. If emissions are held to the 1990 level in 2010, transportation's share of the 1990 level of emissions would be 550 mmtc. Thus, while total carbon emissions are reduced, those from the transportation sector would still grow from current levels, though at a reduced rate from the business-as-usual scenario (USDOE 1998f).

Each nation committed to the Kyoto Protocol determines how to meet its target and would have several implementation options (see, e.g., Heinz Center 1998). Each sector could be affected differently by the various options. It is possible, as in the EIA scenario, that U.S. transportation would not have to make any actual reduction from current levels of emissions, but if it does not at least limit growth of emissions, other sectors will have to make deeper reductions and implement more expensive options.

Carbon emissions from automobiles can be limited by: 1) improving efficiency, 2) a shift in consumer purchases to favor more efficient cars, 3) the use of nonfossil fuels, or 4) driving less.

In the transportation sector, reducing carbon emissions is almost the same as saving oil. Measures to raise vehicle efficiency, such as the Partnership for a New Generation of Vehicles, could produce substantial reductions, as discussed above. These measures could be applied to all classes of vehicles.

A consumer shift to more fuel-efficient vehicles would be a reversal of a long-term trend toward larger, more powerful cars and light trucks, including sport utility vehicles. As noted earlier, that trend has balanced improvements in efficiency, and average new vehicle fuel economy has remained essentially flat since 1988. Furthermore, that shift would have to be massive to make much difference.

Alternative fuels have been discussed above. Cars and conventional fuels incorporating alternative components are being developed by manufacturers largely to meet urban air pollution regulations. The impact AFVs could have on carbon emissions depends on the particular alternative fuel. Natural gas has some advantage, but not as much as fuel derived from renewable energy sources. Ethanol produced from conventional grain may have little advantage, but fuels made from cellulosic ethanol would be more advantageous. Emissions from electric vehicles depend on how the power is produced. If the electric sector switches much of its coal-fired generation to natural gas and increases its use of renewable sources, carbon emissions should be significantly lower than for conventionally fueled cars. In any case, an entirely new energy distribution system would need to be developed along with the vehicle technology.

Mass transit and carpooling are two ways to reduce driving without curtailing activities. Both are important in urban areas, but people would have to greatly increase their use of these options to make a large contribution to carbon emissions reduction. U.S. development patterns are diffuse, making it difficult for many people to permanently shift to mass transit or to carpooling. More compact development patterns could evolve or be encouraged, but would take many years to have much of an impact on people's transportation choices. Passenger-miles are likely to continue to climb, albeit perhaps at a slower rate if carbon emissions controls are initiated.

Emissions from the transportation sector will continue to grow unless new technology is introduced at an unusually rapid pace, or people make major changes in their buying patterns. All of the four options for achieving reductions discussed above are likely to play a role, but efficiency improvements will be the most important.

ENVIRONMENT [2]

As with most activities that contribute to the nation's economic growth, transportation has adverse impacts on the environment. This section begins by discussing pollution generated during the use of transportation vehicles, vessels, and aircraft. It then discusses transportation infrastructure (such as airports and highways) and the impacts from the manufacture of transportation equipment. Finally, the section examines impacts arising from vehicle maintenance and the disposal of the equipment and infrastructure when their useful life ends. At each of these phases in the life cycle of the transportation system, a range of impacts occurs. Such analysis provides a more complete appraisal of the system, but the available data are limited.

Pollutant emissions estimates generally are used as a surrogate for impacts in this section. For the vehicle use (or travel) phase, the Environmental Protection Agency's (EPA's) national estimates of emissions trends for six categories of air pollutants, called "criteria and related pollutants" extend back to 1970 and cover all transportation modes. (The term reflects their regulatory status under the Clean Air Act (CAA) of 1970). EPA is now building an air toxics database that in the future may provide emissions estimates for over 100 pollutants. This database will also contribute to a better understanding of emissions impacts during other transportation-related phases, such as infrastructure development and vehicle maintenance and disposal.

Data on transportation-related water pollution, solid and hazardous waste generation,

[2] Environmental Protection Agency (EPA) data are used throughout this section. EPA relies on various models and calculation techniques to estimate emissions. For information about models, the reader is referred to the EPA references cited in this chapter or the EPA website at www.epa.gov.

noise, and the physical disruption of habitat are collected or estimated too infrequently to provide reliable national trend data for all modes and phases. An exception is the vehicle manufacturing phase, where many kinds of trend data are available by equipment type. Overall, however, data are inadequate to confidently make comparisons across modes. Also, data are inadequate to generalize about the complex relationship between the transportation network, diffuse development patterns, and environmental quality; the secondary effects of transportation for land use are not addressed in this report.

Vehicle Travel

Most analyses of transportation-related environmental impacts focus on air pollutants emitted during the travel phase. Cars, trucks, locomotives, planes, and boats emit a wide variety of air pollutants when they are operated: criteria and related pollutants, toxic pollutants, and chlorofluorocarbons (CFCs), among others. The constituents contribute to ill health, acid deposition, smog, stratospheric ozone depletion, and climate change.

With the exception of CFCs, air pollution from transportation is a consequence of the fuels consumed, which vary by mode. Passenger cars primarily use gasoline; freight trucks and freight locomotives, diesel. Commercial aircraft consume jet fuel, while general aviation aircraft use aviation gasoline or jet fuel. Marine vessels burn residual oil, diesel, gasoline, and coal. These different fuels and the way they are consumed (and regulated) result in differing mixes of pollutants. Diesel highway vehicles, for instance, were responsible for only 3 percent of the total estimated carbon monoxide (CO) emitted by onroad vehicles in 1997, but 61 percent of total emissions of particulate matter under 10 microns in diameter (PM-10).

Transportation emissions can and have been reduced in a number of ways, primarily by altering existing fuels, changing the way vehicles burn these fuels, or adding emissions control devices that absorb and alter pollutants before they are emitted. Another option is to switch to alternative fuels.

► Criteria and Related Pollutants

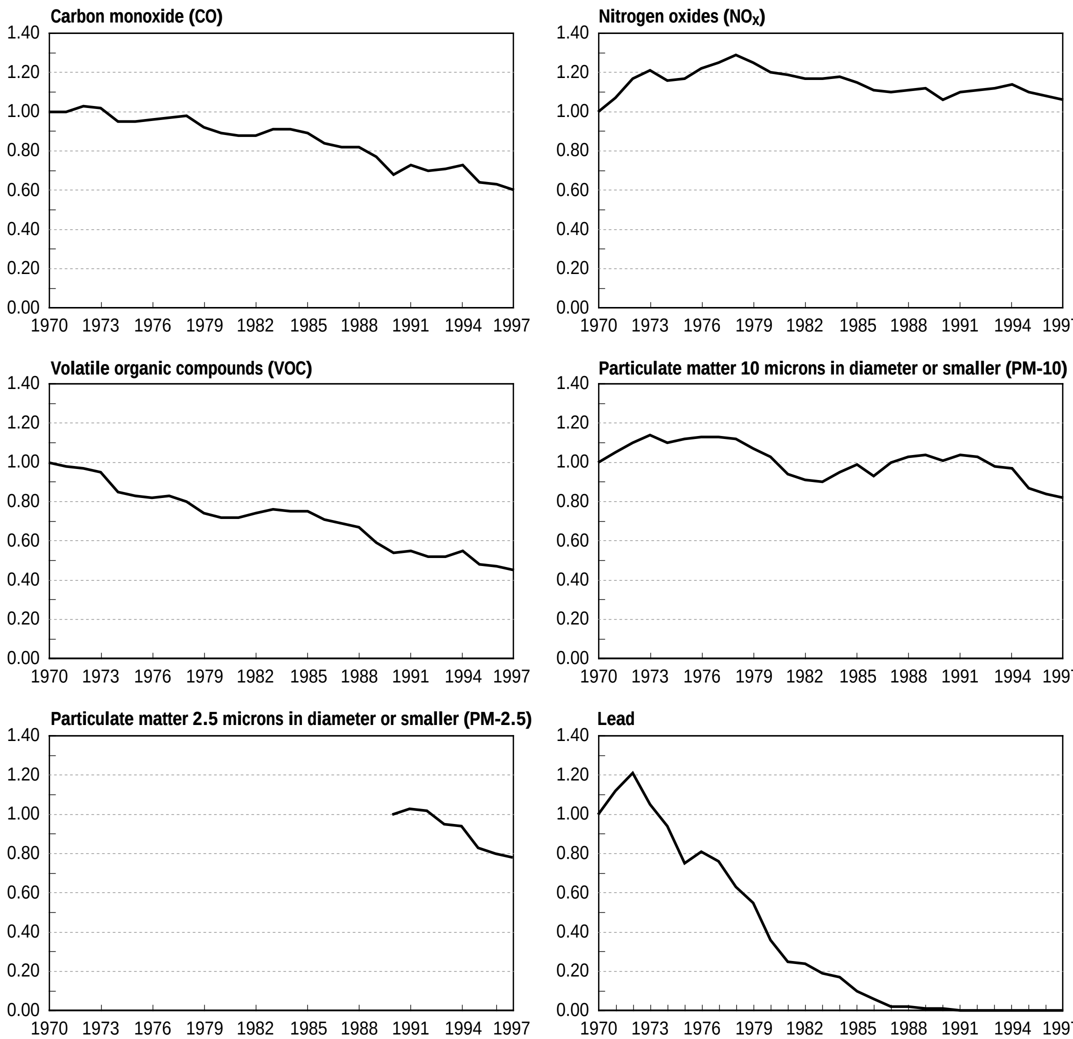
National estimates of emissions of the six criteria and related pollutants—CO, nitrogen oxides (NO_X), volatile organic compounds (VOC), sulfur dioxide (SO_2), PM, and lead—have been made since the early 1970s. These estimates, from EPA's National Emission Trends (NET) database, cover both mobile and stationary (onroad and nonroad) sources of air pollution. Onroad mobile sources include light-duty gasoline vehicles and motorcycles, light-duty gasoline trucks, heavy-duty gasoline vehicles, and diesel vehicles. Nonroad mobile sources cover aircraft, marine vessels, railroad locomotives and maintenance vehicles, and recreational and airport service gasoline and diesel vehicles.[3]

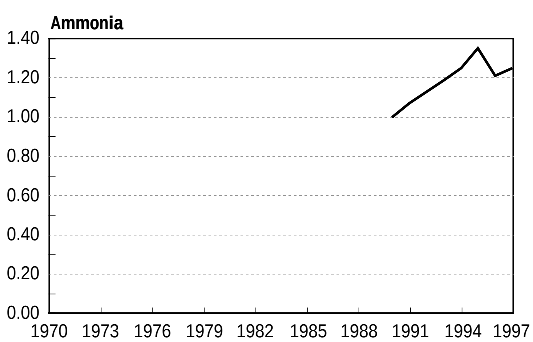
EPA national emissions estimates are modeled, not directly measured. EPA updates its estimates each year, often revising estimates for prior years as well. County-level vehicle-miles traveled (vmt) and emissions factors are used to estimate emissions from onroad vehicles. The emissions factors are derived from models that vary depending on the pollutant.

Figure 5-8 shows the trends in transportation emissions from 1970 to 1997. As shown, sizable reductions in most emissions categories since the early 1980s are apparent even though vmt has increased appreciably. For 1997, in comparison with all sources for which EPA estimates emissions,

[3] The NET database also includes construction, industrial, lawn and garden, farm, light commercial, and logging equipment in the nonroad category. These are not included here. (See USDOT BTS 1996 for a detailed discussion.)

Figure 5-8
National Transportation Emissions Trends Index: 1970–97
1970 = 1.0; 1990 = 1.0 for PM-2.5 and ammonia





NOTE: In estimating criteria and related pollutant emissions for 1997, the Environmental Protection Agency (EPA) made adjustments to prior years. For onroad mobile sources, EPA revised 1996 data. For nonroad mobile sources, EPA revised some estimates back to 1970. The figure reflects those changes and supercedes the similar figure 4-8 in *Transportation Statistics Annual Report 1998.*

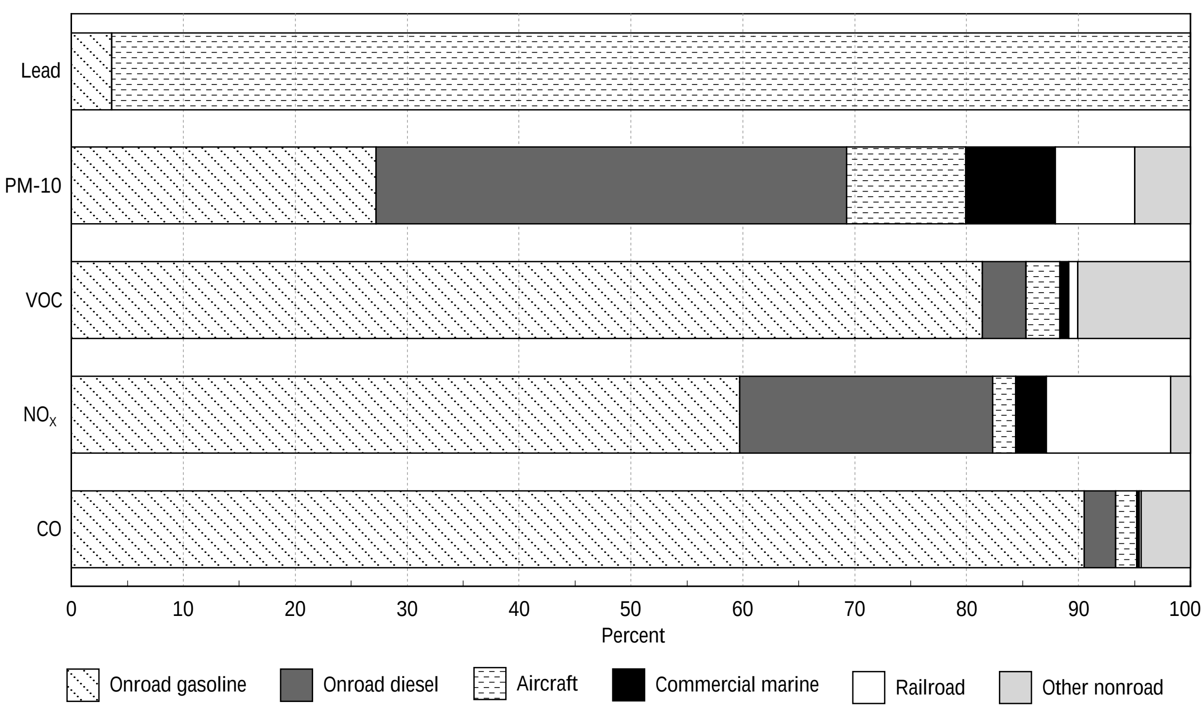
SOURCE: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, National Air Pollution Emission Trends, 1900–1997, available on the EPA website at www.epa.gov/ttn/chief/trends97/emtrnd.html.

mobile sources contributed 62 percent (53,842,000 short tons) of all CO, 36 percent (8,573,000 short tons) of NO_X, 32 percent (6,138,000 short tons) of VOC, and 13 percent (522 tons) of lead. Mobile source lead emissions have declined significantly since 1970 when they were 82 percent of all lead emissions. Today, vehicle-use lead emissions come primarily from general aviation, nonroad engines, marine vessels, and motor racing vehicles fuels (63 *Federal Register* 49240).

While mobile sources are only responsible for 1 percent (414,000 short tons) of PM-10 emissions, the contribution rises to 4 percent (324,000 short tons) for the smaller size PM-2.5 emissions (particulate matter of 2.5 microns or smaller). EPA has added a new pollutant for 1997—ammonia—with data estimated back to 1990. Mobile sources provided 8 percent (243 tons) of total ammonia emissions in 1997. Onroad gasoline vehicles generated 98 percent of mobile source emissions from ammonia; the balance came from highway diesel vehicles, railroads, and marine vessels. Gaseous ammonia reacts in the air with SO_2 and NO_X, resulting in ammonium sulfate and nitrate particles that are found in PM-2.5. As figure 5-8 shows, estimated annual mobile source ammonia emissions have been erratic but have risen sharply since 1990.

Modal shares of the 1997 emissions of five pollutants are shown in figure 5-9. When com-

Figure 5-9
Modal Shares of Key Criteria Pollutants from Transportation Sources: 1997



KEY: CO = carbon monoxide; NO_X = nitrogen oxides; PM-10 = particulate matter 10 microns in diameter or smaller; VOC = volatile organic compounds.

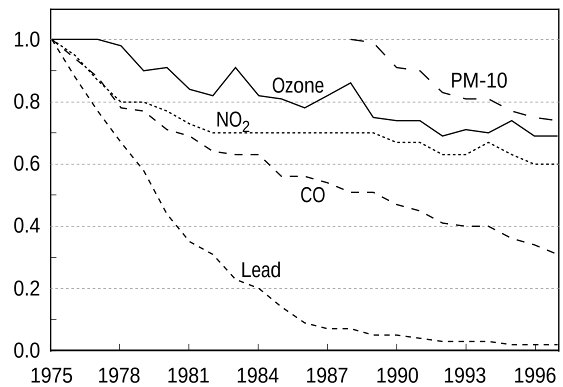
NOTES: Other nonroad includes recreational vehicles, recreational marine vessels, airport service vehicles, and railroad maintenance equipment. Does not include farm, construction, industrial, logging, light commercial, and lawn and garden equipment.

SOURCE: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, National Air Pollution Emission Trends, 1990–1997, available on the EPA website at www.epa/ttn/chief/trends97/emtrnd.html.

pared with revised 1996 data, it shows that, in general, minor shifts have occurred from onroad gasoline vehicles to onroad diesel and nonroad mobile sources.

The decline in emissions of criteria and related pollutants from transportation vehicles has played a major role in improving the nation's air quality over the last three decades. Figure 5-10 shows air quality trends from 1975 to 1997. During this 22-year period, CO concentrations declined 69 percent; nitrogen dioxide (NO_2), 40 percent; ozone, 31 percent; and lead, 98 percent. PM-10 has declined 26 percent since 1988, when monitoring began for this size particulate. (Since these data are directly measured by monitoring stations, they are not attributable to any particular source, such as transportation.) While the long-term downward trends are unmistakable, for 1996 and 1997 the concentration levels of NO_2, ozone, and lead remained the same with PM-10 declining only fractionally. Meanwhile, measured concentrations for CO continued to decline in 1997.

Figure 5-10
National Air Quality Trends Index for Criteria Pollutants: 1975–97
1975 = 1.0; 1988 = 1.0 for PM-10



KEY: CO = carbon monoxide; NO_2 = nitrogen dioxide; PM-10 = particulate matter 10 microns in diameter or smaller.

NOTES: Numbers of monitoring sites that provide raw data vary by pollutant and year. For 1975–77: CO (141 sites), lead (43 sites), NO_2 (40 sites), ozone (149 sites). For 1978–87: CO (208 sites), lead (160 sites), NO_2 (93 sites); ozone (320 sites). For 1988–97: CO (368 sites); lead (195 sites); NO_2 (224 sites), ozone (660 sites).

SOURCE: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality and Planning and Standards, National Air Quality and Emissions Trends Report, 1997, 454/R-98-016, December 1998, available at www.epa.gov/oar/aqtrnd971, table A-9.

► Air Toxic Pollutants

Knowledge about nationwide sources of hazardous air pollutants (HAPs), more commonly called air toxic pollutants, is improving. Air toxics have the potential to cause serious environmental or health effects (e.g., cancer, reproductive disorders, or developmental and neurological problems). EPA's National Toxics Inventory (NTI) now contains national estimates of toxic air emissions in 1990 and 1993. The agency plans to compile estimates for the NTI every third year; 1996 estimates are slated to become available in late 1999.

There is some overlap in coverage between the NTI's air toxics and the NET's criteria pollutants; for example, many air toxics are VOC or constituents of particulates, and lead is included in both databases. Because NTI is a relatively new database, EPA does not have the same level of confidence in the NTI data as it does in the NET.

For 1993, EPA estimated that 8.1 million tons of 166 HAPs[4] were released nationwide (USEPA OAR AQPS 1998). EPA attributed 21 percent (1.7 million tons) to mobile sources (onroad and nonroad), 61 percent to point sources (e.g., factories and powerplants), and 18 percent to area sources (e.g., dry cleaners and solvent cleaning industries).[5] The breakdown among sources varies widely by state, with mobile sources rang-

[4] The Clean Air Act requires EPA to study and potentially regulate 188 HAPs, but EPA only has 166 HAPs in its inventory to date.

[5] Both point and area sources are stationary sources. Point sources emit more than 10 tons per year of an individual HAP or 25 tons per year of aggregate HAPs. Area sources emit less than these amounts per year; however, because there can be more facilities in this category, area sources may generate more pollutants overall than point sources.

ing from 55 percent in Hawaii to 10 percent in Alabama. EPA estimated that in 1993 HAPs released by onroad gasoline vehicles (1.3 million tons) were 16 percent below its 1990 estimate due to use of reformulated fuels required to reduce urban ozone. These data also show that onroad gasoline vehicles emit 76 percent of all mobile source HAPs.[6]

[6] In this and other sections where data other than the NET are used, it has not been possible to eliminate subcategories of nonroad mobile sources mentioned in the criteria pollutant section.

In the 1990s, EPA regulated air toxics through maximum achievable control technology standards, directed primarily at stationary point sources. Because of a CAA mandate, EPA published a draft Integrated Urban Air Toxics Strategy in September 1998 (63 *Federal Register* 49240). The strategy provisionally identifies 33 air toxics as presenting the greatest health risks in urban areas. Mobile sources emitted almost 40 percent of these pollutants in the base year, 1990 (see table 5-3).

EPA expects to publish a final Integrated Urban Toxics Strategy by June 1999 and is con-

Table 5-3

Mobile Source Urban Hazardous Air Pollutants: 1990 Base Year

(Estimated tons per year)

Chemical	Onroad vehicles	% of total[a]	Nonroad aircraft	% of total[a]	Nonroad other	% of total[a]
1,3 butadiene	36,920	47.7	854	1.1	16,628	21.5
Acetaldehyde	28,163	27.5	2,090	2.0	6,394	6.2
Acrolein	8,152	11.6	989	1.4	5,376	7.7
Arsenic and compounds	2	0.1	—		—	
Benzene	208,740	47.6	1,106	0.3	89,998	20.5
Chromium and compounds	28	2	—		17	1.2
Dioxins/furans	9.5×10^{-5}	1.6	—		—	
Formaldehyde	97,506	35.6	6,791	2.5	26,864	9.8
Lead and compounds	1,690	35.8	384	8.1	197	4.2
Manganese and compounds	22	0.7	—		20	0.6
Nickel and compounds	16	0.9	—		9	0.5
Polycyclic organic matter as 16-PAH	76	0.3	5	<0.1	47	0.2
Subtotal	**381,314**		**12,219**		**145,551**	
Polycyclic organic matter as 7-PAH	*34*	*1.7*	*<0.1*	*<0.1*	*24*	*1.2*
Polycyclic organic matter as EOM	*56,157*	*13.9*	—		—	
Styrene	*17,200*	*38.8*	*194*	*0.4*	*4,657*	*10.5*
Total	**454,705**		**12,412**		**15,232**	

[a] Percentage of total emissions, all sources, both urban and rural.

KEY: EOM = extractable organic matter; PAH = polycyclic aromatic hydrocarbon; — = less than 0.01 or no estimate made.

NOTES: Chemicals in italics are those for which the Environmental Protection Agency estimated base-year emissions data; they are not included on the current list of 33 draft urban hazardous air pollutants (HAPs).

SOURCES:
For data: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Strategies and Standards Division and Emissions, Monitoring, and Analysis Division, 1990 Emissions Inventory of Forty Section 112(k) Pollutants, Interim Final Report, available at www.epa.gov/ttn/uatw/112k/112kfac.html, January 1998.

List of 33 draft urban HAPs:
U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, National Air Quality and Emissions Trends Report, 1997, 454/R-98-016, December 1998, available at www.epa.gov/oar/aqtrnd97/, table 5-4.

currently updating a 1993 study on the cancer effects of several mobile source pollutants. Subsequently, EPA plans to promulgate national regulations to control HAP emissions from motor vehicles and fuels, as well as from point and area sources.

► Stratospheric Ozone Depletion

CFCs and other chemicals deplete the stratospheric ozone layer that protects the earth from harmful ultraviolet rays. Before production was halted at the end of 1995, CFC-12 was widely used as the refrigerant for mobile air conditioning (MAC) systems in cars, trucks, and other vehicles. In the late 1980s, MAC systems accounted for 37 percent of total CFC-12 use (Oldenburg and Hirschhorn 1991). The last new MAC units with CFC-12 were shipped in 1994. These units are expected to have a lifetime of 12 years, thus emissions—while declining—are expected to continue to 2006. Emissions of CFC-12 from pre-1995 units occur from leaks during use, while being serviced, and at disposal. Servicing is expected to consume 84 percent of the stocks of CFC-12 available in 1998 (USEPA OAR SPD 1998). An estimated 66 million MAC units were still in operation in 1998 in the United States.

The primary replacement chemical for MAC units has been HFC-134a, although EPA now lists nine other acceptable alternates. Department of Energy preliminary estimates of 1997 emissions from all sources, including transportation, list 24,000 metric tons of CFC-12 and 18,000 metric tons of HFC-134a. During the period 1990 to 1996, CFC-12 emissions declined by 68 percent, while HFC-134a emissions, which are not ozone-depleting, rose 13 percent (USDOE 1998e).

► Aircraft Cruise Emissions

Only criteria pollutant emissions during aircraft landing and takeoff (LTO) are included in EPA's NET data on aircraft emissions. Aircraft engines, however, also emit pollutants, such as CO_2, NO_X, and water vapor while cruising. The quantity of aircraft pollutants emitted is a function of the type of aircraft and engine, modes of operation—taxi/idle-out, takeoff, climb-out, cruise, approach, and taxi/idle-in—and how long engines are operated in each mode.

Cruise-level pollutants are a concern because of their potential impact on global atmospheric problems, such as stratospheric ozone depletion and climate change. However, the extent of these emissions and their impacts are not well known. A Special Report on Aviation and the Global Atmosphere by the Intergovernmental Panel on Climate Change (IPCC 1999) will be used by the International Civil Aviation Organization (ICAO) to consider potential reduction solutions in three categories: changes in technology, operational measures, and market-based options.

A Federal Aviation Administration (FAA) report suggests that air traffic control operational changes that reduce flight restrictions and result in improved aircraft fuel efficiencies could lower NO_X emissions by 10 percent, CO by 13 percent, and hydrocarbons by 18 percent. Over 90 percent of these reductions would occur during flight phases above 3,000 feet (USDOT FAA 1998a). Between 1975 and 1995, U.S. airlines improved fuel efficiency by about 44 percent through technical and operational changes (USDOT BTS 1998a).

► Pipeline Emissions

There are over 200,000 miles of petroleum and 1.3 million miles of natural gas pipeline in the United States (USDOT BTS 1998a, table 1-8). EPA's AIRS Facility Subsystem (AFS) provides insight into the type and magnitude of pipeline emissions. However, because of the physical differences between pipelines and other modes and the ways in which AFS data are collected, the data are difficult to use. Comparisons cannot be made using AFS facility-based and NET mobile source data.

According to the AFS, pipelines emit all of the criteria and related pollutants, as well as toxic pollutants as do other modes. Petroleum pipeline data systems (SIC 46) are more likely to emit more SO_2 and VOC than do natural gas pipeline systems (SIC 49). The latter emit more CO, PM-10, and NO_2. Pipelines also emit a variety of HAPs. For a natural gas distribution system (SIC 4924), one state estimated emissions at the county level of 77 pounds per year of total HAPs. In addition, the record shows emissions of nickel, phenol, toluene, xylenes, formaldehyde, mercury, manganese, and cadmium. The latter three are listed as constituents of total suspended particulate emissions (USEPA OAR AQPS 1999a).

Other Vehicle Travel Impacts

While far less quantitative information is available, it is known that transportation vehicles during use impact the environment in many other ways besides emitting air pollutants. Common to all modes is the problem of accidents and leaks that result in spills of hazardous materials, including crude oil and petroleum products. Noise pollution affects people who live or work along highways, railways, and near airports. Other impacts include fugitive dust emissions from roads, oil and coolant releases from locomotives, roadkill, habitat disruption, introduction of nonnative species, and dumping of solid waste and sewage from marine vessels.

► Noise

The transportation system creates pervasive noise, degrading the quality of life to those exposed. Primary sources are aircraft LTOs and traffic moving along highways and railways. Although there are no national trend data on noise, national standards have been developed by FAA for aircraft and by EPA for medium and heavy highway trucks, motorcycles, locomotives, and railcars.

Noise is measured in decibels (dB) that increase as amplitude doubles or in the A-weighted scale (dBA) that emphasizes sound frequencies people hear best. At 65 dBA noise becomes annoying; 128 dBA is the pain threshold (USDOT BTS 1996, 151). Highway trucks manufactured after January 1988 are subject to a maximum rating of 80 dBA. The standard for motorcycles varies from 70 to 82 dBA depending on the model year (1983 to 1989) and type and whether or not the purchaser is the federal government (49 CFR Part 205). Noise standards for locomotives manufactured after December 1979 range from 70 to 90 dBA depending on whether the locomotives are moving or stationary. Railcars moving more than 45 miles per hour have a limit of 93 dBA. Various standards also apply to railroad switching equipment used in railyards (49 CFR Part 210).

Aircraft LTO noise has come under the most recent scrutiny. Stage 3 noise-certified aircraft are being phased in according to regulations promulgated under the Aircraft Noise and Capacity Act of 1990. Stage 3 aircraft noise levels range from 95 to 105 dBA and differ depending on aircraft weight and LTO operations. By the end of December 1999, all aircraft weighing over 75,000 pounds using U.S. airports must be Stage 3 certified. In August 1998, FAA reported to Congress that 260 domestic and foreign operators had reached a combined fleet mix of 79.8 percent Stage 3 aircraft by the end of December 1997. This was an increase of 4.3 percent over the Stage 3 fleet mix a year earlier (USDOT FAA 1998b).

► Spills of Oils and Hazardous Materials

Mode operators are required by law to report spills of hazardous materials, such as oxidizers, combustible liquids and gases, and corrosive material. Three data sources provide information on the extent and cost of spills. The U.S. Department of Transportation's (DOT's) Hazardous Materials Information System (HMIS) records reported hazardous materials incidents by four modes: highway, rail, air, and water.[7] DOT's Integrated Pipeline Information System in the Office of Pipeline Safety aggregates incident data reported by hazardous liquid pipeline operators and natural gas pipeline distribution and transmission operators. These two databases contain the numbers, costs, and causes of incidents, the number of injuries and deaths caused by the incidents, and the type and volume of commodities spilled.

The U.S. Coast Guard's Modified Marine Safety Information System contains data on oil pollution incidents occurring in U.S. waters. Data released in 1999 show that in 1993 through 1998 there were approximately 9,000 spills on average each year. The yearly average over this time period for volume of oil spilled is approximately 2 million gallons. It should be noted that for 1997 and 1998 the volume of oil spilled fell below 1 million gallons (USDOT USCG 1999). While, historically, the amount spilled each year can vary greatly, these data show a continuation of an overall decline since the early 1970s (see USDOT BTS 1996).

HMIS data show that four modes (highway, air, water, and rail) together averaged 14,385 hazardous materials incidents per year between 1993 and 1997. Highway vehicles were the source of 86 percent of these incidents. This does not necessarily mean that highway vehicles are more prone to hazardous materials accidents, since the data are not normalized by, for instance, vmt, number of trips, or commodity flows by mode. Two classes of hazardous materials—flammable/combustible liquids and corrosive materials—are involved in almost 80 percent of each mode's incidents, a likely consequence of these substances being among the most widely shipped in the United States. Combustible liquids include gasoline, petroleum products, and solvents; and corrosive materials include cleaners and acids (USDOT OHMS 1998).

Hazardous liquid pipelines incurred an average of 200 incidents per year between 1988 and 1997 resulting in an average of 2 deaths, 16 injuries, $34 million in damages, and a net loss of 85,000 barrels of liquid per year. Outside damage and external corrosion were the primary cause of hazardous liquid pipeline incidents in 1997 (USDOT OPS 1998).

Natural gas transmission and distribution operators reported a 1988 to 1997 average of 215 incidents per year, resulting in 18 fatalities, 91 injuries, and $32 million in property damage. In 1997, the primary cause of natural gas pipeline incidents was damage from outside forces. For transmission pipelines alone, internal corrosion ranked second. At the conclusion of a 1996 liquid pipeline accident investigation, the National Transportation Safety Board recommended in late 1998 that the DOT Office of Pipeline Safety make several changes to federal regulations to improve the pipeline industry's ability to prevent accidental releases caused by corrosion (USDOT OPS 1998).

Infrastructure Development and Operation

All transportation vehicles require supporting infrastructure, such as highways and bridges, rail lines and terminals, airports, and marine ports and marinas. In a sense, pipelines could be viewed as stationary vehicles or infrastructure through which commodities pass. All modes require fueling stations or equipment, and servicing and repair facilities. Establishment (and enlargement)

[7] HMIS water data are limited to nonbulk shipments on vessels, and cover all U.S. waters and U.S. carriers wherever they may be at the time of the incident. Coverage does not include major incidents such as tanker spills, which are in the U.S. Coast Guards' Modified Marine Safety Information System.

of these facilities and infrastructure takes land, disrupting the habitats of people and wildlife who were prior users of the space, while their construction, maintenance, and operation generates air and water pollutants, wastes, and noise.

Repairs to roads and railways create wastes, such as railroad ties and rails, concrete, and asphalt pavement. Oil, soot, grease, and chemicals run off roads, airports, railyards, and maintenance facilities with the potential to pollute surface waters or seep into and contaminate underground water. Vehicles themselves do not contribute much to particulate emissions but fugitive dust from paved and unpaved roads generated 44 percent (14.8 million tons) of all PM-10 and 30 percent (2.5 million tons) of all PM-2.5 emissions in 1997 (USEPA OAR AQPS 1999b). The following sections highlight marine facilities and airports.

Marine Facilities

There are more than 1,900 major coastal seaports and Great Lakes terminals, nearly 3,200 berths in the United States, and over 1,800 river terminals are located in 21 states (USDOT BTS MARAD USCG 1999). During operation, ships generate garbage, sewage, and bilge and ballast waters. Bilge water consists of fuel, oil, onboard spills, and wash waters generated during daily operations, as well as solid wastes, such as rags, metal shavings, paint, glass, and cleaning agents. Ballast waters from tankers may contain cargo residues, such as petroleum products. The international Maritime Pollution Convention of 1978, to which the United States is a signatory, covers discharges of these and other substances from ships at sea. Raw sewage, for instance, can be discharged 12 miles from land (USEPA OECA 1997). If not dischargable at sea, ship wastes are supposed to be unloaded while in ports. Ports then become responsible for proper management of the wastes. Port facilities that maintain and repair marine vessels generate additional wastes.

Ports and navigation channels must be periodically dredged to maintain proper depth and for enlargement. From 1993 to 1997, the U.S. Army Corps of Engineers dredged an average of 273 million cubic yards of material per year from navigation channels at an annual average cost of $542 million (USACE 1998). Dredged materials, if classified as hazardous or toxic, may have to be disposed of in confined facilities rather than used beneficially, such as for beach nourishment or fill for industrial or urban development.

► Airport Infrastructure Operations

Airports are an example of transportation infrastructure where modes converge. Airplanes land and take off. Highway vehicles (automobiles, trucks, and buses) deliver and pick up goods and passengers. At some airports, transit rail and ferries may also transport passengers. Airport facilities operate, repair, and maintain aircraft and supporting vehicles. Airports also supply services to passengers and workers, such as food, shopping, and restrooms. All these activities have the potential to impact public health and the environment within the airport and surrounding areas.

There were 566 civil, certificated airports[8] in the United States in 1997 (USDOT BTS 1998a, table 1-2). These airports differ greatly in size and how they operate. In most cases, a local government owns the airport and leases the facilities to airlines, service businesses, and other operators. Chicago O'Hare International Airport, which is one of the largest in the world, handled approximately 38 million enplaned passengers in 1998 (USDOT BTS OAI 1999). It has 162 aircraft gates in 4 terminal buildings and in 1994 had more than 380,000 aircraft departures (USDOT

[8] Certificated airports serve air carrier operations with aircraft seating more than 30 passengers.

FAA n.d., table 4-8). Given the wide variety of activities and multiple operators, data on airport impacts must be aggregated or disaggregated from various sources. Still, a complete quantitative picture of environmental impacts does not emerge.

EPA's criteria pollutant data include airport service equipment in its nonroad mobile category, but there are no national data on emissions of onroad mobile sources specific to airports. The NET contains aircraft LTO data (see table 5-4). Aircraft emissions estimates for 1997 range from 4 percent of total NO_X nonroad 1997 emissions to 100 percent of lead emissions. The percentages increase somewhat when service equipment emissions are added, with NO_X rising to 6 percent, largely due to the use of diesel equipment. Worldwide LTO standards for NO_X, CO, and unburned hydrocarbons (such as VOC) are set by ICAO.[9]

EPA's inventory of 33 urban air toxics attributes emissions of more than 12,000 tons of these pollutants to aircraft LTO operations (see table 5-3 above) (USEPA OAR AQSSD/EMAD 1998). This represents 8 percent of the estimated total nonroad toxic air emissions and includes 1,3-butadiene, acetaldehyde, acrolein, benzene, formaldehyde, and lead. The use by general aviation aircraft of aviation gasoline results in lead emissions.

EPA's Biennial Reporting System on Hazardous Waste has data on Airports, Flying Fields, and Services (SIC 4581) for the years 1989, 1991, 1993, and 1995. EPA, however, does not aggregate and publish the data by SIC. Airport reporting appears to be inconsistent from one year to the next, which most likely results from reporting rules; a facility may have to report one year but not the next depending on the quantity of waste generated and changes in the way a facility manages these wastes. For instance, Buffalo Airport, New York, only reported in 1995. In Virginia, Dulles International Airport reported in 1991, 1993, and 1995; National Airport, only in 1995. Dulles reported that its shops and warehouse building activities generated an average of 53 tons of hazardous waste per

[9] Countries belonging to ICAO can accept the standards or petition ICAO to be exempted. In April 1997, the United States adopted ICAO NO_X and CO emissions standards for commercial aircraft engines.

Table 5-4
Aircraft-Related Criteria Pollutants Emitted at Airports: 1997
(Short tons)

Source	CO	NO_X	VOC	SO_2	PM-10	Lead
Aircraft, landing and takeoff	1,012,026	177,521	186,923	11,914	40,924	503
% of total (nonroad mobile sources)	6.0	3.9	7.7	1.1	8.8	100.0
Airport service equipment						
Gasoline	140,657	3,192	6,436	0	36	0
Diesel	42,995	93,242	10,757	0	11,343	0
Total aircraft and service equipment	**1,195,678**	**273,955**	**204,116**	**11,914**	**52,303**	**503**
% of total (nonroad mobile sources)	7.1	6.0	8.4	1.1	11.2	100.0

KEY: CO = carbon monoxide; NO_X = nitrogen oxides; PM-10 = particulate matter 10 microns in diameter or smaller; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

SOURCE: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Strategies and Standards, National Air Pollutant Emission Trends, 1900–1997, forthcoming on the EPA website, 1999.

year. Among the listed items were degreasing parts cleaner, roof caulking, flammable and corrosive liquids, unused pesticides, mixed freons, and toluene. Some of the largest quantities and varieties of hazardous wastes are reported separately by airline company maintenance facilities. United Airlines' maintenance operations facility at San Francisco International Airport reported in all years except 1989. The facility generated an average of 2,285 tons of hazardous waste per year (USEPA OSW 1999).[10]

Hazardous materials spills occur primarily during aircraft cargo loading and unloading operations and from leaking storage tanks, mainly of petroleum products. According to HMIS data, the air mode averaged 864 spills per year, or 6 percent of all mode spills from 1993 to 1997 (USDOT OHMS 1998). Flammable/combustible liquids and corrosive materials constitute 78 percent of annual spills. Airports store aircraft fuel in aboveground and underground tanks that have the potential to leak. Federal regulations do not cover aboveground tanks of petroleum products unless they are part of a pipeline facility, and EPA has deferred action on underground tanks at airports. Thus, the EPA Corrective Action Measures database on underground tanks does not include airport tanks. Some states, such as Florida and Virginia, are moving toward addressing the issue of the leaks themselves. Virginia is working on a case-by-case basis with airport development plans to assure that storage technology upgrades and leak detection systems are included. The Aerospace Industries Association and the American Petroleum Institute are conducting a study on leak detection technologies for airport fuel storage systems.

An important airport environmental issue is runoff into surface waters and soil of deicing chemicals used during winter months. A summary of deicing and anti-icing of aircraft and airport runways was presented in TSAR98. Some regulatory measures are underway that could provide more information and may alter airport pollutant-generating activities. In early 1997, EPA's Toxics Release Inventory (TRI) office received a petition from environmental groups to add SIC 45 (Transportation by Air) to its annual reporting system. A decision will not be made until late 1999 or early 2000.[11] If the sector is added to the TRI, airports that meet threshold levels of emissions will have to report on certain toxic releases to air, water, and land.

In another effort, EPA's Office of Water is conducting a preliminary study on airport deicing that is scheduled for completion in late 1999 (63 *Federal Register* 29203). The study results could prompt development of a guidance document or regulations leading to effluent guidelines for airports.

Vehicle and Parts Manufacturing

Factories that manufacture transportation vehicles and parts generate air and water pollutants and solid wastes, some of which are classified as hazardous.[12] Many of these facilities are required to report annually to the TRI on their releases and transfers of toxic chemicals. This information will help determine the environmental impacts of vehicle and parts manufacturing. However, differences between TRI data and the NET criteria and related pollutant data that EPA estimates for mobile sources make comparisons

[10] The average was calculated using 1989, 1991, 1993, and 1995 data from U.S. Environmental Protection Agency (USEPA OSW 1993–97).

[11] An EPA working group must first report on the current TRI motor vehicle exemption.

[12] This section does not cover pipeline manufacturing and only reviews the final manufacturing and assembly stages related to highway, air, marine, and rail vehicles and parts. A more comprehensive review, such as during a life-cycle assessment, would also consider environmental impacts from primary stages, such as raw material extraction and refining.

with other phases of the transportation system difficult.

TRI data are estimated by facilities, but the facilities do not have to report emissions below a threshold.[13] The list of TRI chemicals has changed from year to year. Some have been removed because they were determined not to meet the criteria for listing; others have been added. The list started in 1987 (the first reporting year) with 308 chemicals; in 1995, it contained more than 600 chemicals and 28 chemical categories. The set of criteria pollutants has remained constant since the 1970s. Of the criteria pollutants, CO, NO_X, and SO_2 are not on the TRI list; lead is, however. In addition, some of the chemicals on the TRI qualify as VOC or constituents of particulates (PM-10 or PM-2.5). Chemicals in EPA's air toxics inventory (the NTI) are a subset of those in the TRI.

Analysis of the environmental impact of transportation equipment manufacturing is also complicated by the sizable international trade in this industry. Thus, the environmental impacts from manufacturing in the United States are not proportional to the numbers of vehicles American's use. For instance, over 12 million passenger cars, trucks, and buses were produced in the United States in 1994 (AAMA 1995). Many of the parts for these vehicles may be imported. Furthermore, while just over 1 million cars, trucks, and buses produced in the United States were exported in 1994, imports totaled almost 5 million vehicles. Data on the value of other modal vehicle trade show U.S. exports exceed imports, especially for civilian aircraft. One exception may be motorcycles and parts; 1997 data list only imports (USDOC 1998).

[13] Manufacturing facilities in SICs 20–39 report if they have 10 or more full-time employees and release/transfer from manufacturing or processing more than 25,000 pounds of a listed chemical or more than 10,000 pounds from "otherwise use." Methods of estimation used by facilities can vary.

► Toxic Pollutants[14]

Facilities in the transportation equipment manufacturing (TEM—SIC 37) sector report to EPA's TRI annually on environmental releases of toxic air and water pollutants and hazardous wastes. They also report on the transfers of these chemicals offsite of their facilities (for recycling, energy recovery, treatment, and disposal) and to publicly owned treatment works.[15]

Among the manufacturing sectors that reported 1996 data to the TRI, TEM is ranked fourth in total onsite releases and sixth in total transfers offsite (USEPA OPPT 1999). Table 5-5 compares the sector's releases and transfers by mode. It shows that highway vehicle and parts manufacturers were responsible for 65 percent of the sector's releases and 77 percent of the transfers in 1996. For all modes, air emissions were the most significant in terms of total pounds released onsite. Just 15 chemicals contributed 92 percent of all these releases. They include xylene, styrene, glycol ethers, toluene, methyl ethyl ketone, manganese, and others.

EPA has compared year-to-year SIC 37 TRI data, based on a core set of chemicals that have been consistently reported. Between 1988 and 1996, subsectors (by 4-digit SIC) have reduced onsite releases, ranging from 34 percent for motor vehicle and car bodies (SIC 3711) to 96 percent for aircraft engines (SIC 3724). Most of the reductions are due to lower air emissions. An exception is SIC 3751 (motorcycles, bicycles,

[14] The basis for this discussion is facilities that report to the TRI under SIC 37 (transportation equipment industry). However, many vehicle parts are manufactured by facilities that report under other SICs. They include tires (SIC 30), automotive glass (SIC 32), batteries and lighting systems (SIC 36), portions of engines (SIC 35), and automotive seats (SIC 25). In addition, the stamping process is represented in fabricated metals (SIC 34). In most of these categories, vehicle parts data are comingled with data on other products.

[15] Facilities must also report on the amount of and how they manage chemicals onsite. These data are not included in this discussion.

Table 5-5

Toxic Release Inventory Data for Transportation Equipment Manufacturing: 1996

(In pounds, except as noted)

		Onsite releases					Transfers offsite			
Sector by mode	**SIC**	**Air emissions**	**Surface water discharges**	**Under-ground injection**	**Land releases**	**Total onsite releases**	**For disposal**[a]	**For waste management**[b]	**Total offsite**	**Totals**
Motor vehicle and car bodies	3711	40,561,496	10,428	0	15,310	40,587,234	1,517,251	46,128,216	47,645,467	88,232,701
Truck and bus bodies	3713	4,719,018	3,257	0	47,986	4,770,261	133,698	4,308,171	4,441,869	9,212,130
Motor vehicle parts and accessories	3714	15,634,030	83,564	0	363,251	16,080,845	4,348,414	103,728,587	108,077,001	124,157,846
Truck trailers	3715	1,705,764	265	0	115,727	1,821,756	16,370	996,221	1,012,591	2,834,347
Motorcycles, bicycles, and parts	3751	721,200	0	0	0	721,200	9,050	679,411	688,461	1,409,661
Highway vehicles total		*63,341,508*	*97,514*	*0*	*542,274*	*63,981,296*	*6,024,783*	*155,840,606*	*161,865,389*	*225,846,685*
Aircraft	3721	4,247,896	16,719	0	15,866	4,280,481	62,547	2,283,762	2,346,309	6,626,790
Aircraft engines and engine parts	3724	484,200	86,909	0	73,773	644,882	430,432	11,984,305	12,414,737	13,059,619
Aircraft parts and equipment, nec	3728	2,396,026	324	0	15,949	2,412,299	120,680	2,504,350	2,625,030	5,037,329
Aircraft total		*7,128,122*	*103,952*	*0*	*105,588*	*7,337,662*	*613,659*	*16,772,417*	*17,386,076*	*24,723,738*
Ship building and repairing	3731	2,707,317	19,752	0	23,922	2,750,991	191,201	7,760,908	7,952,109	10,703,100
Boat building and repairing	3732	11,274,153	0	0	27,134	11,301,287	11,007	469,057	480,064	11,781,351
Marine vessels total		*13,981,470*	*19,752*	*0*	*51,056*	*14,052,278*	*202,208*	*8,229,965*	*8,432,173*	*22,484,451*
Railroad equipment	3743	1,328,150	1	0	1	1,328,152	210,868	1,983,439	2,194,307	3,522,459
Railroad total		*1,328,150*	*1*	*0*	*1*	*1,328,152*	*210,868*	*1,983,439*	*2,194,307*	*3,522,459*
Miscellaneous[c]		12,323,358	2,901	0	5,501	12,331,760	578,421	18,724,061	19,302,482	31,634,242
Total (pounds)		***98,102,608***	***224,120***	***0***	***704,420***	***99,031,148***	***7,629,939***	***201,550,488***	***209,180,427***	***308,211,575***
TOTAL (tons)		**49,051**	**112**	**0**	**352**	**49,516**	**3,815**	**100,775**	**104,590**	**154,106**

[a] Disposal is an environmental release that occurs offsite.

[b] Waste management categories include recycling, energy recovery, treatment, and publicly owned treatment works.

[c] Data for facilities that reported more than one Standard Industrial Classification (SIC) 37.

NOTES: This table does not include data for all facilities that report under SIC 37. Space vehicles, guided missiles, and parts (SIC 3761, 3764, and 3769), travel trailers and campers (SIC 3792), tanks and tank components (SIC 3795), and transportation equipment not elsewhere classified (nec) (SIC 3799) have been excluded.

SOURCE: U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances, 1996 Public Data Release: Ten Years of Right-To-Know, available at www.epa.gov/opptintr/tri/pdr96/2drhome.htm, 1999.

and parts), which increased total onsite releases by 125 percent between 1988 and 1996.

▶ Criteria and Related Air Pollutants

Current data sources do not provide data comparable to that of mobile sources on the emissions of criteria and related pollutants from TEM. AIRS AFS contains data for key SIC 37 categories, but not necessarily for all facilities nationwide (see above). For the NET, EPA makes national emissions estimates for stationary sources but does not necessarily align them with SICs.

The NET does not contain data for all stationary source categories across all pollutant categories. For the transportation equipment industry, EPA estimates CO, NO_X, and VOC emissions. For 1997 and prior years, CO and NO_X emissions estimates are zero, which means they are less than 1 ton. Using AIRS data, however, EPA's Office of Enforcement and Compliance Assurance estimated that just three TEM sectors—motor vehicles and bodies, motor vehicle parts and accessories, and shipbuilding and repair—emit over 15,000 tons of CO and 28,000 tons of NO_2 per year (USEPA OECA 1998). Under the NET's solvent utilization category, EPA shows VOC emissions for surface coating of autos and light trucks, large ships, aircraft, and railroad vehicles. EPA also estimates VOC emissions from rubber tire manufacturing. The combined VOC emissions for these source categories, as well as TEM, total 162 tons for 1997; surface coating of autos and light trucks are 81 percent of the total.

▶ Nonhazardous Wastes

Little is currently known about the nationwide amount of nonhazardous solid waste (called industrial wastes) generated by transportation (or any other) sector facilities. EPA's most recent industrial wastes estimate was for 1985. It found that the TEM sector generated 13 million tons in that year (US Congress OTA 1992). Since the estimate only included wastes managed in land-based units, such as landfills, it most likely covered only part of the sector's total generation. Of the 16 manufacturing sectors for which EPA estimated such wastes, the transportation equipment sector ranked 14th and generated less than 1 percent of the total.

▶ Regulation of Manufacturing Sectors

Manufacturers must comply with environmental regulations, chief among them are those related to air emissions, water discharges, and hazardous waste. Hazardous waste regulations are not industry-specific but apply broadly to any facility that generates, stores, or transports hazardous wastes above a threshold amount. EPA has not set specific water discharge standards for TEMs as a sector; however, TEM facilities that discharge wastewaters into surface waters must obtain permits (usually at the state or local level) to do so. Many TEM facilities could become subject to standards EPA expects to propose by late 2000 for facilities that manufacture, maintain, or rebuild finished metal parts, products, or machines.

In the 1970s and 1980s, EPA's regulatory concentration focused on VOC from stationary sources, such as TEM facilities, to help areas meet air quality standards. In the 1990s, EPA's focus on reducing HAP emissions affected several TEM categories. Since late 1996, shipbuilding manufacturers have been required to make use of maximum achievable control technology (MACT) standards to reduce emissions of HAPs. Targeted chemicals include xylene, toluene, ethylbenzene, methyl ethyl ketone, methyl isobutyl ketone, ethylene glycol, and glycol ethers. EPA expects the standards to reduce emissions by 350 tons per year from a base of nearly 1,500 tons per year (60 *Federal Register* 64330). Aerospace manufacturing and rework facilities became subject to new standards in late 1995. The standards apply to specific operations at over 2,800 facilities that are major sources of HAPs.[16] EPA expects the standards to reduce nationwide emissions of chromium, cadmium, methelyne chloride, toluene, xylene, methyl ethyl ketone, ethylene glycol, and glycol ethers by 124,000 tons (60 *Federal Register* 45948).

EPA is now developing MACT and VOC requirements for styrene emissions from boat manufacturing and, by late 1999, expects to propose standards for rubber tire production, auto and light-duty truck manufacturers (surface coating operations), asphalt concrete manufacturers, and engine testing facilities. EPA, operating under a consent decree, has a deadline to finalize most of these (and other) rules by the end of 2000.

Vehicle Maintenance and Support

The nation has a myriad of facilities that clean, maintain, repair, and fuel transportation equipment and vehicles. Servicing the vehicles and equipment generates air and water pollutants and hazardous and solid wastes. Little national data are available that would enable comparisons among modes nor with other areas of the transportation system.

Many of the troublesome wastes generated during maintenance of vehicles also pose problems during the disposal phase (see below). For many wastes, determining how they are disposed depends on their classification under state or local regulations. A hazardous or special waste classification may prohibit placing wastes in municipal landfills. For instance, 38 states had laws in 1995 that either banned rubber tires from landfills or required them to be shredded or cut prior to disposal in a landfill (RRI 1996). At the federal level, EPA identified the open burning of scrap tires in 1998 as a source of polycyclic organic matter, a HAP regulated under a special provision of the CAA. EPA issued a final rule in late 1998 to reduce VOC emissions from automobile refinishing operations by 31,900 tons per year (63 *Federal Register* 48806). Instead of setting emissions standards for refinishing shops, EPA required manufacturers of automobile refinish coatings to reduce the VOC content of their products.

The American Trucking Association's "Green Truck" website (www.trucking.org/greentruck/) lists 16 problematic wastes and cautions facilities to check with local landfill operators before throwing them away. The list includes various fluids, used antifreeze, used solvents (including those that are citrus-based), batteries, shop rags, oil spill absorbent material, catalytic converters, and so on. A special program at a U.S. Postal Service maintenance facility in New England demonstrated that the amounts of four types of waste can be reduced by implementing good operating procedures and making process modifications. From 1992 through 1995, the facility eliminated used parts solvent, used antifreeze, and brake cleaning solvent wastes, and reduced waste paint and solvent by 90 percent (USPS n.d.).

Small service stations and repair facilities have been a focus for many state pollution prevention and small business technical assistance programs. For instance, in 1992, Washington's Department of Ecology (WDE) initiated a campaign to help automotive repair shops better understand and voluntarily meet hazardous waste requirements. There are 10,000 of these shops that manage some 30 different wastes that are potentially hazardous. WDE visited over 1,700 shops, particularly those specializing in auto bodies, auto dealerships, auto repair, machine shops, radiator shops, service stations, tire dealers, and transmission shops. WDE estimated that, statewide, automotive repair shops

[16] A major source is a facility that emits more than 10 tons of a specific HAP per year or more than 25 tons of any combination of HAPs.

were responsible for 1.2 million gallons of used antifreeze, 1 million used fuel filters, 35 tons of used lead solder, 4,000 55-gallon drums of used paint thinner and solvent, and 1.3 million aerosol spray cans used for lubrication and degreasing per year (WDE 1994).

► Fueling

Air pollutants are emitted during the fueling of transportation vehicles. Because gasoline evaporates more readily than diesel fuels, gasoline vehicles contribute more to this problem. EPA separates fuel-related evaporative emissions into Stage I (distribution to markets) and Stage II (refueling of vehicles) categories. Service station Stages I and II and other operations emitted an estimated 825,000 short tons of VOC in 1997, with refueling responsible for 52 percent (427,000 short tons), according to EPA's NET. Total VOC emissions in the nonmobile source category of NET, called Storage and Transport (of which Stages I and II are part), were estimated at 1,377,000 short tons for 1997. As noted earlier, total mobile source VOC emissions in 1997 were 6,138,000 short tons; Storage and Transport are not part of this total. EPA has sought to control retail gasoline evaporative emissions through such measures as requiring dispensing facilities to install fuel pump devices to recover refueling emissions and requiring manufacturers to install vapor recovery systems in new light-duty vehicles.

EPA's NTI lists four Stages I and II gasoline toxic pollutants—benzene, polycyclic organic matter as 16-PAH, ethylene dichloride, and lead—and estimated total emissions of 11,575 tons in urban areas for the baseline year of 1990. EPA also estimated lead emissions for both stages of aircraft gasoline distribution at 0.15 tons in urban and rural areas. In 1998, EPA announced that it would consider the development of regulations to control lead emissions from evaporative losses associated with aviation gasoline transfer and storage, aircraft refueling, and spillage.

Data on emissions from the fueling of locomotives are not disaggregated by EPA; however, locomotive fueling's contribution to air pollution is most likely minor. First, freight locomotives are generally powered by diesel fuels. Second, passenger train locomotives are often powered by electricity. While this means that related emissions occur at powerplants and depend on the type of fuel used to generate the electricity, they are relatively minor. The Department of Energy reports that railroads and rail transit systems purchased less than an average of 3 percent per year from 1993 to 1997 of all kilowatt-hours sold in the United States (USDOE 1998d).

► Leaking Underground Storage Tanks

The need for fueling also creates the potential for underground water contamination. Most fuel storage tanks are buried underground, especially at retail gasoline stations. These tanks have a history of leaking due to corrosion, overflows, and spills. In response to legislation, EPA set up the Underground Storage Tank (UST) Program in the mid-1980s to remediate leaking tanks holding petroleum products and establish regulations on leak detection and tank standards. Data reported to EPA by states, as of September 1998, show that the country has almost 900,000 active regulated tanks and that 1.2 million tanks have been closed and over 300,000 cleanups initiated since 1990. This leaves 168,000 known releases not yet cleaned up (USEPA OSW OUST 1998).

To prevent leaks, detection rules became effective in the early 1990s, but EPA gave facilities subject to the tank standards 10 years (until December 22, 1998) to comply. Options for UST owners have been to close, upgrade, or replace tanks that do not meet the standards. In early December 1998, EPA estimated that 56 percent of the USTs then in operation met the federal standards and issued a guidance document on pending enforcement efforts (USEPA OECA/OSWER 1998). EPA expects most enforcement efforts, especially those affecting small business and local government, to be conducted by states. In 22 states, for instance, distributors are not allowed to deliver gasoline to facilities that are not yet in compliance.

▶ Transportation Equipment Cleaning

EPA's Office of Water proposed effluent guidelines in mid-June 1998 for facilities that clean the interiors of tank trucks, rail tank cars, or barges that have been used to transport cargo. In general, these pending guidelines will affect independent operators because other facilities are part of industry sectors already covered by Clean Water Act effluent guidelines. Ninety-five percent of transportation equipment cleaning facilities that discharge wastewater do so to publicly owned treatment works. The majority of the barge facilities (77 percent), however, discharge directly to U.S. surface waters (63 *Federal Register* 34685).

In addition to the residual products from tanks being cleaned, wastewater generated by the transportation equipment cleaning industry includes water and steam used to clean the tank interiors, prerinse solutions, chemical cleaning solutions, final rinse solutions, tank exterior washing wastewater, boiler blowdown, tank hydrotesting wastewater, and safety equipment cleaning rinses. Aside from conventional pollution (e.g., oil and grease, elevated levels of suspended solids or biological oxygen demand, and Ph affects), these operations produce priority toxic and nonconventional pollutants, including chemicals listed in the TRI. Toxic and nonconventional pollutants differ depending on the type of cargo being washed out. EPA has done a pollutant reduction and cost analysis based on different technical options. Ultimate reductions will depend on the technologies chosen for the effluent guidelines, expected in mid-2000.

Disposal of Vehicles and Parts

Vehicles are generally disposed of when they reach the end of their useful lifetimes. While they are in service, old parts are discarded as repairs are made. Components of transportation infrastructure, such as railroad rails and ties and highway pavement, also must be disposed of or reused in some way. The disposal of vehicles, parts, and infrastructure results primarily in solid wastes, some of which are hazardous. As with the maintenance phase (see above), disposal data are limited.

The number of vehicles scrapped in the United States each year varies. Between 1992 and 1996, for instance, an annual average of 11 million passenger cars and 2.8 million trucks were scrapped (USDOT BTS 1998a, table 4-43). Similar data for other vehicle modes are not available. Some aircraft and ships are kept for possible future refurbishing and use. Rail locomotives are commonly remanufactured, prolonging their useful life. In addition, a portion of the nation's stock of used highway vehicles, locomotives and railcars, marine vessels, and aircraft are exported to other countries for continued use.

Prior to disposal, transportation vehicles are generally dismantled. For automobiles, much of the material generated can be recycled. For instance, almost three-quarters of the 12.8 million tons of material generated from retired automobiles was recycled in 1994. The remainder (3.5 million tons) was placed in landfills (USDOT BTS 1996). The process of dismantling vehicles, however, has the potential to generate many hazardous wastes if not done properly (see table 5-6). For instance, the commingling of different fluids during dismantling can reduce recycling options. EPA requires that mobile air conditioner fluids be extracted and handled separately. CFC-12 can be sold to certified handlers

Table 5-6
Wastes from Vehicle Dismantling Operations that may be Classified as Hazardous

Air bags
Antifreeze
Asbestos
Auto body shop waste
Auto fluff
Brake fluid
Fuel and fuel filters
Lead parts
Lead-acid batteries
Mercury switches
Refrigerant (CFCs)
Shop towels
Spray cans
Sump sludges
Transmission filters
Transmission fluid
Used oil
Used oil filters
Wastewater
Windshield washer fluid

SOURCE: Washington State Department of Ecology, Hazardous Waste and Toxics Reduction Program, *Vehicle Recycling Manual: A Guide for Vehicle Recyclers* (Olympia WA: October 1997).

and eventually is used by facilities that service old MAC units. An estimated 5 million pounds of CFC-12 is reclaimed each year from all sources (USEPA OAR SPD 1998).

► Batteries and Used Oils

Lead-acid batteries are used in highway vehicles, marine vessels, and aircraft. Mandatory recycling programs for lead-acid batteries now exist in some form in 30 states (EXIDE 1998). Between 1991 and 1996, an estimated annual average of 94.6 percent of the lead available from old batteries in the United States was recycled. Onroad and nonroad mobile sources batteries contributed 88 percent, 72 percent of which came from highway vehicles[17] (BCI 1998). Other types of batteries—such as alkaline, lithium, magnesium, nickel-cadmium, and nickel-mercury batteries—are now found in vehicles. Their disposal may be regulated and recycling encouraged at the state or local level.

Many states encourage the recycling of used oil. According to EPA, an estimated 380 million gallons of used oil are recycled each year (USEPA OSWER 1996). Vehicles contain a wide variety of oils that become contaminated with dirt, metal scrapings, water, or chemicals during use. Oils include motor oil, transmission fluid, lubricating oil, gear oil, cutting oil, hydraulic oil, differential oil, power-steering fluid, and transaxle fluid. Used motor oil can be refined and reused as motor oil or processed for furnace fuel oil.

► Marine Vessel Dismantling

In 1998, the General Accounting Office (GAO) released a report detailing problems involved in scrapping U.S. vessels. Ship scrapping is complicated by an extremely high level of environmental and worker safety risks. Ships can contain hazardous materials, such as asbestos, polychlorinated biphenyls (PCBs), lead, mercury, and cadmium. The materials can be released during the dismantling process, polluting land and water surrounding the site (US Congress GAO 1998).

DOT's Maritime Administration (MARAD) is the U.S. government's disposal agent for surplus merchant-type vessels of 1,500 gross tons or more.[18] The Merchant Marine Act of 1936 (as amended) authorizes MARAD to sell obsolete vessels for scrap in domestic and foreign markets.

In August 1999, MARAD had 111 vessels ready to be scrapped with 16 more awaiting transfer by the U.S. Navy. Many of these ships are in poor condition and most were built with polychlorinated biphenyls (PCBs), a hazardous material used in capacitors, transformers, electri-

[17] It is not possible to break out modes other than marine vessels from these data. Motorcycle and aircraft battery data are included in the totals but individually hidden for confidential reasons.

[18] Federal Property and Administrative Services Act of 1949.

cal equipment, cables, paint, gaskets, and adhesives.

In 1993, EPA advised MARAD of its position that the export for scrapping of a government ship containing regulated quantities of PCBs was prohibited under the Toxic Substances Control Act. On September 23, 1998, the Vice President issued a moratorium prohibiting overseas scrapping through October 1, 1999, with an exception provided for MARAD to request a waiver from the Council for Environmental Quality after January 1999.

Prior to 1994, MARAD sold most of its ships for scrapping overseas. Between 1987 and 1994, MARAD sold 130 ships, and then did not sell any more ships for scrapping until 1997, when 2 were sold to domestic scrappers in Brownsville, Texas. In 1998 and 1999, MARAD awarded 22 ships to domestic scrappers located in Brownsville, but to date the scrappers have only taken delivery on 6. Awards are based on a bidder's technical compliance plan and record relating to environmental and worker health and safety. MARAD will dispose of all unassigned vessels in the National Defense Reserve Fleet by September 30, 2001 ". . . in a manner that maximizes the return on the vessels to the United States.”[19]

DATA NEEDS

Energy

Transportation energy data are good, but not as good as they should be. Deficiencies in data inhibit understanding of how well current policy is working and the differences changes might make. Much of the energy discussion in this report involves data that are based in part on estimates and extrapolations rather than directly measured values. Furthermore, some important details are missing. Areas where better data would allow more accurate analysis include: automobile efficiency, trends in petroleum consumption and imports, and growth of nonpetroleum fuels in the transportation sector. Better data on how and where people drive and the energy they consume doing so would also aid in understanding and controlling urban sprawl.

Of greatest concern is the uncertainty in the area of light-duty vehicle fuel use. This information is not measured directly but inferred from data supplied by the states that procure it in the process of collecting fuel tax revenues. While fairly accurate on a gross basis, it provides no detail on matters such as fuel consumption by make and model, vehicle occupancy, or vmt.

Estimates of the costs of reducing carbon emissions from the transportation sector are very uncertain because of the lack of this detail. There is only a general, largely theoretical, sense of how people would react to higher prices or stricter economy standards. Under changing conditions, such as carbon restrictions, vehicle selection and miles traveled, occupancy rate, and other factors, are likely to be different, but they are hard to predict unless sufficient detail on how people behave exists.

An extensive, accurate, and frequent survey of light-duty vehicle energy consumption by make, model, and year, coupled with odometer readings would go a long way toward filling this need. This survey could collect the same sort of data as the Truck Inventory and Use Survey (TIUS), as discussed in TSAR97 and TSAR98, but be directed at all vehicles. A Vehicle Inventory and Use Survey would have to be conducted somewhat differently from TIUS because it is unlikely to be mandatory, but the results should be valuable.

It is also important to improve data on nonpetroleum fuels, especially those used for blending with gasoline. As noted in TSAR98, some additives, especially ethers, are not accounted for, and

[19] National Maritime Heritage Act of 1994.

the components of imported reformulated gasoline often are not known exactly. Both these factors are of increasing importance. In addition, the production of grain alcohol requires a large amount of petroleum, both on the farm and at the distillery. Energy from petroleum may approach or even exceed the energy of the alcohol produced, yet it is assigned to the industrial sector. A better understanding of the entire system of alcohol production and use could provide a more accurate energy (and carbon) accounting. Blending is far more important than alternative fuels on their own, and it is important to understand just what is being used.

If electric and hybrid-electric vehicle production grows as rapidly in coming years as some analysts believe, it will be important to understand where the power is coming from and how it is used. The groundwork should be laid now to determine the data that must be collected and how to collect it.

Other areas of inadequate data include heavy-truck load factors and bus energy use. Trucks often are required to make return trips empty, but surveys do not usually distinguish between fuel consumption on loaded and unloaded trips. Very little energy data are collected on intracity and school buses. Overall energy consumption accuracy would be improved with better data on buses.

Environment

In general, environmental data are collected and aggregated in ways that are useful to those who oversee the separate air, water, and solid waste laws and regulations. Some of these data are collected regularly; others, only occasionally. Because of this, data provide some but not full understanding of the environmental consequences of transportation. To achieve a full understanding, trend data are needed on emissions of a range of pollutants for all modes and several phases in the life cycle of vehicles. In addition, information is needed on how emissions impact public health and the environment and how this changes over time.

Sufficient, equivalent data to enable comparisons among the phases—travel, infrastructure, manufacturing, maintenance, and disposal—are not available. Modal comparisons are only possible within the travel and manufacturing phases. Overall, transportation environmental data are particularly weak in showing the effects of pollutants emitted. Difficult questions such as how and to what extent they damage human health, agriculture, ecosystems, and so on remain unanswered.

► Travel Phase

From an environmental perspective, travel (or the use of vehicles and other transportation equipment) is the most often considered phase of the transportation system. This is also the phase for which data is most complete.

Data on six criteria air pollutants generated by highway vehicles, aircraft, marine vessels, and rail locomotives are the most comprehensive transportation environmental data available. The prime reason is that the Clean Air Act, unlike other environmental legislation, directs EPA to consider both stationary and mobile (i.e., transportation) sources of air pollution. In addition, EPA annually estimates emissions of these pollutants and has done so for over two decades. These National Emissions Trends data are complemented by data EPA aggregates annually from monitoring stations across the nation, providing long-term trends in the nation's air quality.

Air emissions data are improving. EPA is in the process of building the National Toxics Inventory database of estimated emissions of 188 hazardous air pollutants for both stationary and mobile sources on a biennial basis. There is, however, no monitoring system in place that will provide measurements of actual HAPs in the nation's air. Such data are collected only sporadically and usually for only one specific pollutant or set of pollutants.

Not all modes are thoroughly covered by the NET and the NTI air emissions data. EPA, for instance, only estimates aircraft criteria and toxic pollutant emissions occurring during landing and takeoff operations. However, aircraft produce most of their emissions while at altitudes above 3,000 feet, where their impact is more global than local.

In addition, EPA does not consider pipelines to be mobile sources. EPA's AIRS Facility Subsystem database provides insight into both criteria and toxic air pipeline emissions; however, the data are difficult to use. AFS data are estimated at the facility level and submitted to AFS by states. The data are not valid as national trend data. Only large sources are included, not all states report each year, and states may only submit data for areas that have not reached attainment status under the CAA. At best, AFS data can be normalized by the number of facilities included in the database for any given category to show average estimated emissions per facility type per year. Pipelines, however, do not fit the concept of a facility; AFS pipeline data show, in essence, emissions within a specific county of a particular pipeline.

Noise pollution and spills of hazardous materials are the other known, major environmental problems occurring during the travel phase. FAA produces data intermittently on population exposure to unacceptable levels of aircraft noises but, in the last decade, no national-level data have been available that quantify exposure to highway or railroad noise. Annual national data on the volume and types of hazardous materials spilled from all modes, including pipelines, are available. These data do not provide information about the residuals that are not cleaned up or whether they ultimately contaminate groundwater, nor do they enable modal comparisons.

► Infrastructure

Transportation depends on infrastructure that includes highways, marine ports and marinas, airports, and rail lines and terminals. With the exception of waterway dredging by the U.S. Army Corps of Engineers (USACE), there are no trend data on infrastructure impacts.

A major impact of infrastructure is the land it displaces from other uses. Yet, land use and habitat degradation are topics about which very little is known on a national scale. Construction, operation (or use of), and maintenance of infrastructure generates air and water pollution and solid wastes. Some of these data are available on a trend basis, but can be difficult to aggregate by facility type (e.g., airports, rail terminals) or modal source. Other data are estimated periodically. For instance, EPA is currently studying the amount of debris created by highway and bridge construction and renovation.

USACE annual data identify the amount of materials dredged from the nation's navigable waterways and the cost of doing so. There are only sporadic collections of similar data for dredging done by private port authorities. Other than on a case-by-case basis, little is known about impacts of contaminated dredged materials.

► Manufacturing Phase

Comprehensive data are available for U.S. manufacturing sectors for several pollutant categories. For the most part, it is possible to attribute these data to modes. The Toxics Release Inventory contains a decade of data reported annually by manufacturing facilities on hundreds of toxic chemicals released to air, surface water, and the land. These data are collected by SIC. Conveniently, one major grouping

(SIC 37) covers the transportation equipment industry and is subdivided by modes. It does not, however, include pipelines.

The transportation equipment industry group contains the bulk of vehicle manufacturing, especially the assembly stage. Many vehicle parts, however, are manufactured by facilities that report under other SICs, where vehicle parts data are comingled with data for other products. These parts include tires, automotive glass, batteries and lighting systems, portions of engines, and automotive seats. In addition, the vehicle stamping process is represented in fabricated metals.

In addition to TRI data, EPA biennially collects data on the amounts of hazardous waste generated by manufacturing facilities, but these are not aggregated by SIC. EPA's AIRS data contain criteria pollutant emissions by SIC, but the limitations of use described above for pipelines apply here as well. EPA made the most recent estimate of nonhazardous solid wastes generated by the transportation equipment industry in 1985.

► Vehicle and Parts Maintenance and Disposal

Vehicles and parts must be maintained and then disposed of when their useful life is ended. Data deficiencies for this phase make it the most difficult to understand on a national scale. Recent state-level actions taken to improve environmental performance of small businesses, such as auto repair shops, have resulted in improved knowledge about the types of hazardous and nonhazardous materials these facilities generate. While some states have made estimates of the amounts generated, there is little national-level data. Exceptions include national annual estimates of tire and lead-acid battery recycling and disposal.

The numbers of cars and trucks scrapped each year is known. An occasional study estimates the amount of end-of-life automobile solid wastes recycled and disposed of, but little is known about the ultimate fate of trucks, railway cars and locomotives, airplanes, and marine vessels. Furthermore, there are no data on the amount or consequences of parts disposal during the lifetime of vehicles, or on the host of liquids also disposed of as vehicles are repaired and scrapped. Because it is an ozone-depleting substance phased out under the Montreal Protocol, the amount of HC-134a used annually and recycled for mobile air conditioning units is available. EPA estimates the amount of motor oil recycled each year, but the amounts and fate of other liquids, such as transmission and power-steering fluids, are unknown.

REFERENCES

American Automobile Manufacturers Association (AAMA). 1995. *World Motor Vehicle Data, 1996 Edition*. Detroit, MI.

Battery Council International (BCI). 1998. *National Recycling Rate Study*. December. Papillon, Nebraska.

Davis, S.D. 1998. *Transportation Energy Data Book, Edition 18*. Oak Ridge, TN: Oak Ridge National Laboratory, Center for Transportation Analyses.

EV WORLD. 1998. News from the Electric, Hybrid and Fuel Cell Vehicle Industry. Online news files available at www. evworld. com/.

EXIDE. 1998. Recycling Lead Batteries at EXIDE. Available at www.exideworld.com/ environ.htm.

Federal Register 60:45948, 1 September 1995.

____. 60:64330, 15 December 1995.

____. 63:29203, 28 May 1998.

____. 63:34685, 25 June 1998.

____. 63:48806, 11 September 1998.

____. 63:49240, 14 September 1998.

H. John Heinz III Center for Science, Economics, and the Environment. 1998. *Designs for Domestic Carbon Emissions Trading*. Available at www.heinzctr.org/publications/index. htm.

Intergovernmental Panel on Climate Change (IPCC). 1999. *Aviation and the Global Atmosphere, Special Report*. Geneva, Switzerland: United Nations Environment Program and World Meteorological Organization.

Oldenburg, K.U. and J.S. Hirschhorn. 1991. *Prosperity Without Pollution: The Prevention Strategy for Industry and Consumers*. New York, NY: Van Nostrand Reinhold.

Recycling Research Institute (RRI). 1996. *State Scrap Tire Management Programs*. Suffield, CT. January.

U.S. Army Corps of Engineers (USACE), Institute for Water Resources, Navigation Data Center. 1998. *Actual Dredging Cost Data for 1963–1997 Long-Term Continuing Cost Analysis Data*. Available at www.wrsc.usace. army.mil/ndc/ddcosts.htm

U.S. Congress, General Accounting Office (GAO). 1998. *Federal Surplus Ships: Government Efforts To Address the Growing Backlog of Ships Awaiting Disposal*, GAO/ NSIAD-99-18. 22 October. Available at www. gao.gov/AIndexFY99/abstracts/ns99018.htm.

U.S. Congress, Office of Technology Assessment (OTA). 1992. *Managing Industrial Solid Wastes*, OTA-BP-O-82. Washington DC: U.S. Government Printing Office. February.

U.S. Department of Commerce (USDOC), U.S. Census Bureau. 1998. *U.S. International Trade in Goods and Services, Annual Revision for 1997*. Exhibit 6, Exports of goods by end-use category and commodity. Exhibit 7, Imports of goods by end-use category and commodity. Available at www.census.gov/ foreign-trade/Press-Release/ 97_press_releases/Final_Revisions_1997/.

U.S. Department of Energy (USDOE), Energy Information Administration. 1998a. *Alternatives to Traditional Transportation Fuels 1997*. Washington, DC.

_____. 1998b. *Annual Energy Review 1997*. Washington, DC.

_____. 1998c. *East Asia: The Energy Situation*. Washington, DC.

_____. 1998d. *Electric Utility Consumer Data Tables (from Annual Electric Utility Report)*. Available at www.eia.doe.gov/cneaf/ electricity/page/at_a_glance/con_tabs.html.

_____. 1998e. *Emissions of Greenhouse Gases in the United States 1997*. Washington, DC.

_____. 1998f. *What Does the Kyoto Protocol Mean to U.S. Energy Markets and the U.S. Economy?* Washington, DC.

_____. 1999. *Monthly Energy Review*. Washington, DC. January.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS). 1996. *Transportation Statistics Annual Report 1996*. Washington DC.

_____. 1998a. National Transportation Statistics 1998. Available at www.bts.gov/btsprod/nts.

_____. 1998b. *Transportation Statistics Annual Report 1998*. Washington, DC.

_____. Forthcoming. *National Transportation Statistics 1999*. Washington, DC.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS), Maritime Administration (MARAD), and U.S. Coast Guard (USCG). 1999. *Maritime Trade & Transportation 1999*. Washington, DC.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI). 1999. Personal communication.

U.S. Department of Transportation (USDOT), Federal Aviation Administration (FAA). 1998a. *The Impact of National Airspace Systems (NAS) Modernization on Aircraft Emissions*, DOT/FAA/SD-400-98/1. Washington, DC. September.

_____. 1998b. *Report to Congress: 1997 Progress Report on the Transition to Quieter Airplanes*. Available at www.faa.gov/arp/arphome.htm. August.

_____. n.d. *Statistical Handbook of Aviation*. Available at www.api.faa.gov/apo_pubs.htm.

U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). 1998. *Automotive Fuel Economy Program: Twenty-Second Annual Report to Congress, Calendar Year 1997*. Washington, DC.

U.S. Department of Transportation (USDOT), Office of Hazardous Materials Safety (OHMS). 1998. Special data run from the Hazardous Materials Information System database. 10 November.

U.S. Department of Transportation (USDOT), Office of Pipeline Safety (OPS). 1998. Summary reports. Available at www.ops.dot.gov/stats.htm.

U.S. Department of Transportation (USDOT), U.S. Coast Guard (USCG). 1999. Personal communication. 5 August.

U.S. Environmental Protection Agency (USEPA), Office of Air and Radiation (OAR), Air Quality Planning and Standards (AQPS). 1998. *National Air Quality and Emissions Trends Report, 1997*, 454/R-98-016. Available at www.epa.gov/oar/aqtrnd97/. December.

_____. 1999a. Atmospheric Information Retrieval System Facility Subsystem (AFS) pipeline data. Special retrieval for BTS.

_____. 1999b. *National Air Pollutant Emission Trends, 1900–1997*. [publication pending as of 2/9/99 and expected to be published only on EPA website]

U.S. Environmental Protection Agency (USEPA), Office of Air and Radiation (OAR), Stratospheric Protection Division (SPD). 1998. *Report on the Supply and Demand of CFC-12 in the United States*. Washington DC. 15 May.

U.S. Environmental Protection Agency (USEPA), Office of Air and Radiation (OAR), Air Quality Strategies and Standards Division (AQSSD) and Emissions, Monitoring and Analysis Division (EMAD). 1998. *1990 Emissions Inventory of Forty Section 112(k) Pollutants*, Interim Final Report. Available at www.epa.gov/ttn/uatw/112k/112kfac.html. January.

U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance (OECA). 1997. *EPA Office of Compliance Sector Notebook Project: Water Transportation Industry*, EPA/310-R-97-003. Available at www.es.epa.gov/oeca/sector/index.html. September.

_____. 1998. *EPA Office of Compliance Sector Notebook Project: Air Transportation Industry*, EPA/310-R-97-001. Available at www.es.epa.gov/oeca/sector/index.html. February.

U.S. Environmental Protection Agency (USEPA), Office of Enforcement and Compliance Assurance (OECA) and Office of Solid Waste and Emergency Response (OSWER). 1998. EPA's Inspection and Compliance Assistance Priorities for Underground Storage Tank Systems not Meeting the 1998 Deadline. Memo. Available at www.epa.gov/swerust1/oustnews.htm. Click on December 1998 Supplemental Information Regarding the August 10, 1998 Enforcement Strategy (view the supplemental information).

U.S. Environmental Protection Agency (USEPA), Office of Pollution Prevention and Toxics (OPPT). 1996. *1994 Toxics Release Inventory*, EPA 745-R-96-002. Washington DC. June.

_____. 1997. *1987–1995 Toxics Release Inventory*, EPA 749-C-97-003. Washington DC. August.

_____. 1999. *1996 Public Data Release: Ten Years of Right-to-Know*. Available at www.epa.gov/opptintr/tri/pdr96/2drhome.htm.

U.S. Environmental Protection Agency (USEPA), Office of Solid Waste (OSW). 1993–1997. *National Biennial* RCRA Hazardous Waste Report. Washington, DC.

_____. 1999. *RCRA Biennial Reporting System for Hazardous Waste*. Available at www.rtk.net/www/rtknet/webpage/databas3.html.

U.S. Environmental Protection Agency (USEPA), Office of Solid Waste (OSW), Office of Underground Storage Tanks (OUST). 1998. *Corrective Action Measures for the 2nd Half of FY98*. Available at www.epa.gov/swerust1/cat/camnow.htm.

U.S. Environmental Protection Agency (USEPA), Office of Solid Waste and Emergency Response (OSWER). 1996. *Managing Used Oil: Advice for Small Businesses*, EPA530-F-96-004. Washington, DC. November.

U.S. Postal Service (USPS). n.d. *Environmental Compliance Model Vehicle Maintenance Facility Program*. Windsor, CT.

Washington State Department of Ecology (WDE), Hazardous Waste and Toxics Reduction Program. 1994. *Summary Report: Automotive "Shop Sweeps" Campaign*. Olympia, WA. January.

The State of Transportation Statistics

Transportation statistics are more up-to-date and extensive today than at any time in recent history, yet unprecedented and unmet demands are being placed on the use of those statistics by decisionmakers. The Bureau of Transportation Statistics (BTS) and the transportation and data communities face many challenges in meeting the emerging needs of the information age.

As documented in several reports of the National Academy of Sciences, the transportation community now requires statistics to be more complete, detailed, timely, and accurate than ever before (TRB 1992, 1997a, and 1997b). Today's transportation statistics remain incomplete, although major data-gathering efforts have occurred throughout the past decade. For example, despite intensified interest in the transportation of goods and passengers between countries, the United States does not yet collect data on the domestic movement of commodities traded internationally. Data on this and other currently unmeasured transportation activities could provide valuable insights for decisionmakers. Some transportation activities, however, may prove difficult to measure.

The demand for completeness in transportation data means that fuller information is required not just about transportation activity, but about transportation's impacts as well. It is recognized that transportation plays a central role in the economy, the environment, and many other fields, but there is great uncertainty about the range of transportation benefits and costs. Transportation can have large social impacts on minority populations, those of various ages and income levels, and persons with disabilities. Specific details about traveler characteristics and persons affected by transportation are required, in order to investigate many social concerns.

The demand for specifics extends to geography and time, recognizing that congestion as well as other transportation problems are not general conditions, but arise from concentrating more activity in one location at the same time than the infrastructure can accommodate. The importance of geographic detail can be seen in the effects transportation has on where people and goods go and where they do not. The demand for more timely data recognizes that transportation must respond to rapidly changing conditions, especially in a global economy, and that decisions cannot wait for measurements to be devised.

Greater accuracy in transportation data will improve the credibility and thus the utility of statistics for decisionmaking. The Government Performance and Results Act of 1993,[1] which emphasizes increased accountability in government, also drives the need for accuracy. As a first step, BTS is publishing data accuracy profiles in the 1999 edition of *National Transportation Statistics.*

The basic demands placed on transportation statistics have not changed substantially over the past few years, but the need for improved response has intensified. The Transportation Research Board's *Data for Decisions* (1992) and the first BTS *Transportation Statistics Annual Report* (TSAR94) laid out a group of questions about transportation, so that the appropriate data and information might be obtained. Those questions were listed in table 8-1 of TSAR94 (pp. 179–180), and are updated in table 6-1. These questions remain important, reflect current issues, and need attention in order to determine whether the Department of Transportation's published strategic goals of enhancing safety, mobility, economic development and trade, the natural and human environment, and national security are being attained (USDOT 1997).

The success of public programs in meeting information needs may be measured in various ways, but the consensus view is perhaps best reflected by enacted legislation. Two legislative milestones of the past decade in the field of transportation were the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act for the 21st Century (TEA-21) of 1998. ISTEA established BTS as a new national statistical agency for transportation with a list of statistical mandates. TEA-21 reaffirmed the programs begun under ISTEA and added new topics to be tackled, including global competitiveness, relationships between highway transportation and international trade, bicycle and pedestrian travel, and an accounting of expenditures and capital stocks related to transportation infrastructure. TEA-21 provides increased resources for data initiatives to improve highway safety, and studies were mandated on topics ranging from large trucks to school transportation to ferry boats. TEA-21 also recognizes the need to organize, preserve, and disseminate a wide range of information more effectively by authorizing the National Transportation Library.

Furthermore, TEA-21 requires BTS to establish and maintain the Intermodal Transportation Database (ITDB) as a complete picture of transportation activity, measured in physical and economic terms. The ITDB when fully developed will describe the basic mobility provided by the transportation system, identify the denominator for safety rates and environmental emissions, illustrate the links between transportation activity and the economy, and provide a framework for integrating critical data on all aspects of transportation. The ITDB will also provide a framework

[1] Public Law 103-62, 107 Stat. 286 (1993).

Table 6-1
Transportation Data Needs

What data are needed on passenger and freight transportation?	How are these data useful for public policy, infrastructure planning, and market analysis?
Who travels? How much travel? What moves? How much moves?	Shows source of transportation demand and most direct beneficiaries of transportation investment.
Why do people travel? How valuable is the material being moved?	Indicates relative importance of serving the demand for transportation.
How far do people travel? How far do goods move?	Provides an aggregate measure of transportation consumed.
From where to where?	Shows location of transportation facilities and services consumed; geographic regions and corridors affected.
What is the main mode used?	Provides basic input for debates on intermodal issues.
What other modes were used?	Indicates demand for intermodal connections and local access.
Do the links, nodes, and service providers cover current and anticipated origins and destinations?	Is a basic system performance measure.
How much of the system capacity (links, nodes, vehicles, and services) are consumed by current and anticipated travel and goods movement?	Indicates physical capacity of the system to provide service for basic transportation demand.
How timely is travel and goods movement between origins and destinations? (Traveltime, system speed)	Shows how effective the system is for the user; is a major component of user satisfaction, economic productivity, and international competitiveness.
How reliable are the trips and goods movements between origins and destinations?	Shows how effective the system is for the user; is a major component of user satisfaction, economic productivity, and international competitiveness.
How much does it cost to provide transportation services and infrastructure?	Indicates the efficiency of the transportation system.
How much do shippers and travelers spend to use services and infrastructure?	Shows how efficient the system is for the user; indicates the consequences for economic productivity and international competitiveness; provides input for market analysis.
How much of the costs for services and infrastructure are covered by users, the public sector, or others?	Provides input for analyses of investment, cost allocation, and privatization issues.

(continued on following page)

Table 6-1
Transportation Data Needs ***(continued)***

What data are needed on passenger and freight transportation?	How are these data useful for public policy, infrastructure planning, and market analysis?
How likely is the traveler to be hurt or luggage lost or damaged? How likely is the shipment to be damaged, lost, or stolen?	Indicates safety and security.
Who is the service provider?	Identifies the direct beneficiaries of transportation investment; provides accountability.
What is the financial condition of the service provider?	Identifies the ability of providers to maintain and improve performance and safety, susceptibility to foreign ownership and legal complications.
If the travel is for business, what industry is being served? For goods movement, who are the shippers and receivers?	Identifies the economic sectors receiving direct benefits from transportation investments.
Who else is dependent on the travel or the shipment?	Identifies others receiving direct benefits from transportation investments.
How much damage is done to the physical infrastructure and which users are causing the damage?	Establishes investment needs; indicates where costs should be allocated among users and others.
What is the risk of health-related mishaps?	Identifies safety risks; can present special risks for hazardous materials.
What are the effects on air and water quality, noise, and other environmental concerns?	Mandated by environmental legislation; provides information for the ongoing debate between environmental concerns and interstate commerce.
How much energy is consumed?	Provides basic information on energy conservation and for national security issues and global climate change.
Who and what are affected by these externalities?	Identifies the societal and environmental consequences of transportation, in addition to how endangered species are affected.

for identifying and filling gaps in essential information. One of the biggest gaps involves the domestic transportation of international trade, described in box 6-1.

TEA-21 also requires BTS to establish and maintain the National Transportation Atlas Databases (NTAD), recognizing that transportation exists to overcome the barriers of geography. The NTAD is based on four layers of information:

- facilities (including transportation links, terminals, interchange points, staging areas, and so forth);
- services on those facilities (e.g., railroad trackage rights);

Box 6-1

Domestic Transportation of International Trade

Legislation and the Department of Transportation's strategic plan have increased the already considerable interest by the Bureau of Transportation Statistics (BTS) in the domestic transportation of international trade. The Transportation Equity Act for the 21st Century (TEA-21) directs BTS to provide information on "transportation-related variables that influence global competitiveness" and specifically to conduct a study of the use of domestic highways to move international trade. In addition, economic growth and trade, of which international trade is a major component, is one of the strategic goals of the Department.

These developments require progress in solving the longstanding problem of accurate, high-quality data in the area of international transportation and trade. One of the key issues is obtaining accurate geographic data. The transportation community is concerned with physical geography; that is, does the international shipment enter the territorial limits of the United States and the U.S. transportation system? The trade community is interested in economic geography; that is, does the international shipment enter the U.S. economy? Both transportation and trade communities want to know the states in which the exports originate and the states to which imports are destined. Because of data definitions and collection procedures used by the Census Bureau and the U.S. Customs Service, transportation-related data are not always accurately reported. As an example, some U.S. import shipments arriving from Canada by truck are reported as entering the United States at Dallas, Texas.

BTS recognizes the need to take a comprehensive, multimodal approach to collection, analysis, and dissemination of international trade data. This is because the data problem affects all forms of transportation. For example, the top three gateways between the United States and the rest of the world by value in 1997 were the Port of Long Beach, the highway and rail crossings at Detroit, and John F. Kennedy International Airport in New York. Each of these facilities handled over $80 billion in goods. Understanding the domestic links between gateways and the heartland is vital to supporting America's role in the global economy.

One notable development in the multimodal approach to international transportation and trade data was the transfer of the international waterborne statistics program on October 1, 1998 from the Census Bureau to the U.S. Department of Transportation's Maritime Administration and the U.S. Army Corps of Engineers. BTS intends to become more active in enhancing coverage and increasing the quality of the statistics by bringing together data from the Customs Service, the Census Bureau, and the federal transportation agencies, as well as from our North American partners.

BTS has been working with our North American partners to compile consistent and comparable transportation data across the three countries. For example, the Bureau established a Standard Classification of Transported Goods with the Census Bureau and Statistics Canada to describe and classify commodities in ways that are more useful to the transportation community. BTS is currently working with the transportation and statistical agencies of Canada and Mexico on a North American Transportation Statistics Project, which will include the release of a statistical publication that will provide a continental picture of transportation and reveal differences in data definitions and comparability. Annual meetings of the transportation and statistics agencies of all three countries, through the framework of the North American Transportation Statistics Interchange, promote information exchange and partnership opportunities for the resolution of common problems.

- flows over those facilities (including passenger, freight, and vehicle flows whether by the service providers or by private transportation); and
- background (including political boundaries and the surrounding distribution of people, economic activity, and environmental conditions).

The NTAD is designed to be the primary data source for national-level transportation mapping, spatial and network analysis, and the starting point and model for the transportation framework layer of the National Spatial Data Infrastructure. To meet these needs, NTAD data are compiled at a scale of 1:100,000, in which everything is located within approximately 100 meters of its true location.

TEA-21 and the report of a National Research Council Committee on National Statistics emphasize the need to improve data quality and comparability throughout transportation (TRB 1997a). From the BTS perspective, improvements in data quality and comparability require:

- adoption of common definitions of variables;
- adherence to good statistical practice, particularly in the collection and interpretation of sample data;
- replacement of questionnaires with unobtrusive methods of data collection, perhaps through the use of administrative records and remote sensing; and
- validation of statistics used in performance measures and other applications.

Validation goes beyond determining that a statistic is accurate, reliable, and based on an unbiased set of observations and methods of estimation. The statistic must also be relevant to the concept being represented. Ideally, the statistic should also be transparent and devoid of spurious accuracy.

Many performance measures in transportation fail the relevance test, either because the measure is not readily linked to real-world experience or because the measure fails to capture the desired concept. The commonly used measure of a ton-mile in freight transportation illustrates the problem; very few decisionmakers can visualize a ton-mile or find it relevant to transportation issues. The ratio of the "transportation bill" to Gross Domestic Product as a measure of transportation's share of the economy is another example. The numerator (the sum of all expenditures made annually in the economy on transportation) and the denominator (the annual output of goods and services produced by the economy) are based on entirely different forms of accounting and should not be combined.

Improving transportation statistics may mean developing and institutionalizing new data-collection technologies. Some traditional data-collection tools, such as roadside surveys, on-board travel surveys, travel diaries, and household travel surveys, are relatively expensive and pose reliability problems, or present safety problems for the interviewers. The use of data derived from intelligent transportation systems (ITS) applications offer promise, and opportunities to utilize ITS are worth investigation. However, any new means of obtaining data is likely to require new institutional arrangements and pose new questions of statistical quality. As part of its efforts to improve the quality of statistics, BTS is working with the Federal Highway Administration to coordinate the American Travel Survey and the Nationwide Personal Transportation Survey in order to develop better estimates of mid-range travel (30 miles to 99 miles), and improve data comparability and analysis of the continuum of travel from short walking trips to international air travel.

BTS continues to work with its partners and customers to ensure that its statistics "are relevant for transportation decision-making by [the] Federal Government, State and local governments, transportation-related associations, private businesses, and consumers."[2] BTS is hosting workshops on data needs for transportation safety, and cosponsored a national conference on data needs for economic analysis. In addition, BTS will begin to analyze existing data for the congressionally mandated study of international trade carried over U.S. highways. BTS will continue to cooperate as part of the North American Interchange on Transportation Statistics and host working groups on geospatial data, maritime data, performance measures, and other topics. Through these efforts, BTS and its partners will continue to make transportation count.

[2] 49 U.S.C. 111 (c)(7).

REFERENCES

Transportation Research Board (TRB). 1992. *Data for Decisions: Requirements for National Transportation Policy Making*, Special Report 234. Washington, DC: National Academy Press.

Transportation Research Board (TRB), National Research Council. 1997a. *The Bureau of Transportation Statistics: Priorities for the Future*. Edited by C.F. Citro and J.L. Norwood. Washington, DC: National Academy Press.

_____. 1997b. *Information Needs to Support State and Local Transportation Decision Making into the 21st Century*. Washington, DC: National Academy Press.

U.S. Department of Transportation (USDOT). 1997. *Strategic Plan 1997–2002*. Washington, DC. 30 September.

List of Acronyms

ADA	Americans with Disabilities Act
AFS	AIRS Facility Subsystem
AFV	alternative fuel vehicle
ATS	American Travel Survey
BNSF	Burlington Northern Santa Fe
BTS	Bureau of Transportation Statistics
Btu	British thermal unit
CAA	Clean Air Act
CFCs	chlorofluorocarbons
CFC-12	dichlorofluoromethane
CFS	Commodity Flow Survey
CO	carbon monoxide
CO_2	carbon dioxide
dB	decibels
dBA	A-weighted decibels
DGBS	Differential Global Positioning System
DOT	U.S. Department of Transportation
DWT	deadweight tons
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
EV	electric vehicle
FAA	Federal Aviation Administration
FARS	Fatality Analysis Reporting System
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FY	fiscal year

GAO General Accounting Office
GDD Gross Domestic Demand
GDP Gross Domestic Product
GES General Estimates System
GPRA Government Performance and Results Act
GPS Global Positioning System

HAP hazardous air pollutant
HMIS Hazardous Materials Information System
HPMS Highway Performance Monitoring System
HSR high-speed rail

ICAO International Civil Aviation Organization
IRI International Roughness Index
ISTEA Intermodal Surface Transportation Efficiency Act
IT information technologies
ITCS Incremental Train Control System
ITD International Trade Division
ITDB Intermodal Transportation Database
ITS intelligent transportation system

LPG liquefied petroleum gas
LTO landing and takeoff

MAC mobile air conditioning
MACT maximum achievable control technology
MARAD Maritime Administration
mmtc million metric tons of carbon
mpg miles per gallon
mph miles per hour
MPO metropolitan planning organization
MTBE methyl-tertiary-butyl-ether

N_2O nitrous oxide
NAFTA North American Free Trade Agreement
NET National Emissions Trends
NHTSA National Highway Traffic Safety Administration
NO_2 nitrogen dioxide
NO_X nitrogen oxides
NPIAS National Plan of Integrated Airport Systems
NPTS Nationwide Personal Transportation Survey
NTAD National Transportation Atlas Databases
NTI National Toxics Inventory

OPEC	Organization of Petroleum Exporting Countries
OPS	Office of Pipeline Safety
ORNL	Oak Ridge National Laboratory
PCBs	polychlorinated biphenyls
PCCIP	President's Commission on Critical Infrastructure Protection
PM-2.5	particulate matter of 2.5 microns in diameter or smaller
PM-10	particulate matter of 10 microns in diameter or smaller
POV	privately owned vehicle
PSR	Present Serviceability Rating
PUV	personal-use vehicle
quads	quadrillion
R&D	research and development
SCTG	Standard Classification of Transported Goods
SM/N	small metropolitan/nonmetropolitan
SO_2	sulfur dioxide
TEA-21	Transportation Equity Act for the 21st Century
TEM	transportation equipment manufacturing
TEU	20-foot equivalent container unit
TIUS	Truck Inventory and Use Survey
TRB	Transportation Research Board
TRDD	transportation-related domestic demand
TRFD	transportation-related final demand
TRI	Toxics Release Inventory
TRRL	Transport and Road Research Laboratory
TSAs	Transportation Satellite Accounts
TSAR	*Transportation Statistics Annual Report*
TSAR98	*Transportation Statistics Annual Report 1998*
TTI	Texas Transportation Institute
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
UST	underground storage tank
vmt	vehicle-miles traveled
VOC	volatile organic compounds
VTS	Vessel Traffic Service

WHO	World Health Organization
Y2K	Year 2000
ZEV	zero-emission vehicle

U.S./Metric Conversions and Energy Unit Equivalents

U.S. TO METRIC

Length (approximate)

1 yard (yd) = 0.9 meters (m)
1 mile (mi) = 1.6 kilometers (km)

Area (approximate)

1 square mile (sq mi, mi^2) = 2.6 kilometers (km^2)
1 acre = 0.4 hectares (ha) = 4,000 square meters (m^2)

Mass/Weight (approximate)

1 pound (lb) = 0.45 kilograms (kg)
1 short ton = 2,000 pounds (lbs) = 0.9 metric tons (t)

Volume (approximate)

1 quart (qt) = 0.96 liters (l)
1 gallon (gal) = 3.8 liters (l)

Energy Units (approximate)

1 British thermal unit (Btu) = 250 calories = 1,055 joules
1 calorie (cal) = 4.186 joules (exactly)
1 barrel of oil = 42 U.S. gallons (gal) = 0.16 cubic meters (m^3)
1 quadrillion Btu (quad) = about 170 million barrels of crude oil

METRIC TO U.S.

Length (approximate)

1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 miles (mi)

Area (approximate)

1 square kilometer (km^2) = 0.4 square miles (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

Mass/Weight (approximate)

1 gram (gm) = 0.036 ounces (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 metric ton (t) = 1,000 kilograms (kg) = 1.1 short tons

Volume (approximate)

1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallons (gal)

Energy

1 joule = 0.24 calories (cal)
1 exajoule = 10^{18} joules

SOURCE: U.S. Department of Commerce, National Institute of Standards and Technology.

Index

B

D

E

F

I

J

K

L

N

S

T

U

V

W

Transportation Statistics Annual Report 1999 is a summary of the state of the nation's transportation system and the state of transportation statistics.

Bureau of Transportation Statistics

THE MISSION
To lead in developing transportation data and information of high quality and to advance their effective use in public and private transportation decisionmaking.

THE VISION
Data and information of high quality supporting every significant transportation policy decision, thus advancing the quality of life and the economic well-being of all Americans.

TO OBTAIN THIS AND OTHER BTS PUBLICATIONS CONTACT:

Customer Service
Bureau of Transportation Statistics
U.S. Department of Transportation
400 7th Street SW, Room 3430
Washington, DC 20590

PHONE: 202.366.DATA
FAX: 202.366.3640
EMAIL (product orders): orders@bts.gov
STATISTICS BY PHONE: 800.853.1351
STATISTICS BY EMAIL: statistics@bts.gov

This report and other BTS products are available on the Internet at www.bts.gov.